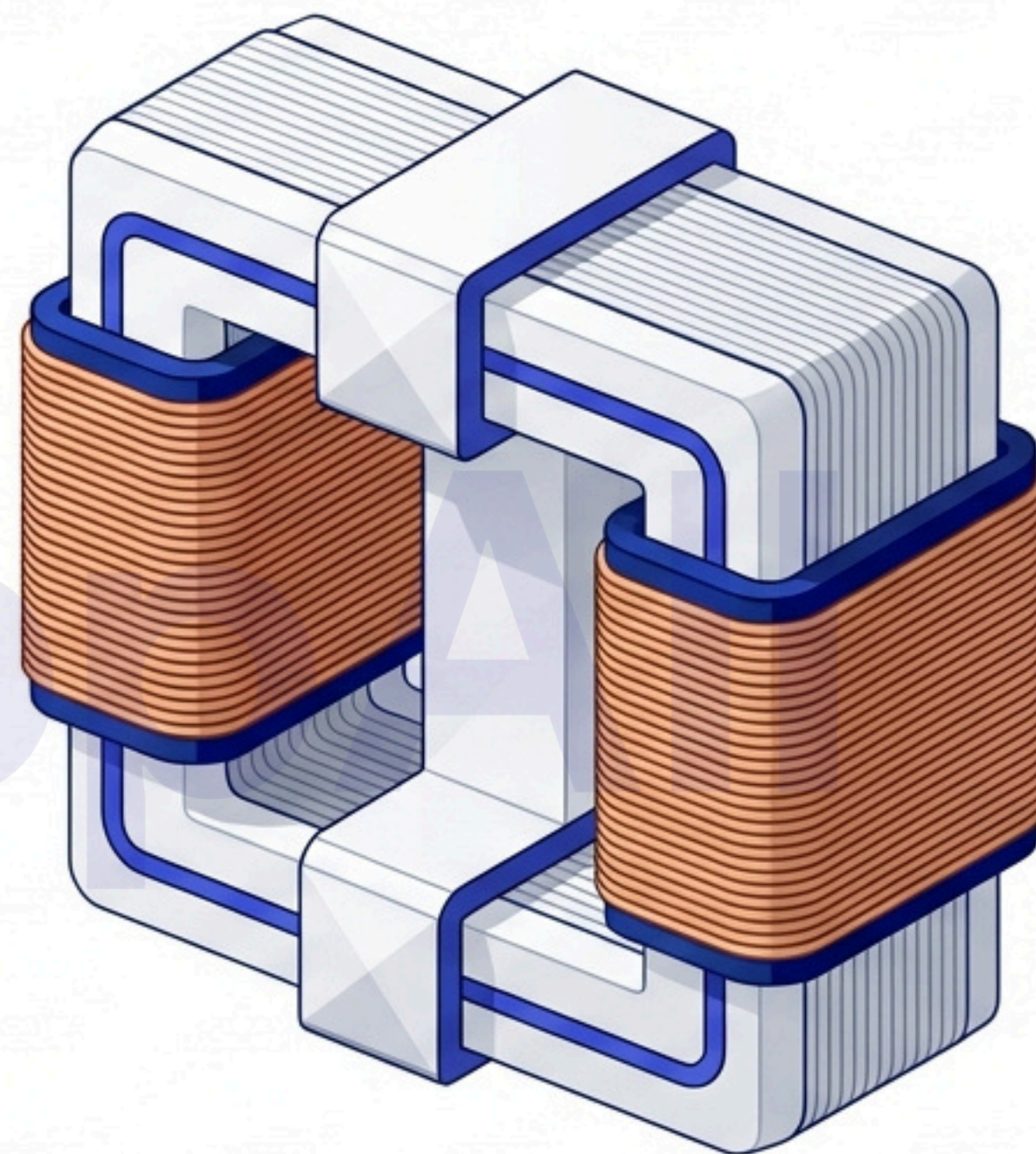


Transformers — How Voltage Is Changed

For many purposes, it is necessary to change an alternating voltage from one value to another. Discover how transformers use magnetic fields to step up or step down voltage with incredible efficiency.

