Tues: Lecture

Weds: Discussion

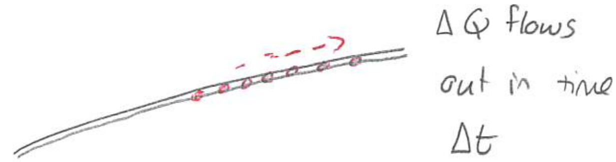
Ex 82, 83, 84, 85, 86, 87, 92, 93

Thurs: Warm Up 6

## Current

Current quantifies the rate at which charge flows. In a wire, for example the magnitude of the current is

$$I = \left|\frac{\Delta Q}{\Delta t}\right|$$




The direction of current is determined by

If charges are positive, current direction is same as direction of motion
If charges are negative, " " " opposite to " " "

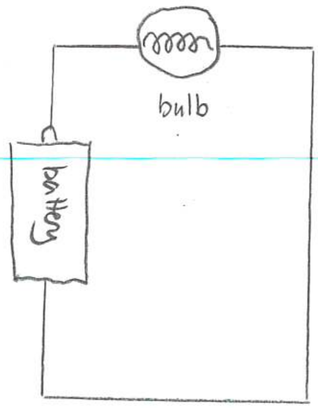
## Circuit behavior

Initially we aim to understand currents in electrical circuits, which are combinations of

1) power sources
2) electrical/electronic devices
3) connecting wires.

We illustrate two examples

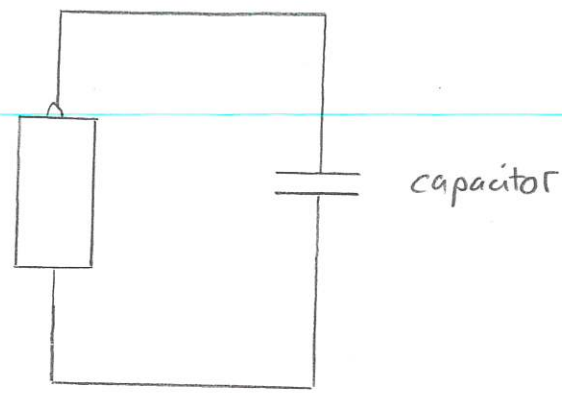
**Battery + bulb**




Demo: PhET Circuit Construction Kit : DC

- Intro – construct ↑
  - close switch

**Charging Capacitor**




Demo: PhET Circuit Construction Kit : AC

- ~~AC Voltage~~ RLC tab
- construct above + include resistor
- show charging – show current with ammeter

Both of these circuits appear to work via a flow of electric charge and we will describe both in terms of current.

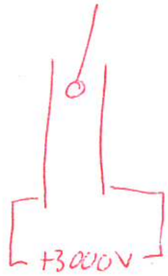
We can first establish whether this current is related to the types of charge we have encountered in electrostatics.

Quiz1 100%

Quiz2 80%

Demo

Ball + capacitor



The demonstration indicates that the same charge that is present in electrostatic situations is involved in current flow.

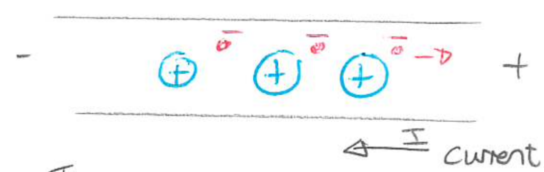
In general when assessing circuit situations we will be interested in the (longer time) steady state behavior. The battery + bulb circuit illustrates this – the current at any location does not vary with time. The capacitor illustrates a situation where the current gets established and this is usually of a short duration.

## Basic circuit rules

We use a few basic rules to analyze all circuits.

