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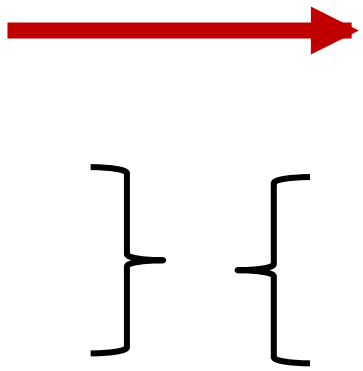

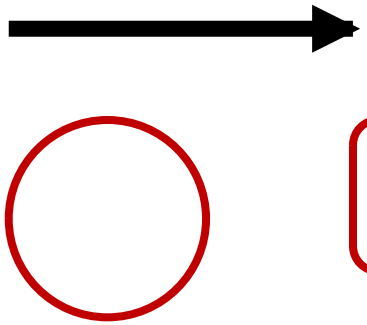

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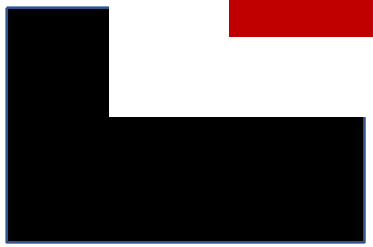
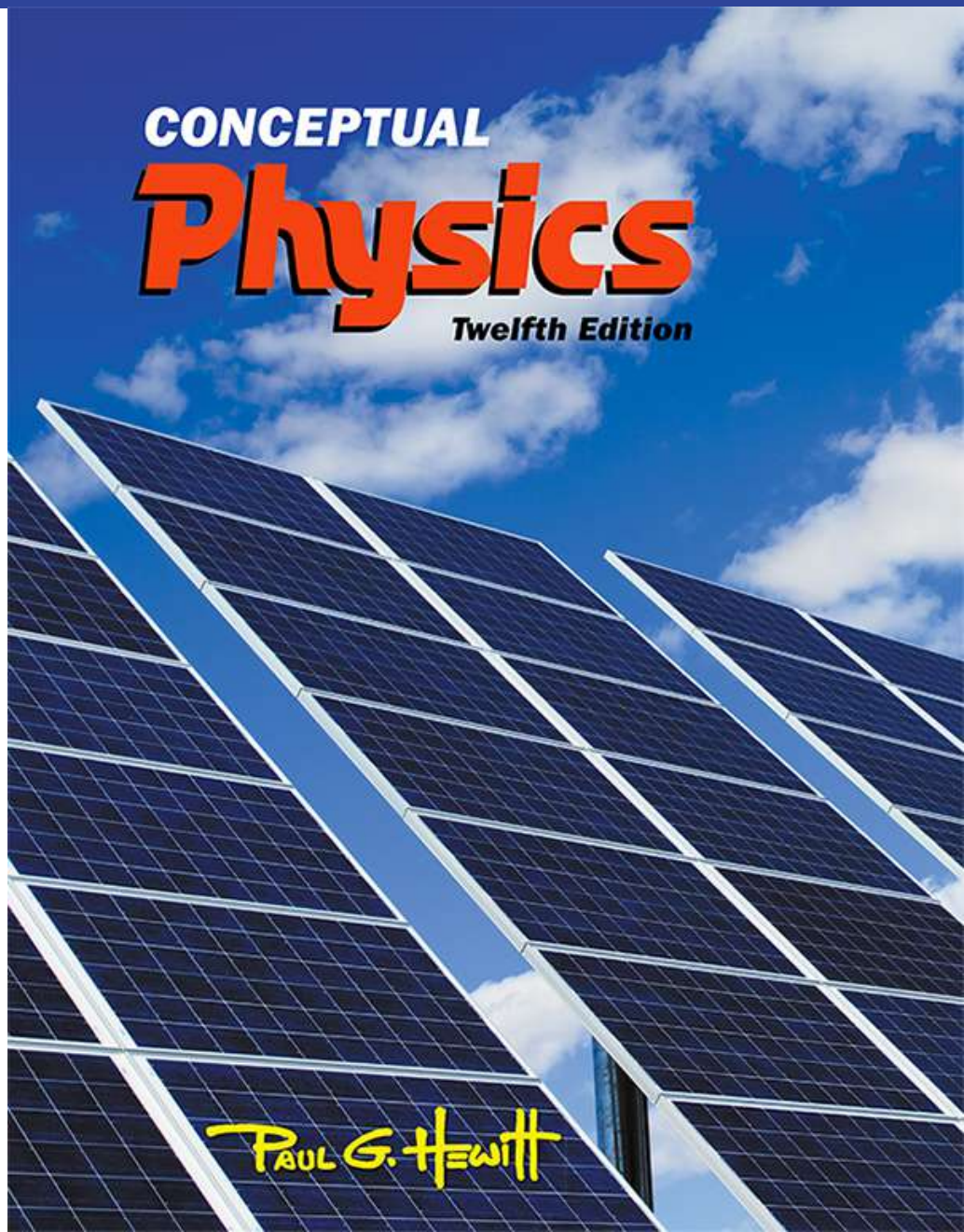