- Works on the principle of mutual induction
- Essential for long-distance power transmission
- Core concept for NEET & JEE AC circuits



STRUCTURE & COMPONENTS

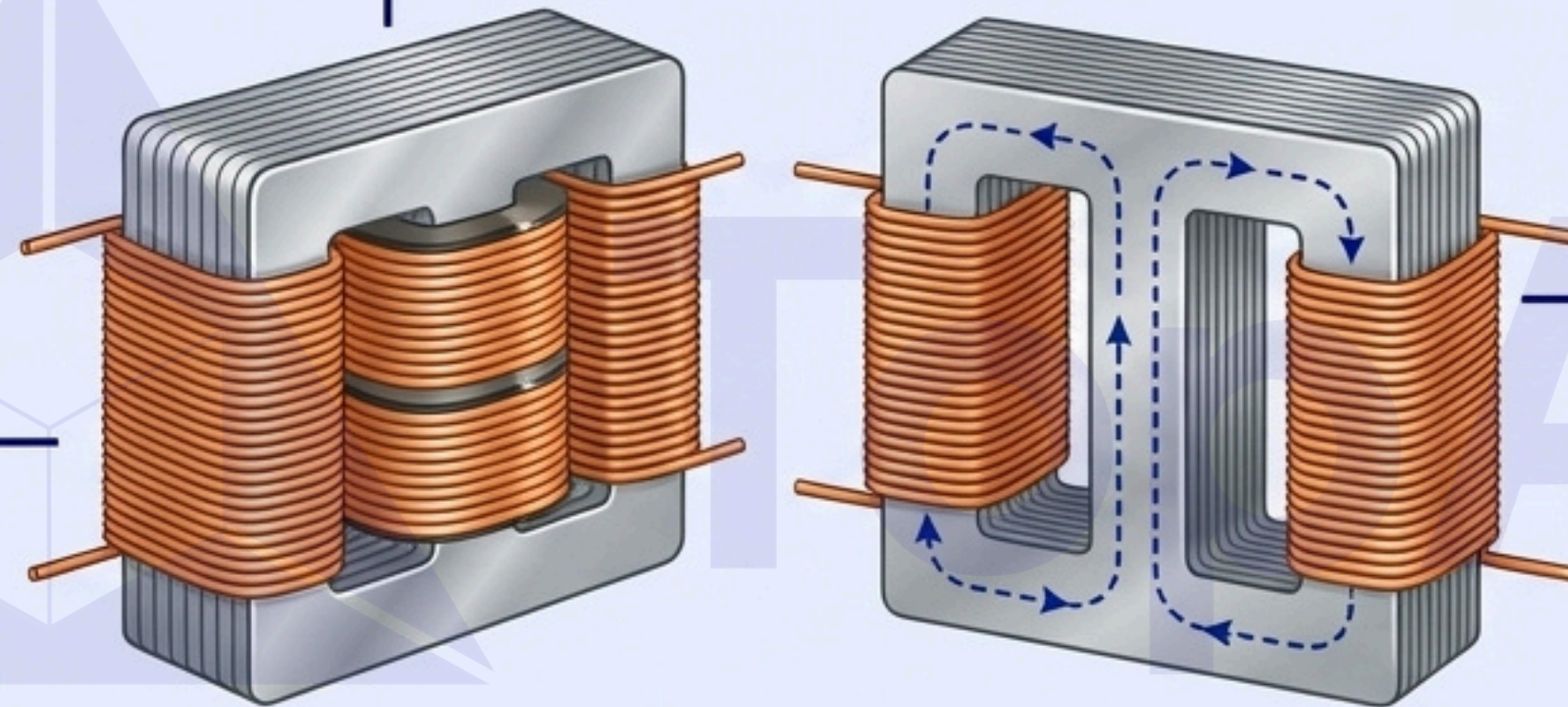
Anatomy of a Transformer

Soft-Iron Core:

Provides a closed path for magnetic flux.

Primary Coil (N_p):

The input coil where alternating voltage is applied.



Secondary Coil (N_s):

