

Transformers

Transforming Voltage
Amplitudes - AC -
Circuits

- **Transformers**

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- Transformers - Voltage
- Transformers - Power

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- Now that we have power dissipated through an RLC series circuit, let's address an important issue.

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- Now that we have power dissipated through an RLC series circuit, let's address an important issue.
- Not all devices require 120-V AC.

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- Now that we have power dissipated through an RLC series circuit, let's address an important issue.
- Not all devices require 120-V AC. Some devices require only 12-V AC.

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- Now that we have power dissipated through an RLC series circuit, let's address an important issue.
- Not all devices require 120-V AC. Some devices require only 12-V AC.
 - How do we “transform” the amplitude of the voltage provided by the power company to another amplitude?

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- If we strategically place two *different* solenoids near each other in an AC circuit, then the EMF through the solenoids will have different values.

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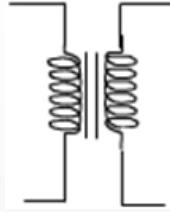
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- The artist rendition below is that of a typical transformer.

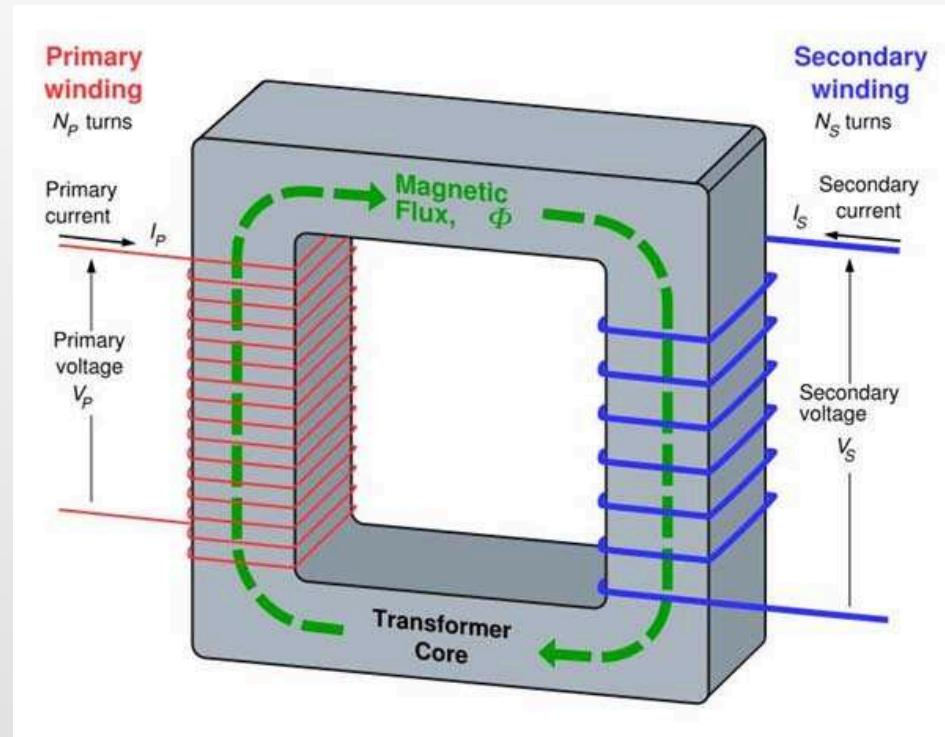
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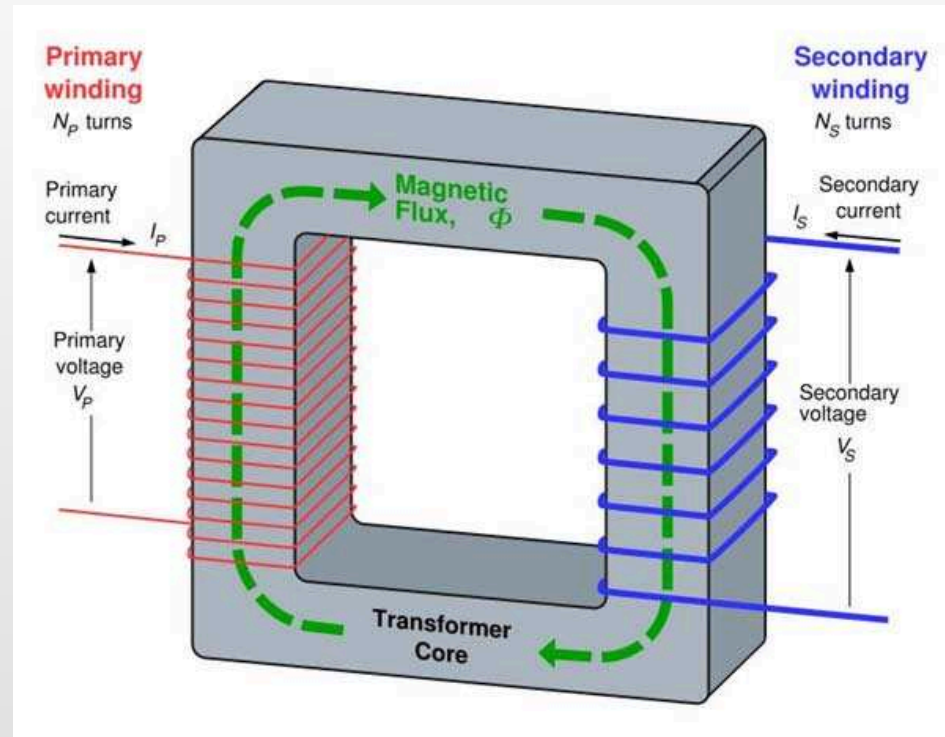
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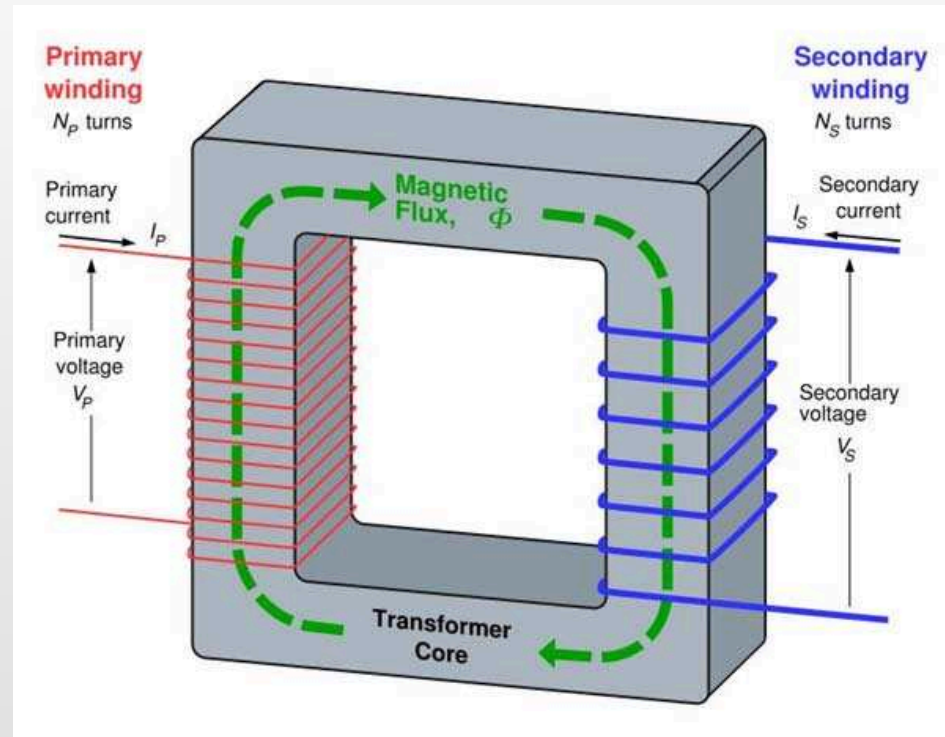
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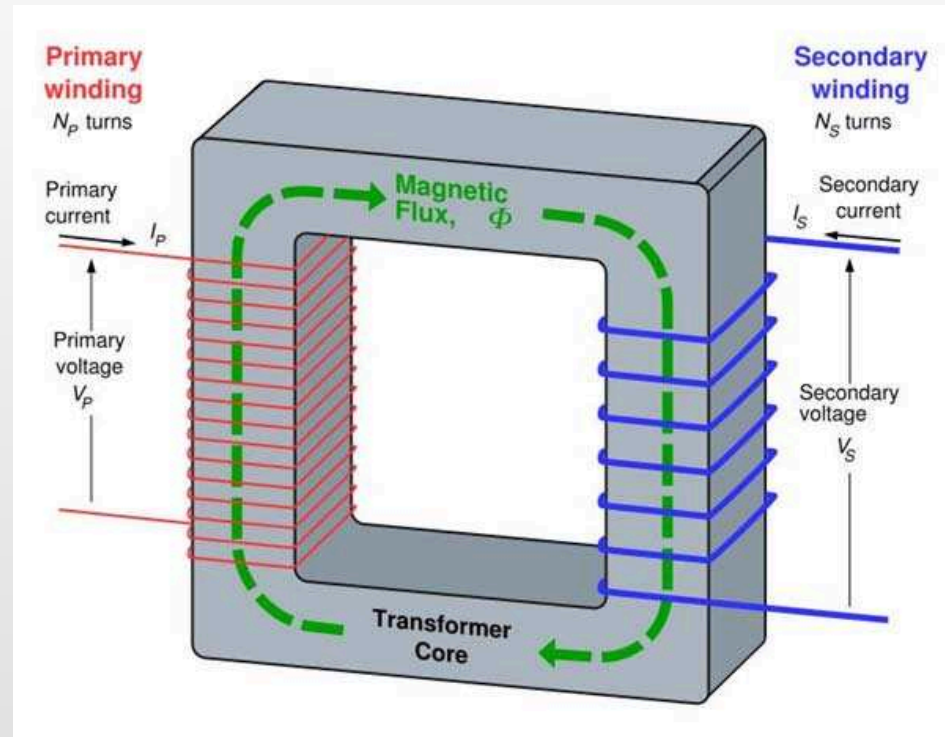
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- Since the magnetic flux is the same through both coils, the rate of change of magnetic flux is the same through the two coils.

