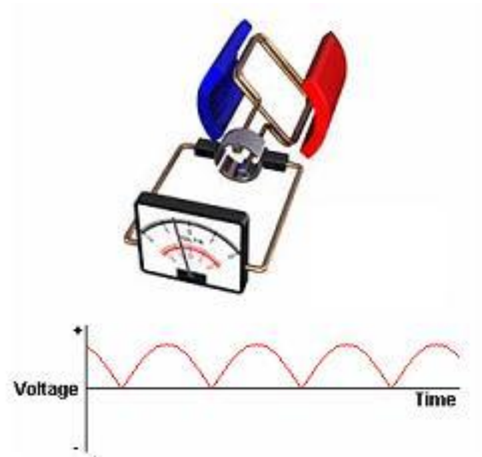
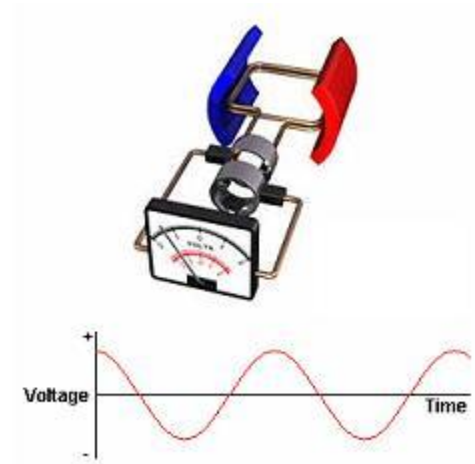
Alternating Current

11.3.1 Describe the e.m.f. induced in a coil rotating within a uniform magnetic field.

11.3.2 Explain the operation of a basic alternating current (ac) generator.



The above is a D.C. generator using a commutator. Notice that the voltage (e.m.f.) varies from zero to a maximum positive value.



Above is an A.C. generator. No commutator is used, this causes the voltage (e.m.f.) to vary from a positive value to an equal but negative value.

In both cases above the voltage is not constant, the voltage is dependent on the angle of the coil. Remember that the e.m.f. induced on a conductor in a magnetic field is:

(1)

$\epsilon=\Delta\Phi / \Delta t=\Delta(AB\cos\theta) / \Delta t$

If the arm is driven by outside force then a current will be generated and the mechanical energy is converted to electrical energy. Vice versa, if a voltage is applied the arm will rotate, the generator operates as a motor. The only different between an electric generator and an electric motor is which end has the outside force applied.

An AC power supply in an circuit diagram is given the symbol:

This can represent a generator or any other AC power source.

11.3.3 Define the concepts of root mean square voltage and root mean square current.

The voltage and current in an AC circuit vary from positive to equally negative values, so what is the voltage and current. How do you do calculations with an AC circuit? The average of the voltage and current is zero, which is useless. Instead what we define is average power.

Power is defined as:

(2)

$P=VI$

The average power can be defined as:

(3)

$P=V0I0 / 2$

Where $V0$ and $I0$ are the peak or maximum values of the voltage and current, respectively. From this we can write:

(4)

$$P = \frac{V_0}{\sqrt{2}} \frac{I_0}{\sqrt{2}}$$

Which is mathematically equivalent to the formula above, from this we can define what is called the root mean square voltage and root mean square current:

(5)

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$ (6)

These equations are in your IB formula book.

Note this argument is actually backwards. The RMS values are averages of a sine function (look it up) and from there we work to average power

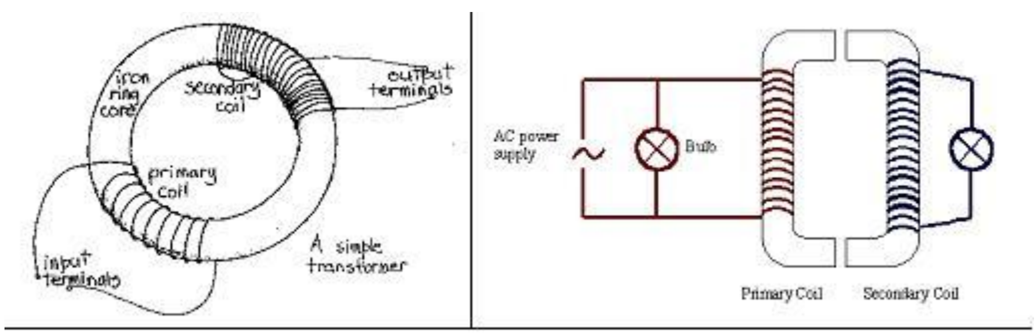
When doing calculation for AC circuit Kirchoff's rules and the definition of resistance are still valid as long as the RMS values of current and voltage are used.