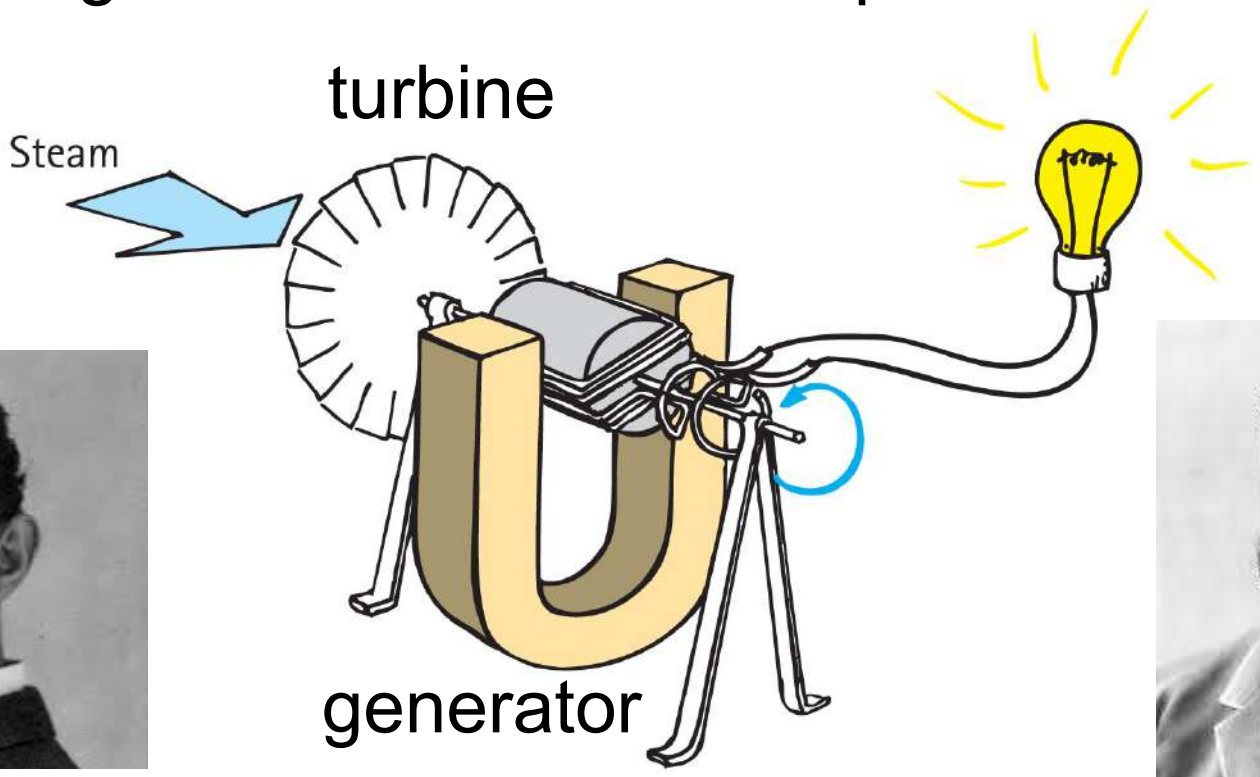
Chapter 25: Electromagnetic Induction

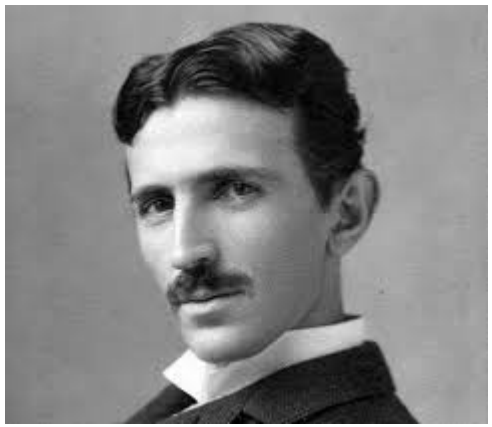
Part 2



Power Production

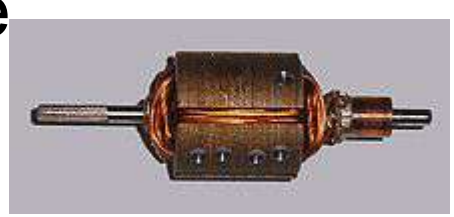
- Using Faraday and Henry's discovery of electromagnetic induction, Nikola Tesla and George Westinghouse showed that electricity could be generated in sufficient quantities to light cities.



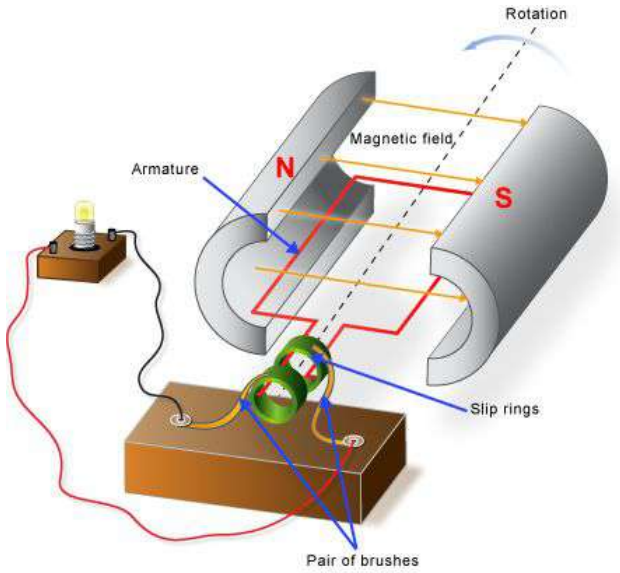


Armature

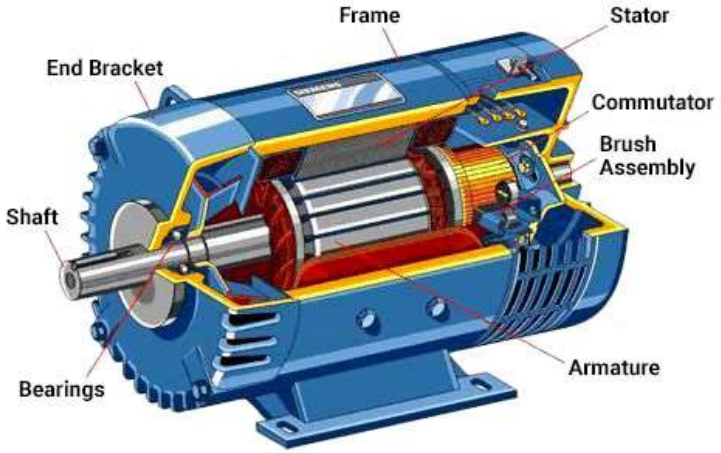
The center of the generator is an armature:



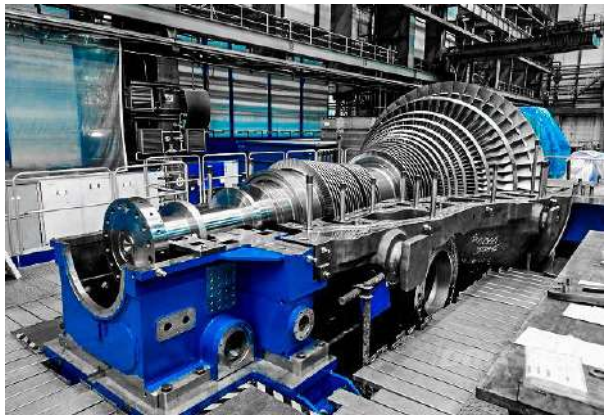
Iron cores wrapped with bundles of copper wire.



