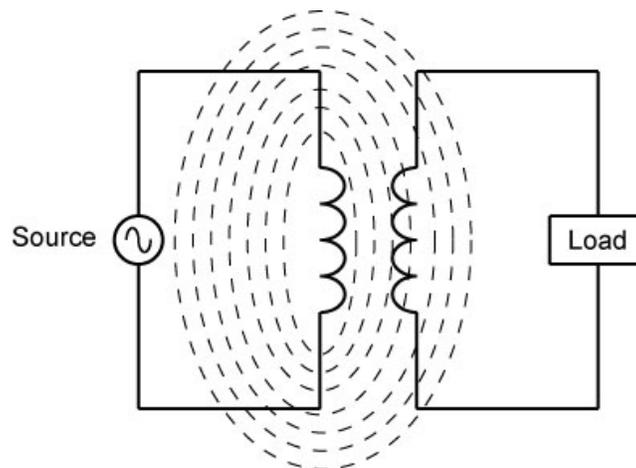


Cornerstone Electronics Technology and Robotics Week 32 Transformers

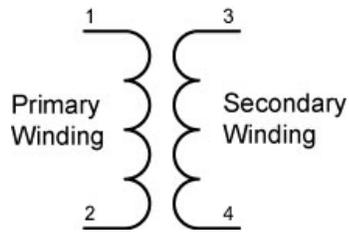
- Administration:
 - Prayer
 - Turn in quiz
- Electricity and Electronics, **Section 12.1**, Transformer Theory:
 - A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors, a process called mutual induction.
 - Mutual Induction:
 - As the alternating current in the primary coil (windings) varies, the magnetic field surrounding the primary windings also varies. When the secondary coil is placed within this changing magnetic field, the magnetic field cuts across the secondary windings and a voltage is induced in the secondary windings. This process is called mutual inductance. See Figure 32-3.



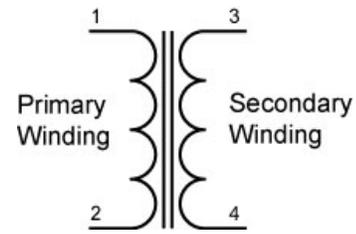
Mutual Induction
Figure 32-3

- Primary and Secondary Windings:
 - Primary winding is the input winding.
 - Receives input from the source
 - Secondary winding is the output winding
 - Secondary outputs to the load
- Transformers like many electronic components, have no moving parts.

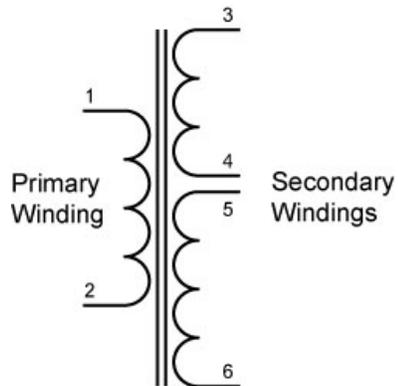
- Symbols:



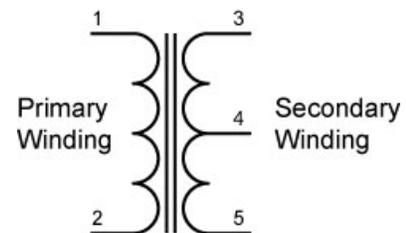
Air Core Transformer
Figure 32-1



Iron Core Transformer
Figure 32-2



Multiple Secondary Windings
Figure 32-3



Multiple Secondary Taps
Figure 32-4

- A transformer typically consists of two or more coils of wire wound around a common laminated iron core.
 - Dissect a transformer, show parts:
 - Coils
 - Common laminated iron core
- Turns Ratio Principle:
 - An important use of transformer is to increase or decrease a voltage. This is done by changing the number of turns in the secondary windings relative to the primary windings.
 - Turns Ratio:

$$\text{Turns Ratio} = N_P / N_S$$

Where: N_P = Number of primary turns
 N_S = Number of secondary turns

For example, if $N_P = 500$ and $N_S = 1500$, the turns ratio equals:

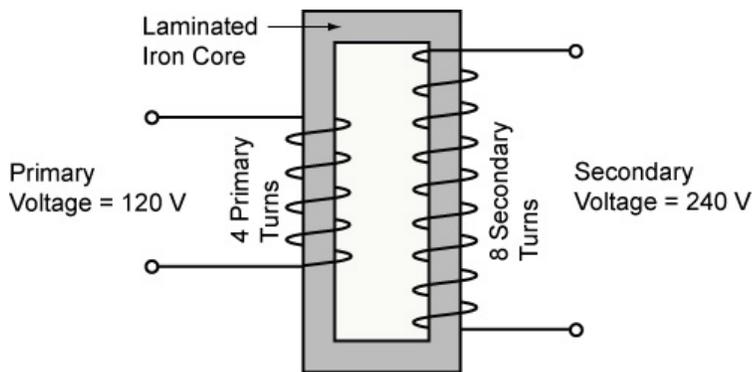
$$\begin{aligned} \text{Turns Ratio} &= N_P / N_S \\ \text{Turns Ratio} &= 500/1500 = 1:3 \end{aligned}$$

- Voltage Ratio:

$$V_P / V_S = N_P / N_S$$

Where: V_P = Primary Voltage
 V_S = Secondary Voltage
 N_P = Number of primary turns
 N_S = Number of secondary turns

For example, in Figure 32 – 5, $V_P = 120$ V, $N_P = 4$ turns, and $N_S = 8$ turns, solve for V_S :



$$V_P / V_S = N_P / N_S$$

$$120 \text{ V} / V_S = 4 \text{ turns} / 8 \text{ turns}$$

$$V_S / 120 \text{ V} = 8 \text{ turns} / 4 \text{ turns}$$

$$V_S = 120 \text{ V} (8 \text{ turns} / 4 \text{ turns})$$

$$V_S = 120 \text{ V} * 2$$

$$V_S = 240 \text{ V}$$

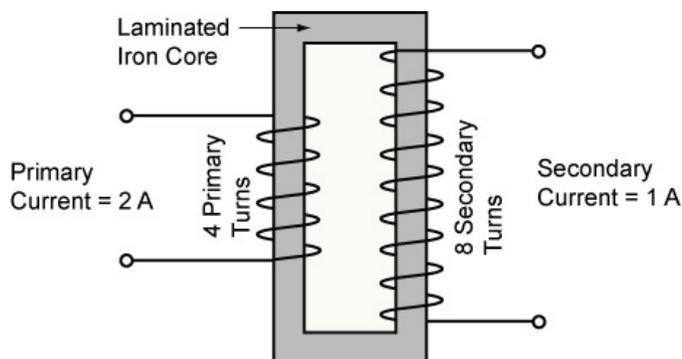
Figure 32-5, Voltage Ratio

- Current Ratio:

$$I_S / I_P = N_P / N_S$$

Where: I_P = Primary Current
 I_S = Secondary Current
 N_P = Number of primary turns
 N_S = Number of secondary turns

For example, in Figure 32 – 6, $I_P = 2$ A, $N_P = 4$ turns, and $N_S = 8$ turns, solve for I_S :



$$I_S / I_P = N_P / N_S$$

$$I_S / 2 \text{ A} = 4 \text{ turns} / 8 \text{ turns}$$

$$I_S = 2 \text{ A} (4 \text{ turns} / 8 \text{ turns})$$

$$I_S = 2 \text{ A} * 1/2$$

$$I_S = 1 \text{ A}$$

Figure 32-6, Current Ratio

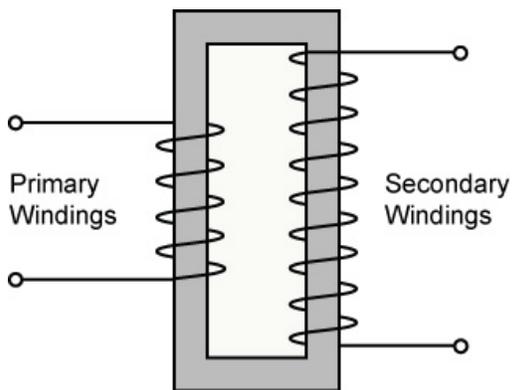
See:

<http://micro.magnet.fsu.edu/electromag/java/transformer/index.html>

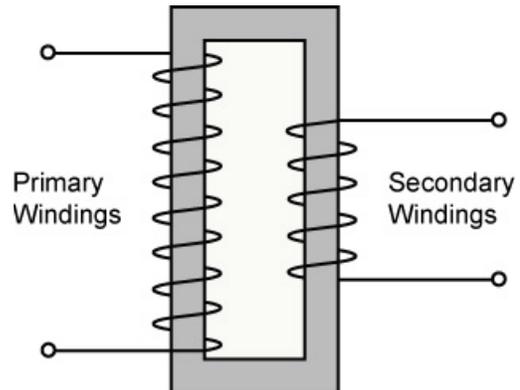
<http://www.falstad.com/circuit/e-transformer.html>

<http://www.ngsir.netfirms.com/englishhtm/Transformer.htm>

- Step-up and Step-down Transformers:
 - In a step-up transformer there are more turns in the secondary than the primary, therefore the voltage increases. See Figure 32-7.
 - In a step-down transformer there are fewer turns in the secondary than the primary, therefore the voltage decreases. See Figure 32-8.



Step Up Transformer
Figure 32-7



Step Down Transformer
Figure 32-8

- Transformer Power:

Assuming there are no internal losses in the transformer:

$$P_P = P_S$$

Where: P_P = Primary on the primary side

P_S = Power on the secondary side

- Transformer Losses:
 - Copper losses
 - Eddy current losses
 - Hysteresis losses

- Phase Relationship in Transformers:
 - The direction of the windings determines the polarity of the voltage across the secondary windings. See Figure 32-9.
 - See Figures 32-9 and 32-10 for the interpretation of the phasing dots in schematics.

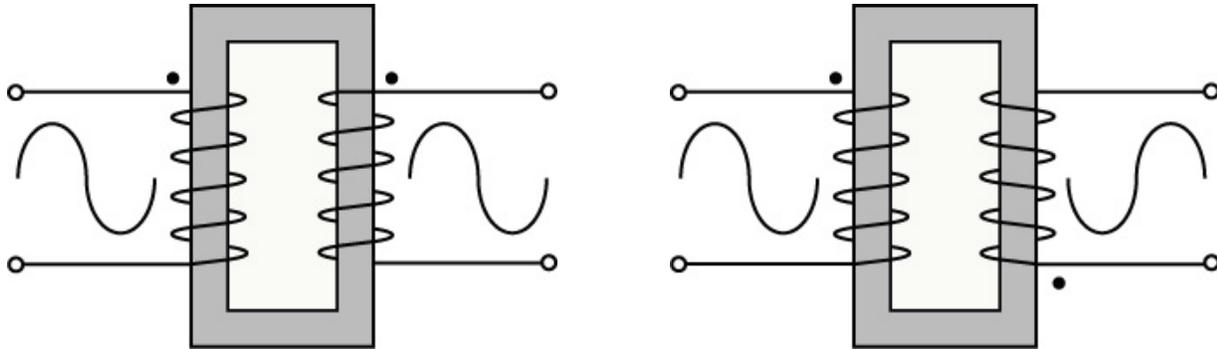


Figure 32-9, Phase Relation between the Primary and Secondary Direction of Windings

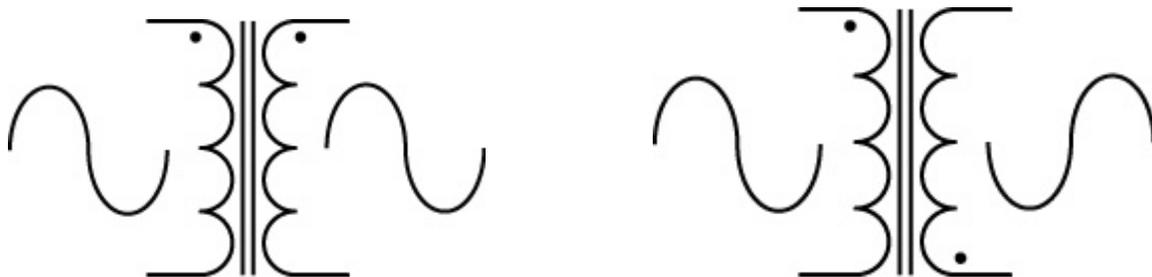


Figure 32-10, Schematic Symbols Showing Dots and Polarity

- Taps
 - Taps are connections in the secondary windings that are not at the ends of the winding.
 - Taps allow one transformer to provide a number of output different voltages.
 - For example, Figure 32-11 illustrates a transformer with a center tap on the secondary windings which yields two 60 V output voltages which are 180 degrees out of phase with each other.

