Phys 112 2019

Lecture 12

Fri: HW by 5pm

Supp ex 45, 46, 47

Ch 22 Q 10

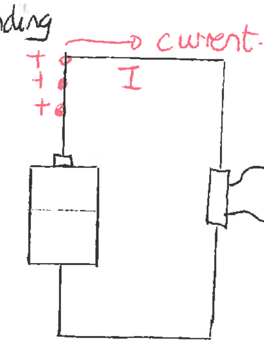
Ch 22 Probs 23, 40, 46, 68

Thurs: Physics seminar 12:30pm

WS 117

Electric circuits

An electric circuit functions as a result of charges that flow around the circuit. The necessary quantities for understanding a circuit are:



1) Current = rate at which charge flows

$$I = \frac{\Delta Q}{\Delta t}$$

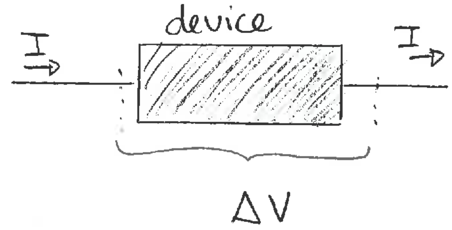
2) Potential difference = energy per 1C of charge required to transport charge from one location to another

$$\text{Energy to move charge } q = \Delta U_{elec} = q\,\Delta V$$

Typically power sources, e.g. batteries, outlets, provide a particular potential difference. We would like to know the resulting current that flows through any attached device.

Electric potential + current.

Consider a device such as a bulb or a resistor. Suppose that the potential difference across the device is known. Then for many, but not all, devices the current is related to the potential difference by Ohm's Law:



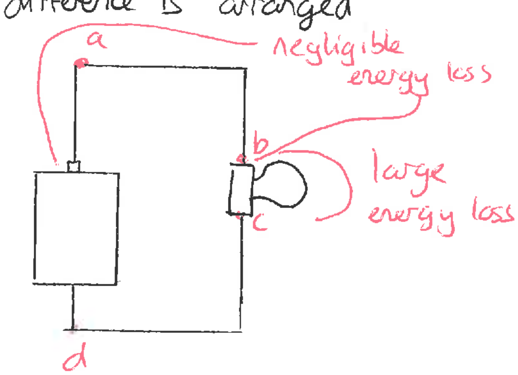
$$\Delta V = IR \quad \text{OR} \quad I = \Delta V / R$$

where R is the resistance of the device. This depends on the device and quantifies the difficulty with which current passes. The units of resistance are Ohms ($\Omega = V/A$)

Quiz 1 10% – 50%

Quiz 2 90%

We can see now how the electric potential difference is arranged around a circuit. In the illustrated circuit the current is the same everywhere.



Then

$$\Delta V_{a \to b} = I R_{a \to b} \leftarrow \text{much smaller}$$

↕ same

$$\Delta V_{b \to c} = I R_{b \to c} \leftarrow \text{much larger}$$

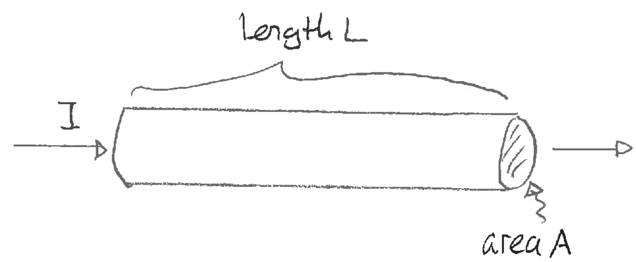
We see that the voltage difference across a wire is very much less (negligible) compare to that across the bulb. Thus the voltage difference across the bulb in the illustrated circuit is essentially the same as across the battery.

Resistivity

The resistance of any object depends on:

1) the material (e.g. copper, iron, tungsten,...
2) the dimensions of the material

For a cylindrical object



$$\boxed{R = \rho \frac{L}{A}}$$

where L = length of the object
A = cross sectional area of object
ρ = resistivity of the material (units $\Omega \cdot m$)
"rho"

Example: A bulb has a filament made of tungsten (resistivity $6.0 \times 10^{-8} \Omega m$) with length 0.050m. When connected to a 12V battery 2.0A flows through the bulb. Determine the radius of the filament.

Answer: Need R and then $R = \rho \frac{L}{A} \Rightarrow A = \frac{\rho L}{R}$ gives area...

We get R via $\Delta V = IR$

$\Rightarrow 12V = 2.0A\, R \Rightarrow R = 6.0\Omega$

Now $A = \rho \frac{L}{R} = 6.0 \times 10^{-8} \Omega m \times \frac{0.050m}{6.0\Omega}$

$\Rightarrow A = 5.0 \times 10^{-10} m^2$

But $A = \pi r^2 \Rightarrow \pi r^2 = 5.0 \times 10^{-10} m^2$

$\Rightarrow r^2 = \frac{5.0 \times 10^{-10} m^2}{\pi} \Rightarrow r^2 = 1.6 \times 10^{-10} m^2$

$\Rightarrow r = 12.6 \times 10^{-6} m$ ☒

Power:

Many practical circuit devices (bulbs, heaters, ...) dissipate energy into their surroundings. We would like to know how to determine the resulting energy produced. This will clearly depend on the time for which the device is operating. So we aim to determine the rate at which energy is produced. The relevant quantity is

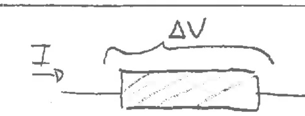
power = rate at which energy is delivered

Formally:

> The power produced by a device is
>
> $$P = \frac{\Delta E}{\Delta t}$$
>
> where ΔE = energy delivered in time Δt

Units: $W = J/s$

In a circuit device we can show

> The power produced is
>
> 
>
>
> $$P = I\Delta V$$
>
> where ΔV is voltage across the device and I current flowing through the device.

Quiz 3 70% – 90%

Example: The heat coil in an electric kettle heats water by supplying heat (energy) $30 \times 10^3 J$ in 5.0 minutes, when connected to a 120V power supply. Determine its resistance.

Answer: If we can get I then $\Delta V = IR \Rightarrow R = \Delta V / I$

We can get I from $P = I \Delta V$ and so we need P and then $I = P/\Delta V$.

To get power:

$$P = \frac{\Delta E}{\Delta t} = \frac{30 \times 10^3 J}{5.0 \times 60 s} = 100 W$$

So $$I = P/\Delta V = \frac{100 W}{120 V} = 0.83 A$$

Thus $$R = \frac{\Delta V}{I} = \frac{120 V}{0.83 A} \Rightarrow R = 144 \Omega.$$