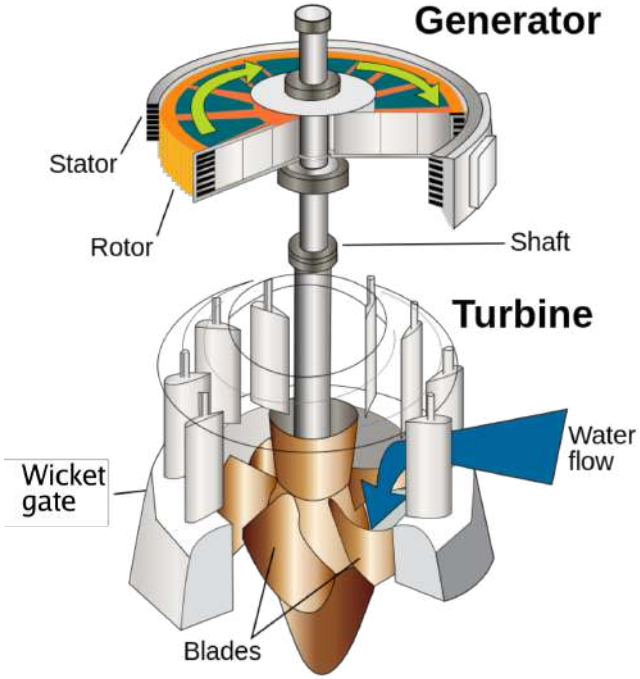
Around the armature is the stator: either a magnet or an electromagnet.



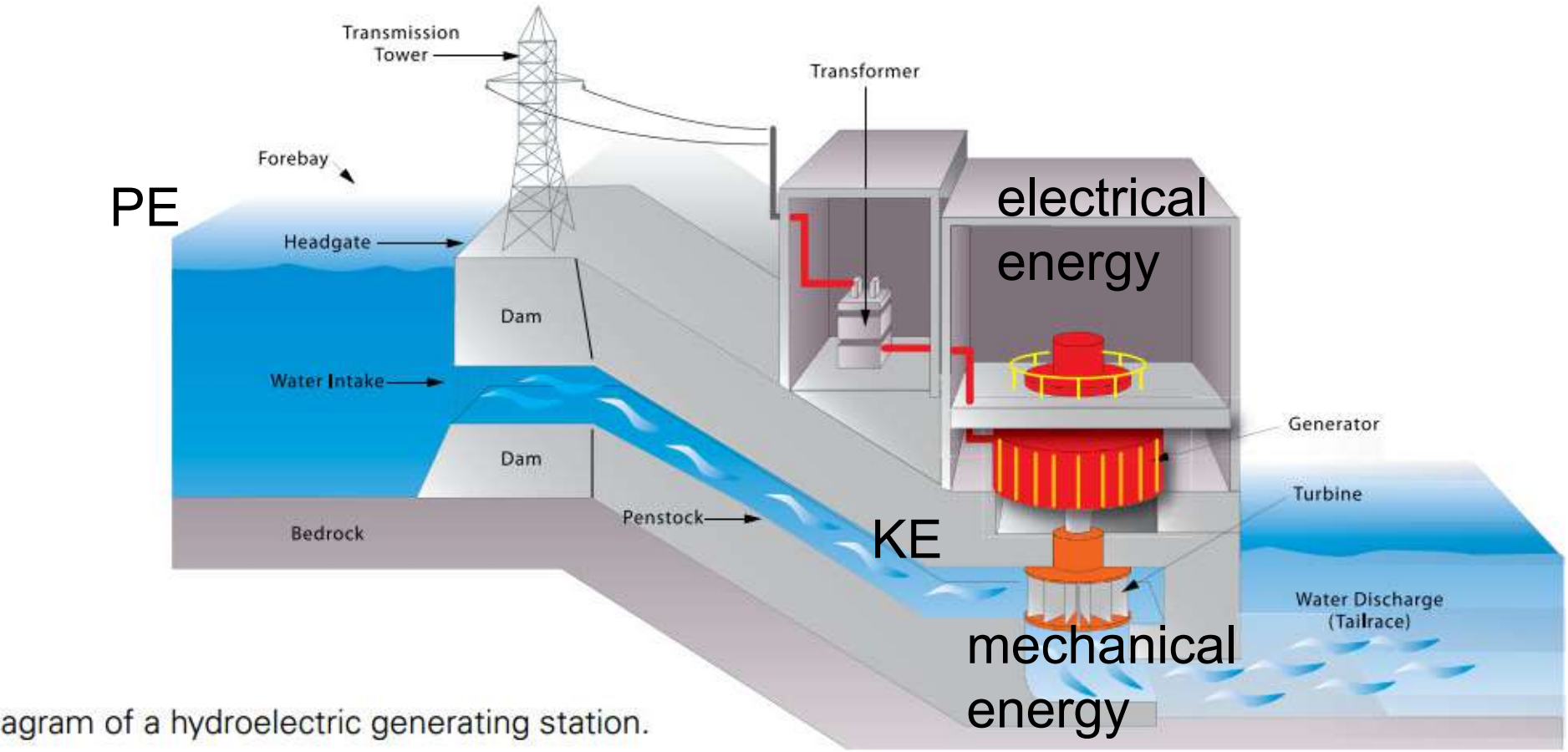
A **turbine** is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work.



It is connected to a generator to convert this energy into electrical energy: **Turbogenerator**