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$$V_P = N_P \frac{d\Phi_B}{dt}$$

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- It seems that the secondary voltage can be arbitrarily large.

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$$I_P V_P = I_S V_S \quad (\text{Statement of Conservation of Energy})$$

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- We started talking about charges

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- We started talking about charges which led to forces

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- We started talking about charges which led to forces which led to electric fields. This led to Gauss's Law for charges:

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- Our discussion of moving charges led us down a path toward Ampere's Law:

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- We then spent a lot of time looking at the effects of time-varying magnetic flux which is called Faraday's Law of induction (together with Lenz's Law):

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A Symmetric Nature.

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A Symmetric Nature.

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- Let's consider an RC - circuit (DC).

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- It is natural to ask the question: “Does a *time-varying electric flux produce a magnetic field?*”
- Let's consider an RC - circuit (DC).
 - A current will exist in the circuit, but will decrease as the capacitor charges.
 - “Conduction” current is not continuous across the capacitor, yet a current exists in the circuit.

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 - “Conduction” current is not continuous across the capacitor, yet a current exists in the circuit.
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- The changing electric flux within the capacitor is “like” a conduction current. James Clerk Maxwell (Scottish physicist) suggested that a changing electric flux should give rise to a magnetic field.

Changing Electric Flux

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- We could quantify the rate of change of electric flux through the capacitor.

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- We could quantify the rate of change of electric flux through the capacitor.
- Start with Gauss's Law

Changing Electric Flux

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$$\int \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q}{\epsilon_0}$$

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$$\int \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q}{\epsilon_0}$$
$$I_d = \epsilon_0 \frac{d}{dt} \int \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}}$$

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- I_d is called the “displacement” current.

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$$\oint_S \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

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$$\oint_S \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

$$\oint_C \vec{\mathbf{E}} \cdot d\vec{\mathbf{l}} = - \frac{d}{dt} \int \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}}.$$

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$$\oint_S \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} = 0.$$

$$\oint_C \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = \mu_0 I_{\text{enclosed}} + \mu_0 \epsilon_0 \frac{d}{dt} \int \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}}.$$