1) the wires are electrically neutral – their net charge is zero

2) the charges that flow are electrons. These flow from the negative to positive terminals of a battery. Thus the current flows from positive to negative

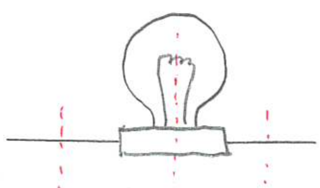



3) charge cannot accumulate or disappear in wires and most other circuit elements (except capacitors)

Quiz 3 95%

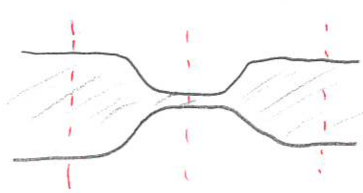
Quiz 4 80%

4) in a simple closed-loop circuit the current is the same everywhere, otherwise charge would appear / disappear



same current

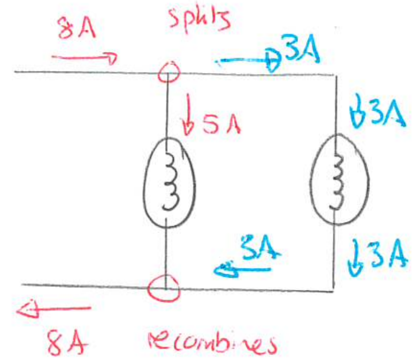
analogous to water flow



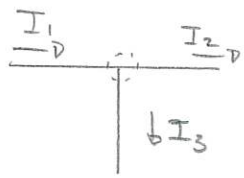
same volume/second at each..

5) currents can split + recombine at any junction subject to:

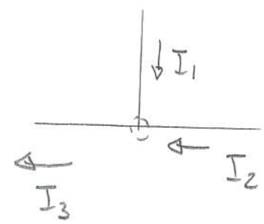
| |
|---|
| At any junction, the total current entering the junction equals the total current leaving |




Thus



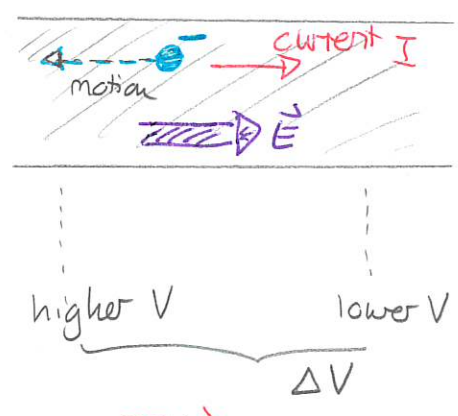

$I_1 = I_2 + I_3$




$I_3 = I_1 + I_2$

## Energy, electric potential + fields in circuits

In general currents require energy and we can assess this using concepts from electrostatics. Consider an electron moving along a wire. The electron will interact with material in the wire and these interacts tend to slow the electron. The electron thus tends to lose energy. This can be restored via an accelerating force provided by an electric field. The detailed mechanism for this involves a non-uniform surface charge density (see pg 776)



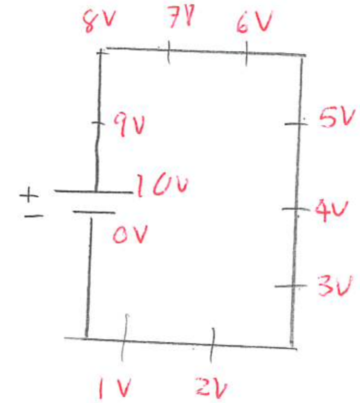

There is an electric potential, decreasing along the direction of the field and we can use this electric potential to describe how the charge travels. Specifically suppose total charge $q$ ($>0$) travels in the direction of the current. This is in the direction of decreasing electric potential

Then the energy lost by the charge is $\Delta U_{elec} = q \Delta V$, where $\Delta V$ is the change in electric potential. So

> If charge $q$ flows along a section whose electric potential difference is $\Delta V$ then it loses energy $\Delta U_{elec} = q \Delta V$

So we see

> In electric circuits the potential drops along the direction of current flow




Quiz 5

Quiz 6