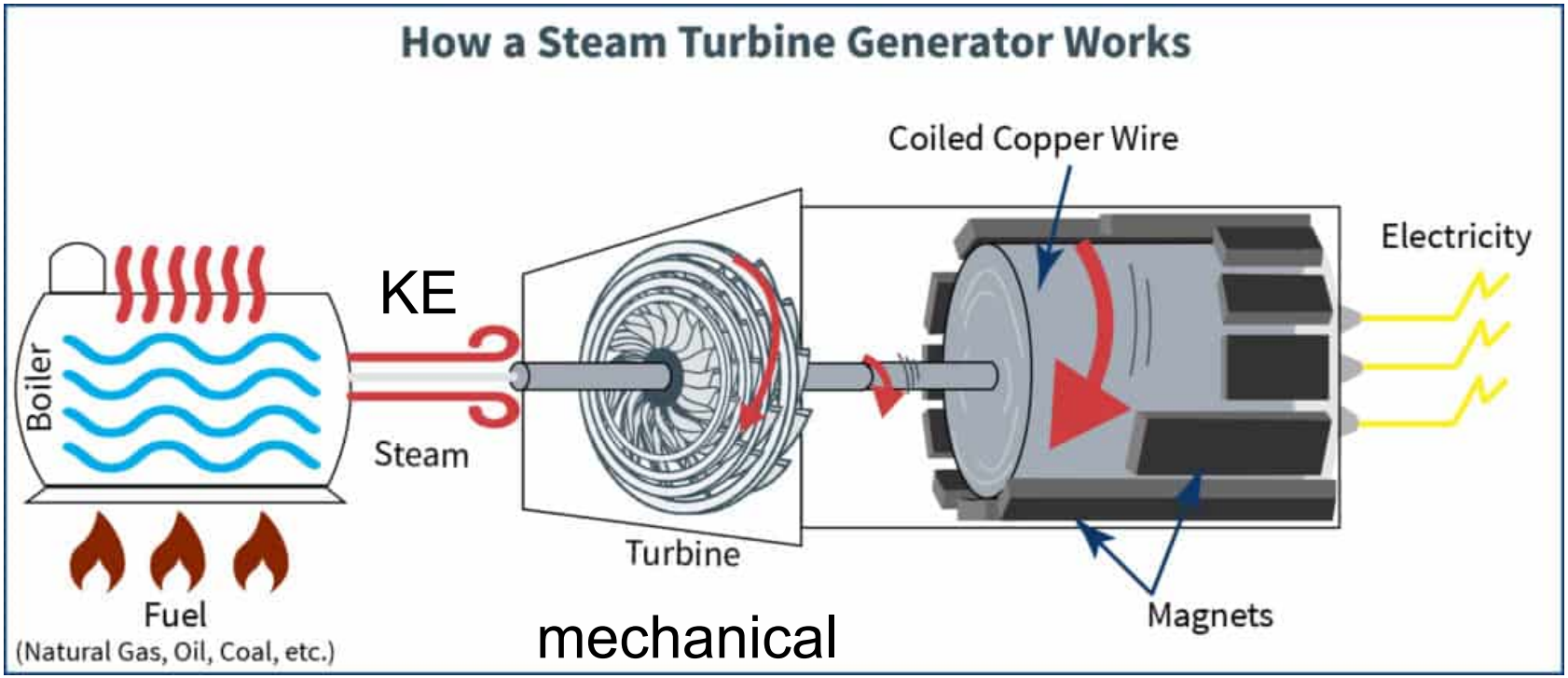


Hydroelectric dams convert:
Gravitational potential energy PE to
the kinetic energy KE of the water to
the mechanical energy of the turbine to
the electrical energy of the generator



agram of a hydroelectric generating station.

Steam turbines convert:
Chemical potential energy to Electrical energy
Fuel can be gas, oil, coal or nuclear