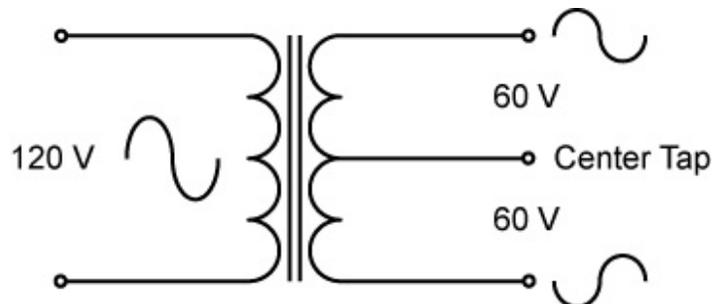
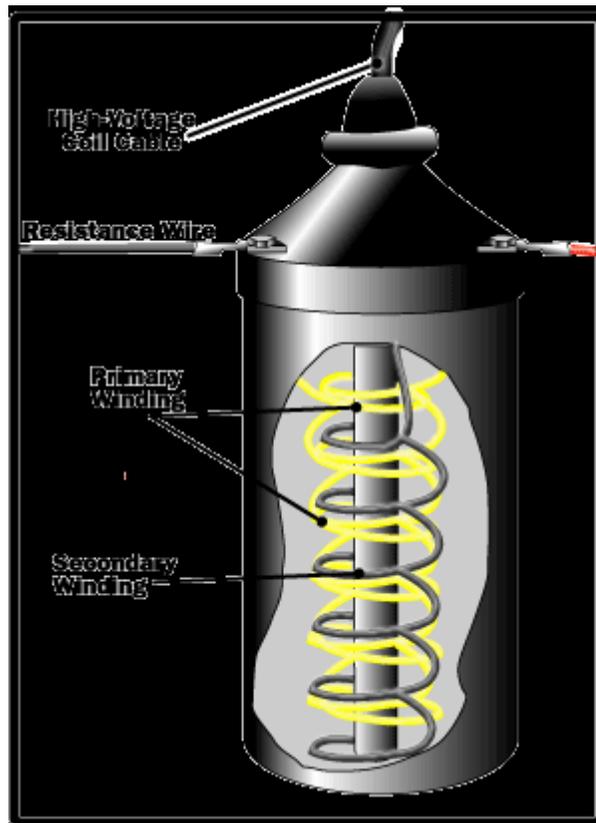


Figure 32-11, Transformer with a Center Tap in the Secondary

- Electricity and Electronics, **Section 12.3**, Special Transformer Applications
 - Autotransformers:
 - The primary and secondary windings are physically joined therefore there is no isolation.
 - Used in low voltage applications
 - Uses and samples
 - Induction Circuit Breaker:
 - Circuit breaker uses induction to trigger a switch to shut off current in a circuit.
 - The circuit must be reset manually.
 - Sample
 - Lighting Ballast:
 - Used in electric discharge lighting, e.g., fluorescent and mercury vapor
 - Two purposes:
 - Creates the necessary voltage to create an arc through the lamp.
 - Also limits the current through the lamp
 - Coupling Transformer:
 - Couples stages in an amplifier circuit
 - Used to match impedances of amplifier stages
 - Isolation Transformers:
 - Separates power systems from sensitive equipment
 - Prevents voltage spikes caused by switching inductive circuits from damaging equipment
 - Automobile Ignition Coil:
 - Produces high voltage, 30,000 or more volts, across the spark gap in a spark plug
 - The secondary coil normally has hundreds of times more turns of wire than the primary coil.



From: <http://auto.howstuffworks.com/ignition-system3.htm>

- Ignition coil is a form of an autotransformer
- The gap in the spark plug is an intentional opening in the circuit to produce a spark to ignite the gasoline vapor in the piston cylinder causing an explosion.
- Student Activity Sheet 12-2.
- Suggested Student Activity Sheet 12-3