# Topic 20 D.C. circuits

## Summary

- The electromotive force (e.m.f.) of a supply measures the electrical energy gained per unit of charge passing through the supply.
- The potential difference (p.d.) across a resistor measures the electrical energy converted per unit of charge passing through the resistor.
- The voltage across the terminals of a supply (the terminal p.d.) is always less than the e.m.f. of the supply when the supply is delivering a current, because of the lost volts across the internal resistance.
- For a supply of e.m.f. $E$ which has internal resistance $r$, $E = I(R + r)$ where $R$ is the external circuit resistance and $I$ is the current in the supply.
- A supply delivers maximum power to a load when the load resistance is equal to the internal resistance of the supply.
- At any junction in a circuit, the total current entering the junction is equal to the current leaving it. This is Kirchhoff's first law, and is a consequence of the law of conservation of charge.
- In any closed loop of a circuit, the sum of the electromotive forces is equal to the sum of the potential differences. This is Kirchhoff's second law, and is a consequence of the law of conservation of energy.
- The equivalent resistance $R$ of resistors connected in series is given by:
  $R = R_1 + R_2 + R_3 + \ldots$
- The equivalent resistance $R$ of resistors connected in parallel is given by:
  $1/R = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$
- Two resistors in series act as a potential divider, where $V_1/V_2 = R_1/R_2$. If $V$ is the supply voltage: $V_{out} = VR_1/(R_1 + R_2)$
- A potentiometer is a variable resistor connected as a potential divider to give a continuously variable output voltage.

## Definitions and formulae

- The e.m.f. of a source is the energy transferred from other forms (e.g. chemical in a cell) to electrical energy per unit charge driving the charge round a complete circuit.
- Kirchhoff's first law states the sum of the currents entering a junction equals the sum of the currents leaving the junction (conservation of charge).
- Kirchhoff's second law states that the sum of the e.m.f.s in a complete circuit equals the sum of the products of $IR$ in that circuit (conservation of energy).
- Resistors in series $R_T = R_1 + R_2$
- Resistors in parallel $1/R_T = (1/R_1 + 1/R_2)$
- The potential divider gives output $V_{out} = (V_{cell}R_1)/(R_1 + R_2)$