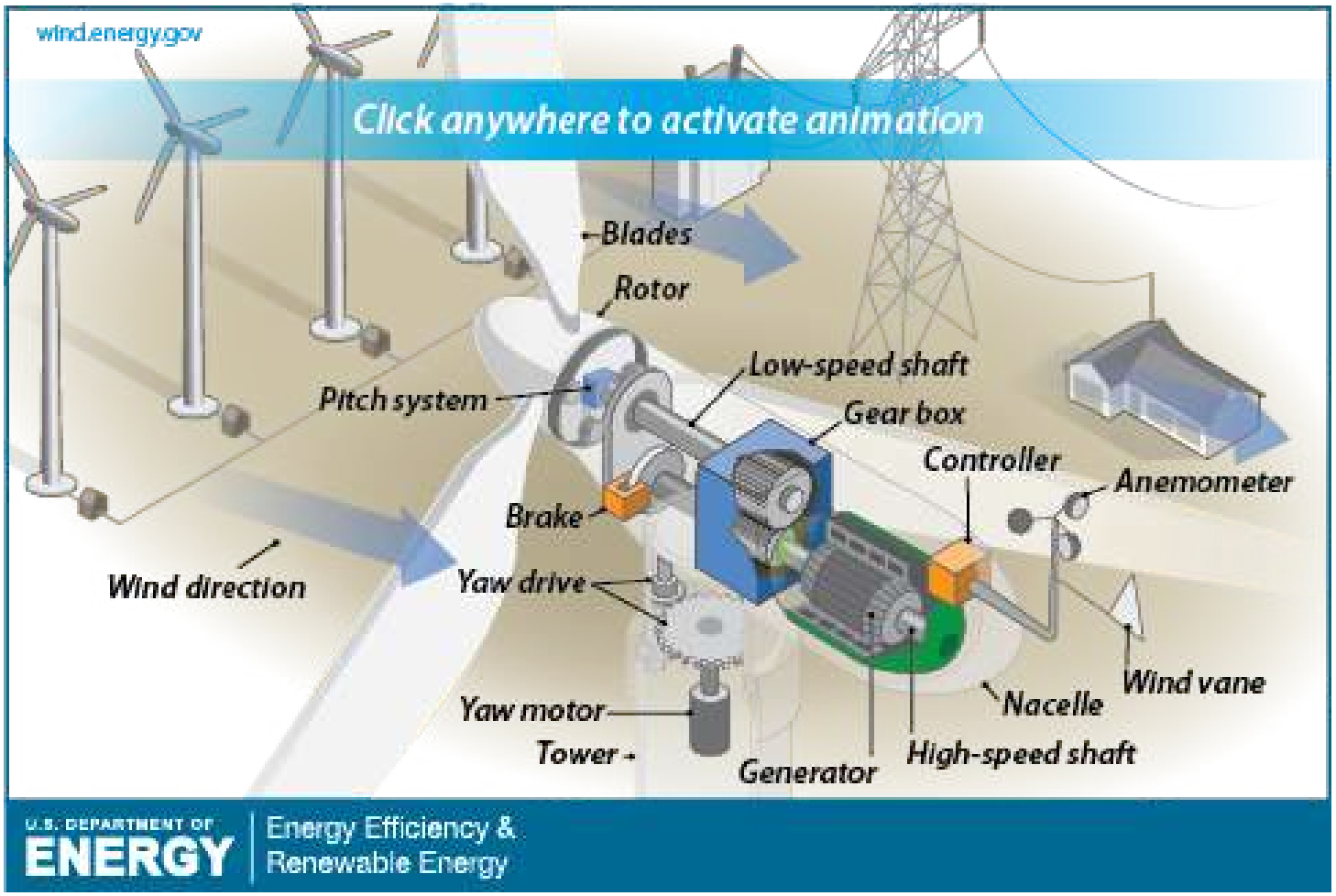
chemical
PE

mechanical
energy

electrical
energy

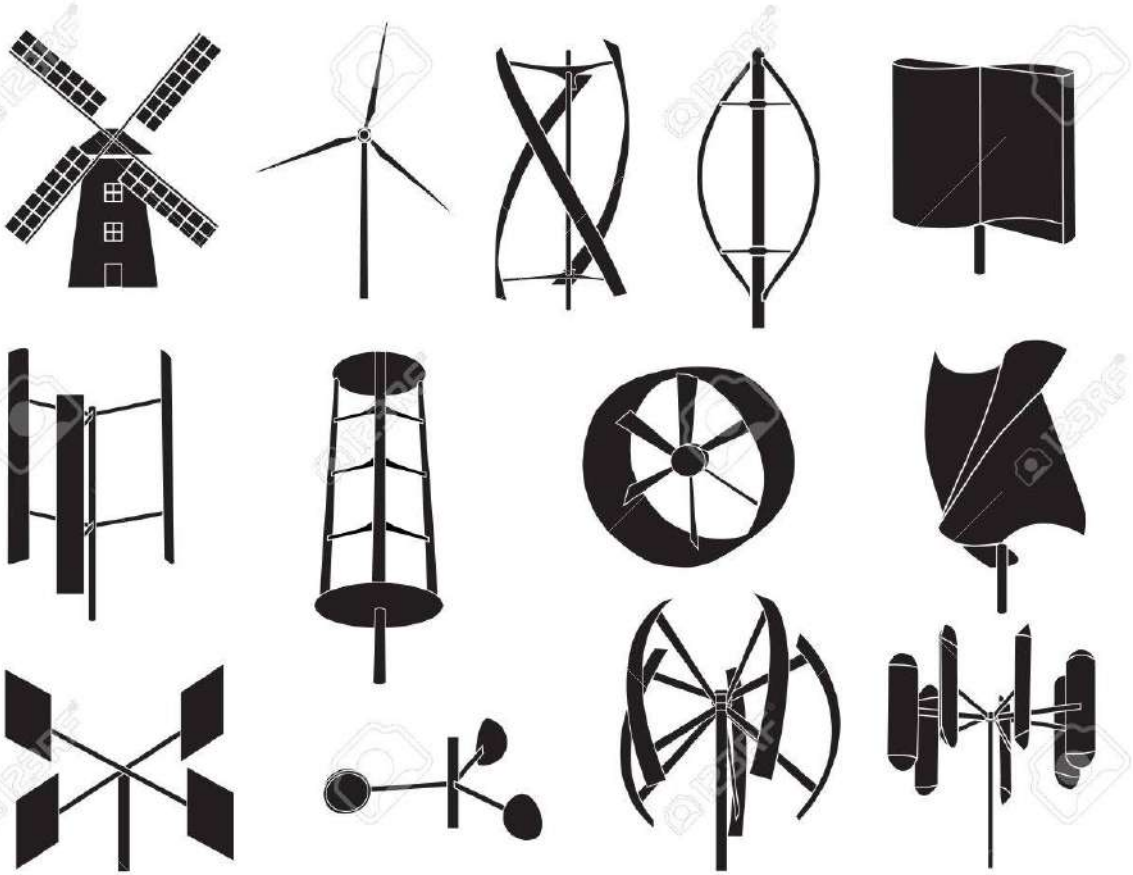

Control Panel
Diesel Engine
AC Generator
Common Base

Wind turbines:
Solar energy creates wind kinetic energy KE
Turbines convert wind KE to Electrical energy



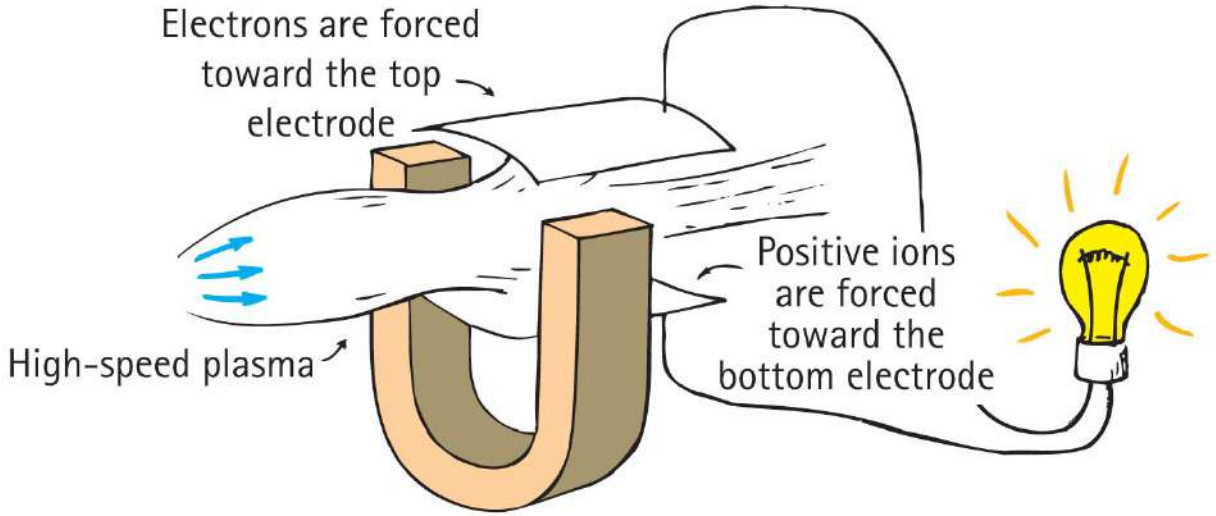
Wind turbine design depends on

- What kind of winds blow: speed, direction, variability
- Space limitations (do you need to point into the wind?)
- Size
- Cost
- Etc.



- MHD (MagnetoHydroDynamic) generator
  - Eliminates the turbine and spinning armature.
  - plasma of electrons and positive ions expands through a nozzle and moves at supersonic speed through a magnetic field.