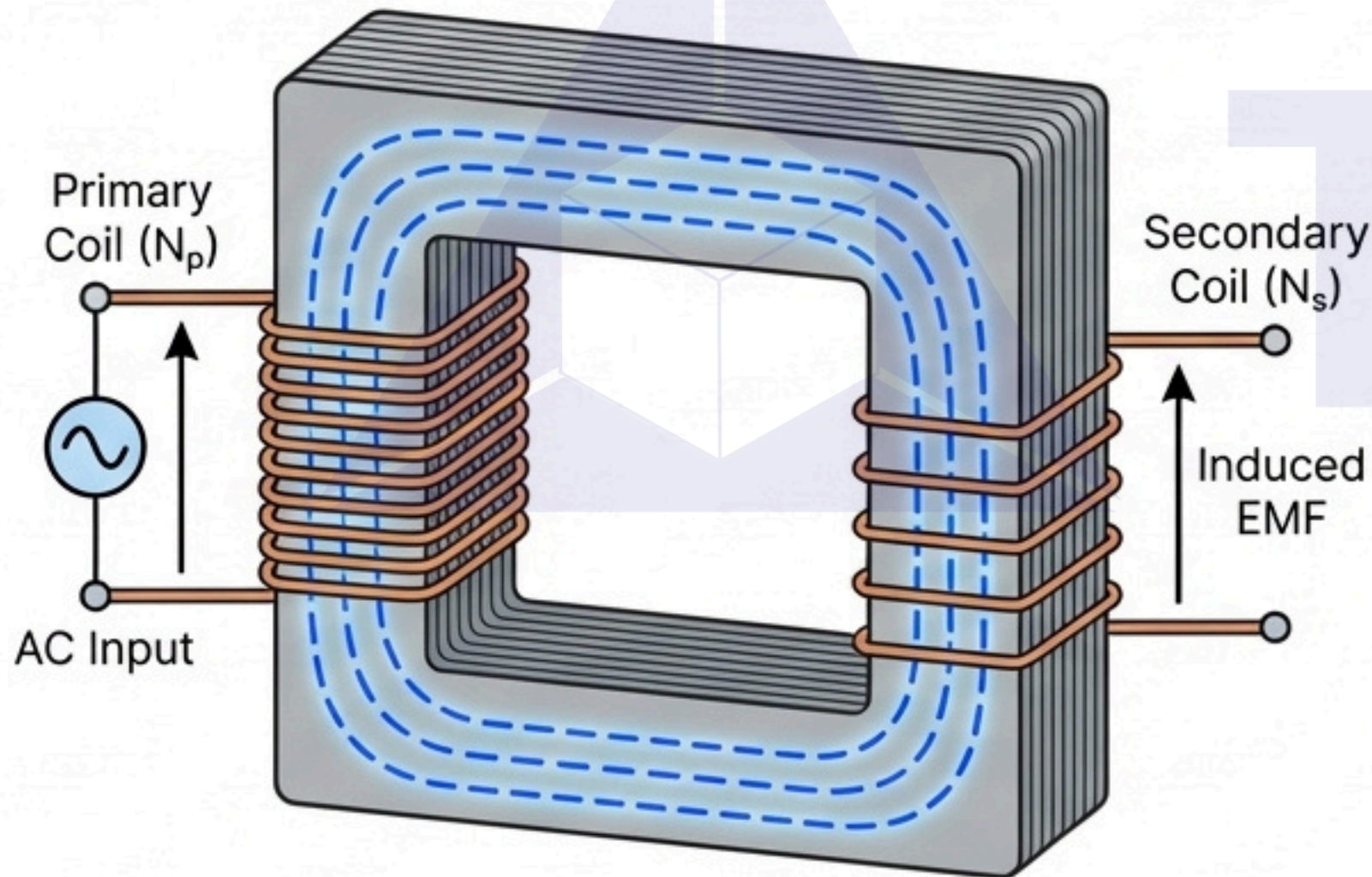
The output coil where induced emf is generated.

EXAM TIP

The two sets of coils are electrically insulated from each other but magnetically linked through the core.

The Principle of Mutual Induction

An alternating voltage in the primary produces an alternating magnetic flux. This flux links to the secondary coil, inducing an emf.



PRIMARY BACK EMF

$$\varepsilon_p = -N_p \left(\frac{d\Phi}{dt} \right)$$

SECONDARY INDUCED EMF

$$\varepsilon_s = -N_s \left(\frac{d\Phi}{dt} \right)$$

IDEAL TRANSFORMER Primary resistance is negligible, and all flux links both coils perfectly ($v_p = \varepsilon_p$ and $v_s = \varepsilon_s$).