11.3.4 Solve ac circuit problems for ohmic resistors.

11.3.5 Describe the components and characteristics of an ideal transformer and explain its operation

Transformer is used to change the voltage in an electrical circuit. This is done in power transmission, computer, and most electrical equipment.

A basic transformer consists of a iron core, often shaped as a hollow rectangle. The input and output are on opposite sides of the transformer. The input and output are wound or coiled around the transformer, the ratio of input to output coils dictates how the voltage/current are transformed.



A transformer must still obey the law of energy conservation. In an ideal transformer the input power is equal to the output power. So if the transformer is used to step up the voltage the current must go down, if the transformer is used to step down the voltage the current must go up.

So how does it work? The input is AC which generates an alternating magnetic field in the iron core, which in turn generates an alternating current in the output coils. It should be noted that transformers of type described above work only for AC circuits.

The ratio change in flux generated by the primary coil (input) is:

(7)

$$\Delta\Phi p / \Delta t = -N p \epsilon p$$

The change in flux in the secondary coil is proportional to the change in flux of the primary coil:

(8)
$$\Delta\Phi_p / \Delta t \propto \Delta\Phi_s / \Delta t$$

If the transformer is 100% efficient (an ideal transformer) we can say:

(9)
$$-N_p \epsilon_p = -N_s \epsilon_s$$

Thus the ratio of voltages (e.m.f.) is equal to the ratio of the number of turns or coils around the transformer coil:

(10)
$$V_p / V_s = N_p / N_s$$

Where the subscript p is for the primary (or input) and s is for secondary (or output). This equation is in your IB formula book.

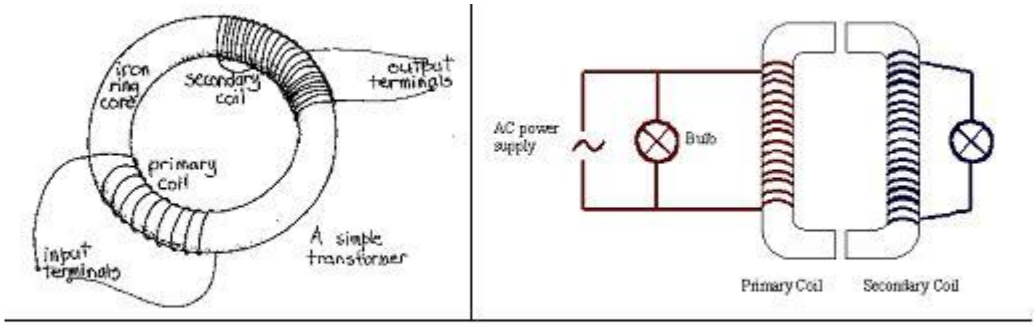
11.3.6 Explain the use of high voltage step-up and step-down transformers in the transmission of electric power.

When power is transmitted very high voltages and high currents are required in order to transmit enough power for home or industrial use. However the power dissipated in the wire is equal to:

(11)
$$P = I^2 R$$

So if a high current is used most of the power is lost to heat before it gets to the user. Therefore when power is transmitted long distances transformers are used to step up the voltage so that the current is low and only a small amount of power is wasted. In high voltage power lines the power is transmitted at voltages over 100,000 V! This results in a very small current, but is more dangerous in that high voltage can spark long distances, making it not so good for house hold use. As a result another transformer is used to step down the voltage before it gets to the user. Often there are a series of transformers, with the last one being in the final building or only a short distance away (10-30m).

In a circuit diagram transformers are given the symbol:



Source: http://ibphysicsstuff.wikidot.com/alternating-current