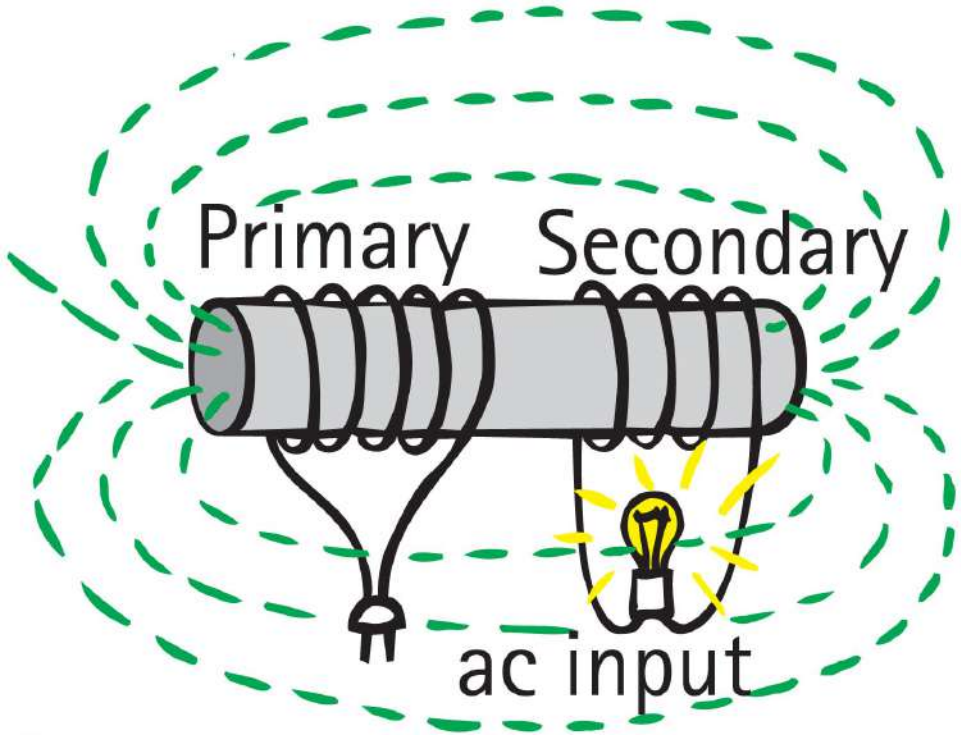
- The motion of charges through a magnetic field gives rise to a voltage and flow of current as per Faraday's law.



Transformers

- Use electromagnetic induction to change voltages and currents

- Conservation of Energy:
- Energy or power cannot be increased.

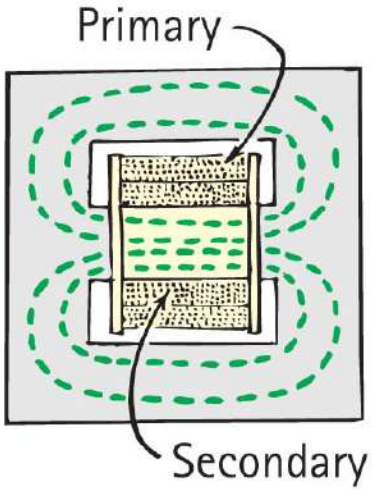


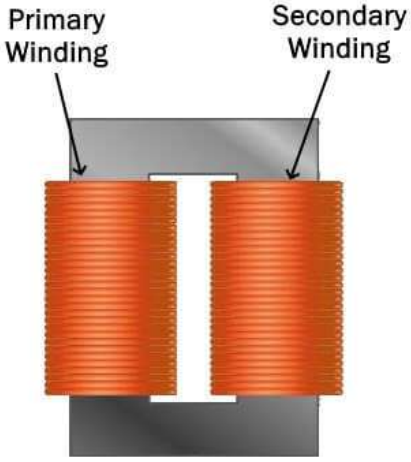
Input coil of wire—the **primary** powered by ac voltage source

Output coil of wire—the **secondary** connected to an external circuit

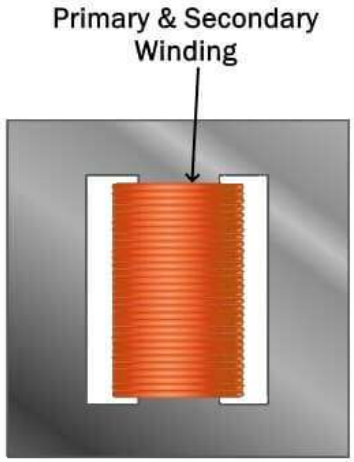
→ The two coils are not connected---only close to each other

- Transformer:
  - Both wound on a common iron core so that the magnetic field of the primary passes through the secondary
  - Use an alternating current and voltage in one coil to induce an alternating current and voltage in a second coil
  - Sometimes coils are wrapped around each other





Core Type Transformer



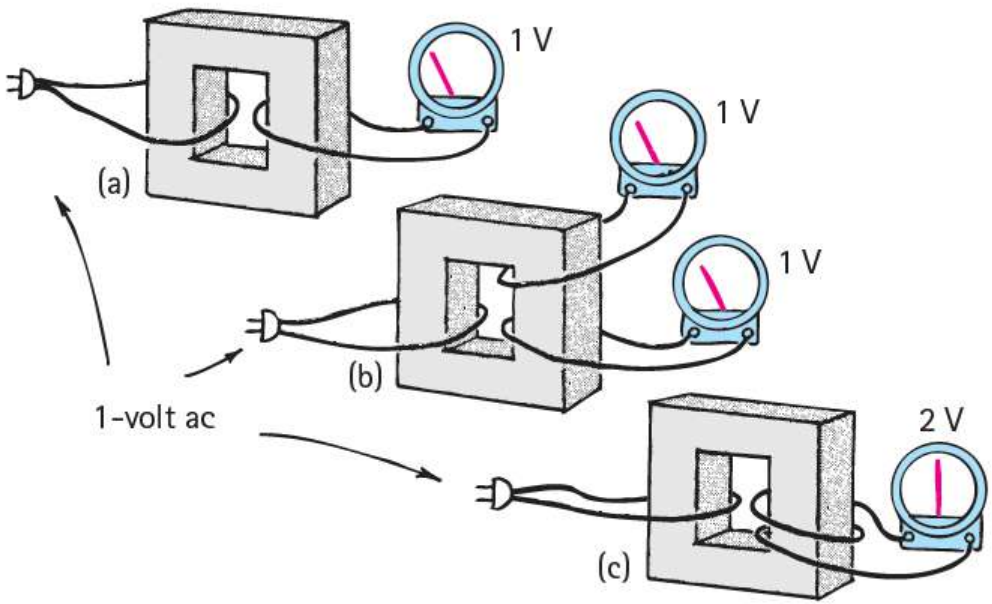
Shell Type Transformer

More coils in secondary…

Each coil in secondary generates the same voltage as a coil in the primary.