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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Key Highlights

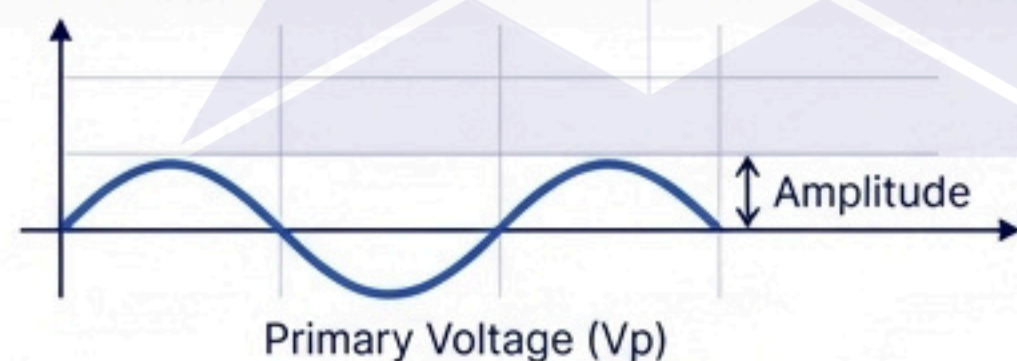
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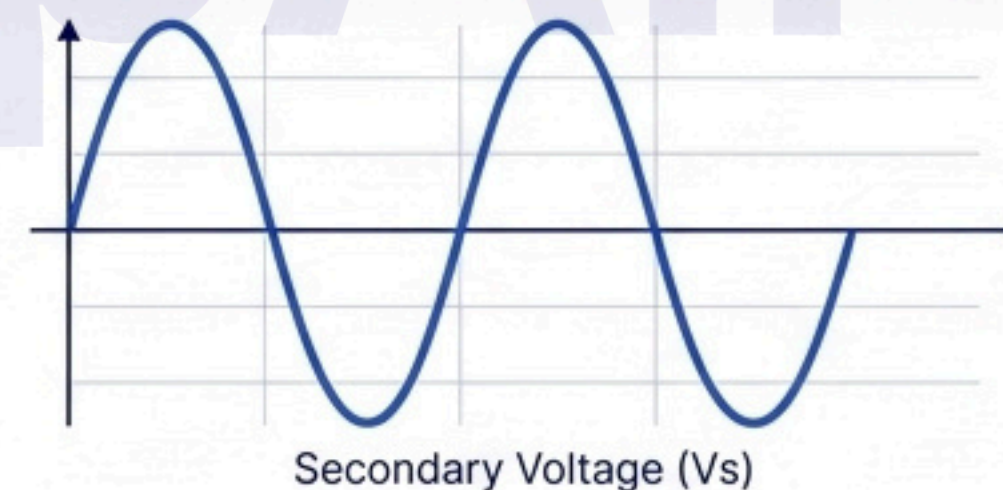
The Voltage Relation and Turns Ratio

VOLTAGE RELATION

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$



Scaled by N_s/N_p



- V_s and V_p are the secondary and primary voltages.
- N_s and N_p are the number of turns in the coils.
- The ratio N_s/N_p dictates exactly how the voltage will transform.

Step-Up vs. Step-Down Transformers

CURRENT RELATION (100% EFFICIENCY) $I_s / I_p = N_p / N_s$ (Power In = Power Out)

Step-Up Transformer

- $N_s > N_p$
- Voltage is stepped up ($V_s > V_p \uparrow$)
- Current is stepped down ($I_s < I_p \downarrow$)

Step-Down Transformer

- $N_s < N_p$
- Voltage is stepped down ($V_s < V_p \downarrow$)
- Current is stepped up ($I_s > I_p \uparrow$)

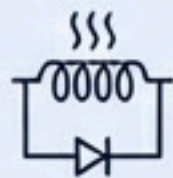
Power Transmission & Energy Losses

Transformers make long-distance electrical transmission highly economical. Stepping up voltage reduces the current, which drastically cuts down I^2R heating losses in the wires.



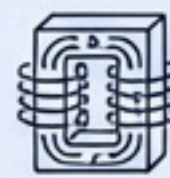
Flux Leakage

Not all flux passes to the secondary.



Resistance

I^2R heat loss in the copper windings.



Eddy Currents

Heating in the iron core (reduced by laminated cores).



Hysteresis

Energy spent repeatedly reversing core magnetization.

Chapter Summary & Next Steps

KEY TAKEAWAYS

- Transformers operate on mutual induction using an alternating magnetic flux.
- Voltage scales with turns: $V_s / V_p = N_s / N_p$.
- Current scales inversely to voltage: $I_s / I_p = N_p / N_s$.
- Transformers save energy in power grids by enabling low-current, high-voltage transmission.

Start Practice: Try Chapter 7 MCQs Next →



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