Notes for Physics 6B

Circuit "Dividers"

0 Comment

You may find the formulae below useful, or you may just prefer to work from the fundamental equations every time you do a problem. The fundamental equations used to derive these formulae are the definition for resistance (Ohm's law), $V = \pm IR$, the definition for capacitance, $\pm Q = CV$, Kirchhoff's voltage law (or "loop rule", to confirm that circuit elements in parallel have the same voltage), and Kirchhoff's current law (or "junction rule", to confirm the relationship between currents at a junction). Physical reasoning is also used to show that capacitors in series have the same polarity charges.

1 Resistors

- Voltage Dividers

  Resistors in series "divide" the total voltage across them. $$V_i = \frac{R_i}{R_{\text{eq}}} V$$

- Current Dividers

  Resistors in parallel "divide" the total current through them. $$I_i = \frac{R_{\text{eq}}}{R_i} I$$

2 Capacitors

- Voltage Dividers

  Capacitors in series "divide" the total voltage across them. $$V_i = \frac{C_{\text{eq}}}{C_i} V$$

- Charge Dividers

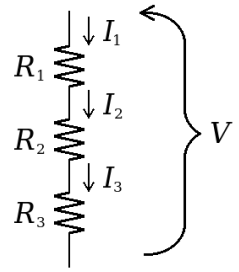
  Capacitors in parallel "divide" the total polarity charge[1] on them. $$Q_i = \frac{C_i}{C_{\text{eq}}} Q$$

3 Proofs

Here are some diagrams drawn to help you write your own proofs. Note that you should define the individual voltages V_i (where $i = 1, 2, 3$) in the same direction as the total voltage V.

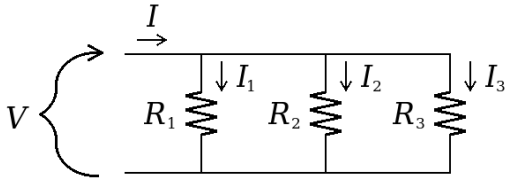
[1] Usually, capacitors have no net charge, since if one side has charge q the other side has charge $-q$. So I prefer to call q the "polarity charge" rather than "the charge on the capacitor".

Resistors in Series



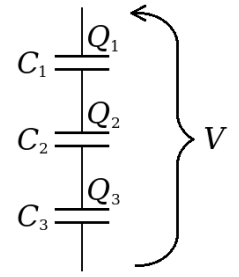
$$I_1 = I_2 = I_3 \equiv I$$
$$V = V_1 + V_2 + V_3$$

Resistors in Parallel



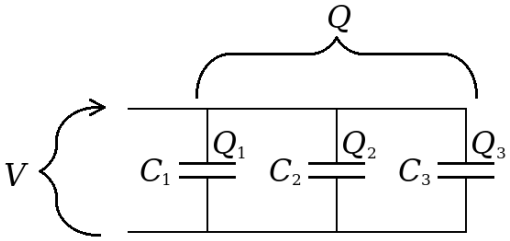
$$V_1 = V_2 = V_3 \equiv V$$
$$I = I_1 + I_2 + I_3$$

Capacitors in Series



$$Q_1 = Q_2 = Q_3 \equiv Q$$
$$V = V_1 + V_2 + V_3$$

Capacitors in Parallel



$$V_1 = V_2 = V_3 \equiv V$$
$$Q = Q_1 + Q_2 + Q_3$$