More coils → add up to more voltage

Voltage in: input or primary



Voltage out: output or secondary

- Transformers can be step-up or step-down
- Step-up transformer reduces (steps down) voltage
  - increasing voltage is more efficient
- Step-down transformer
  - reducing voltage makes it safe for toys

→ **CANNOT step up energy or power**

- Transformer *transfers* energy from one coil to other.

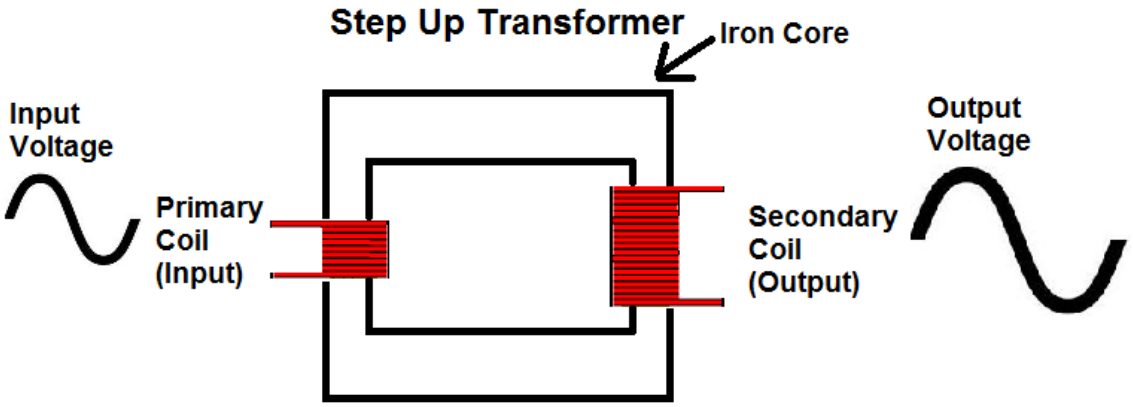
→ Rate of energy transfer is power.

Power into primary = power out of secondary

$(\text{voltage} \cdot \text{current})_{\text{primary}} = (\text{voltage} \cdot \text{current})_{\text{secondary}}$

Step up Transformer

- More turns in secondary coil
- Voltage is increased (stepped up).
- Current is decreased by the same factor.

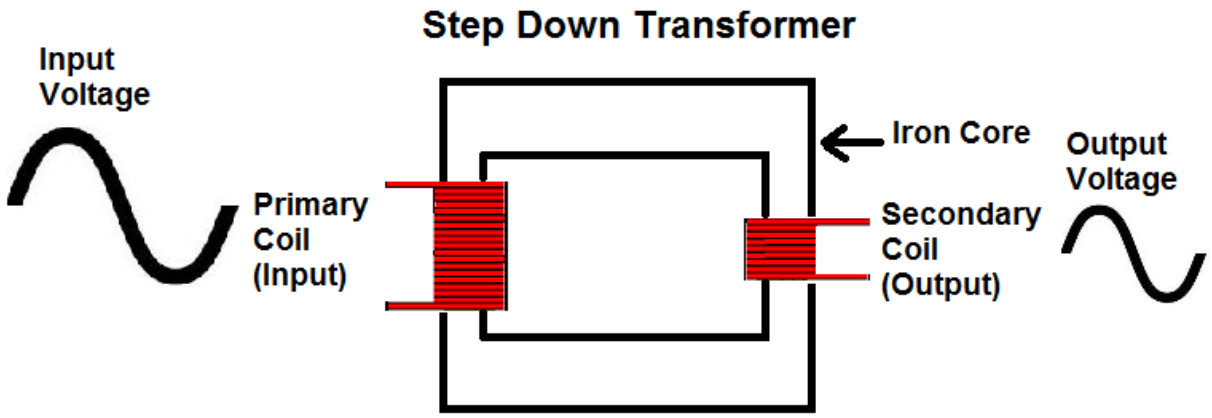


Power in = Power out

$V_p \cdot I_p = V_s \cdot I_s$

Step down Transformer

- Less turns in secondary coil
- Voltage is *decreased* (stepped down).
- Current is *increased* by the same factor.



Power in = Power out

$V \cdot I = V \cdot I$

- Transformer relationship:

$$\frac{\text{Primary voltage}}{\text{Number of primary turns}} = \frac{\text{secondary voltage}}{\text{number of secondary turns}}$$

Ex 1. The primary coil of a transformer connected to 120 V has 30 turns. The secondary has 3000 turns. What is the output voltage at the secondary?

Is this a step up or step down transformer?

- Transformer relationship:

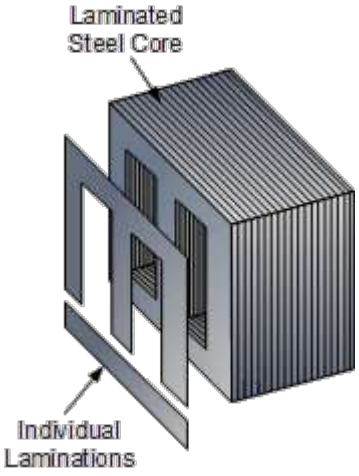
$$\frac{\text{Primary voltage}}{\text{Number of primary turns}} = \frac{\text{secondary voltage}}{\text{number of secondary turns}}$$

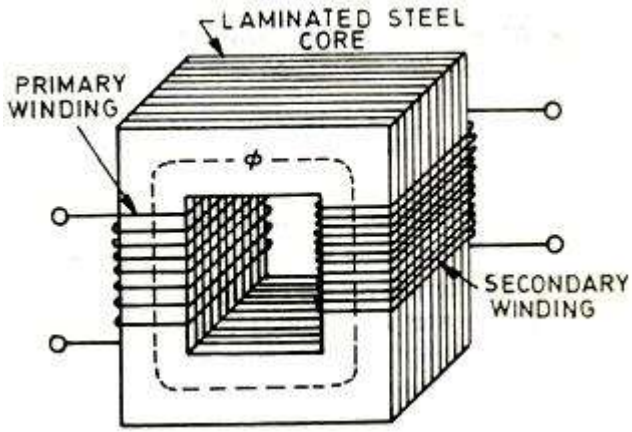
Ex 2. The primary coil of a transformer connected to 120 V has 600 turns. The secondary has 30 turns. What is the output voltage at the secondary?

