Chapter 28

Direct Current Circuit

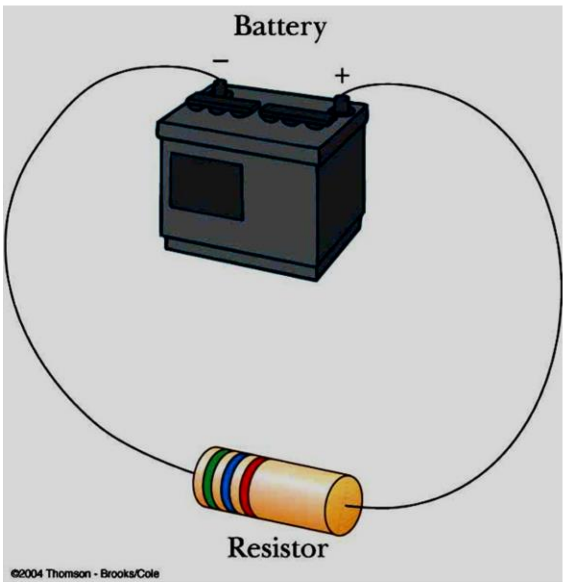
28.1 Electromotive Force (*emf)*

Here, we will consider only circuits that are in a steady state, meaning that the currents in the circuit remain constant in both magnitude and direction. A current that is constant in direction is called direct current (DC). We will study alternating current (AC), in which the current changes direction periodically, in Chapter 33.

A constant current can be maintained in a closed circuit through the use of a source of *emf, (such as a battery or generator)* that produces an electric field and thus may cause charges to move around a circuit.

The emf describes the work done per unit charge, and hence the SI unit of emf is **the volt.**

The electromotive force is defined as the maximum voltage that produced by the energy source.



In the figure above, assume that the connecting wires have no resistance.

- The positive terminal of the battery is at a higher potential than the negative terminal. If we neglect the internal resistance of the battery, the potential difference across it (called the terminal voltage) equals its emf.

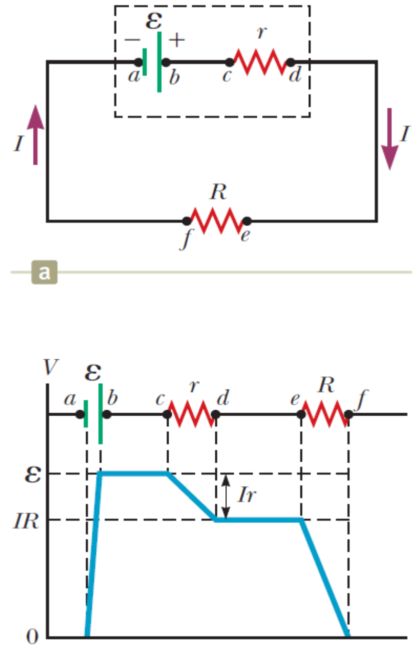
- However, because a real battery always has some internal resistance *r*, *the terminal voltage is not equal to the emf for a battery in a* circuit in which there is a current.

In the figure in front, As we pass from the negative terminal to the positive terminal, the potential *increases by an amount* ε.

As we move through the resistance *r*, *the potential decreases by an amount Ir, where I is the current* in the circuit.

ΔV=ε-Ir (28-1)

ε*:* is equivalent to the open-circuit voltage—that is, the *terminal voltage when the current is zero. The emf is the voltage labeled on a* battery,… .



The terminal voltage *V must equal the potential difference across the external* resistance *R, often called the load resistance.*

The resistor represents a *load on the battery because the battery must supply energy to* operate the device. The potential difference across the load resistance is

ΔV = IR (28-2)

$$\varepsilon = IR + Ir = I(R + r) \qquad (28\text{-}3)$$

$$I = \frac{\varepsilon}{(R + r)}$$

The total power output *I*ε *of the battery is delivered to the external load resistance in the* amount I^2R *and to the internal resistance in the amount* I^2r.

$$I\varepsilon = I^2R + I^2r$$

Example-1:

A battery has an emf of 12.0 V and an internal resistance of 0.050 V. Its terminals are connected to a load resistance
of 3.00 V.

(A) Find the current in the circuit and the terminal voltage of the battery.

(B) Calculate the power delivered to the load resistor, the power delivered to the internal resistance of the battery, and the power delivered by the battery.

Exampl-2:
A battery has an emf of 15.0 V. The terminal voltage of the battery is 11.6 V when it is delivering 20.0 W of power to an external load resistor R. (a) What is the value of RR? (b) What is the internal resistance of the battery?