Is this a step up or step down transformer?

Efficiency

- Transformer transfers energy from one coil to another. There is always so energy converted to heat because the changing magnetic field induces currents in the iron core that heat the core
- To reduce the heating, the core is laminated (layered).
- This increases the efficiency of the transformer.





Power Production
CHECK YOUR NEIGHBOR

A step-up transformer in an electrical circuit can step up

A. voltage.
B. energy.
C. Both A and B.
D. Neither A nor B.

Power Production
CHECK YOUR ANSWER

A step-up transformer in an electrical circuit can step up

A. voltage.

Explanation:

Stepping up energy is a conservation of energy no-no!

Power Production
CHECK YOUR NEIGHBOR, Continued

An efficient transformer in an ac electric circuit can change

A. current.
B. energy.
C. power.
D. All of the above.

Power Production
CHECK YOUR ANSWER, Continued

An efficient transformer in an ac electric circuit can change

A. current.

15. What name is given to the rate at which energy is transferred?

16. Is it correct to say that a transformer boosts electric energy? Defend your answer.

17. Which of these does a transformer change: voltage, current, energy, power?

18. How does the power input to an efficient transformer compare with the power output?

19. What exactly does a step-down transformer step down?

20. In a step-down transformer, how does the input current compare with the output current?

21. Why does a transformer require ac?

22. What is the principal advantage of ac over dc?

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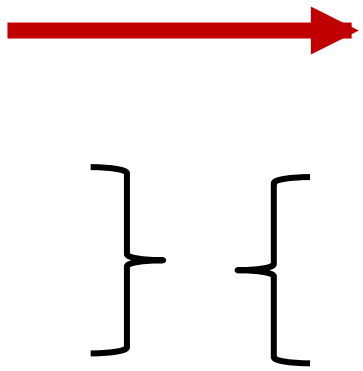

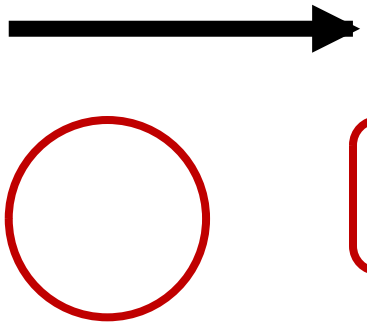

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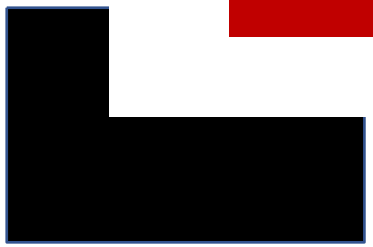

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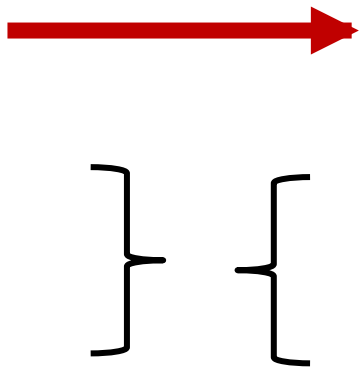

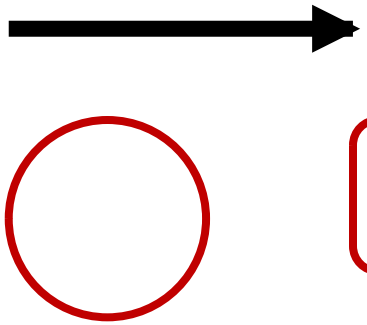

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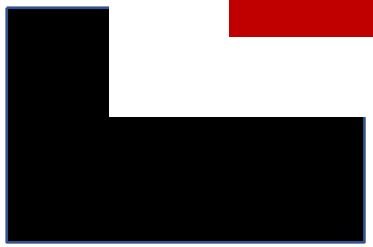
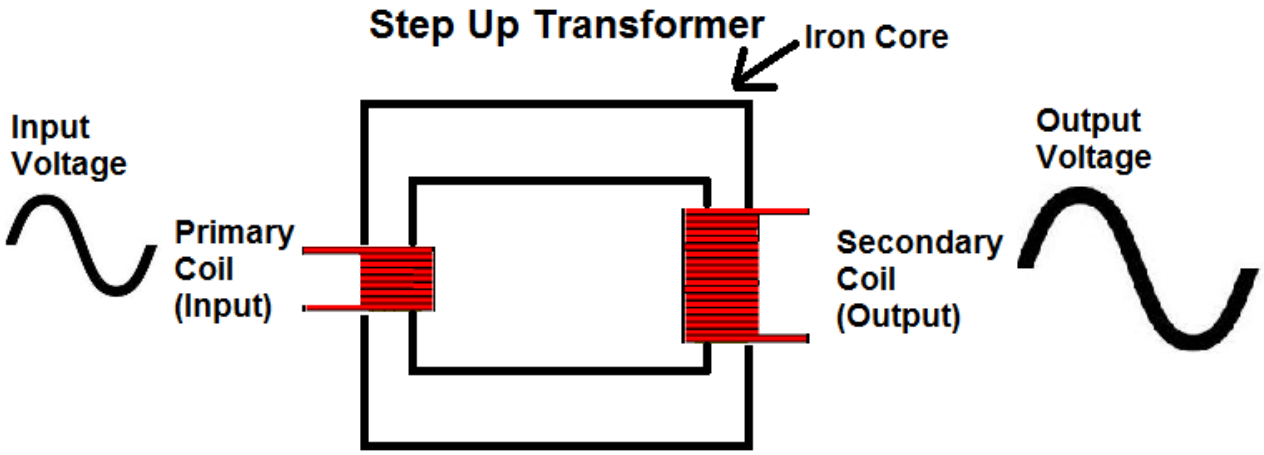


Step up Transformer

More turns in secondary coil

Voltage is increased by coil ratio.

Current is decreased by coil ratio.



Power:

V I.