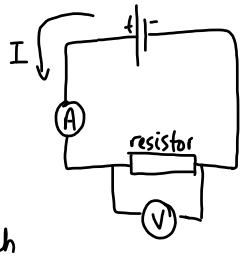
# 5.2 Electric Circuits

emf = $\frac{\text{energy gained}}{q}$

## Electromotive force (emf)




Potential Difference across the resistor is the electrical potential energy lost in the resistor by each small test charge, per unit charge

$\text{pot diff} = \frac{\text{energy lost}}{q}$

So the emf of the battery is the potential energy gained by each small test charge, per unit charge as it passes through the battery.

Definition of EMF:

EMF ($\mathcal{E}$) is the amount of electrical potential energy gained per unit charge by each small test charge as it passes through a battery or other device which provides energy to a circuit.

- electromotive force is NOT a force
- note that we are dealing with a small test charge
- battery or other device which provides energy (generator or photovoltaic cell)

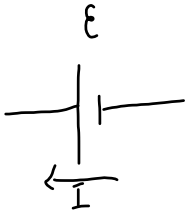
Alternative definition:

The emf of a source is the power supplied by the source per unit current.

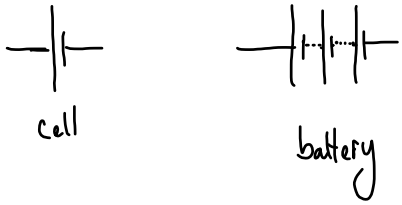
Why can it be defined like this?

$P = \mathcal{E}I$

$\therefore \mathcal{E} = \frac{P}{I}$



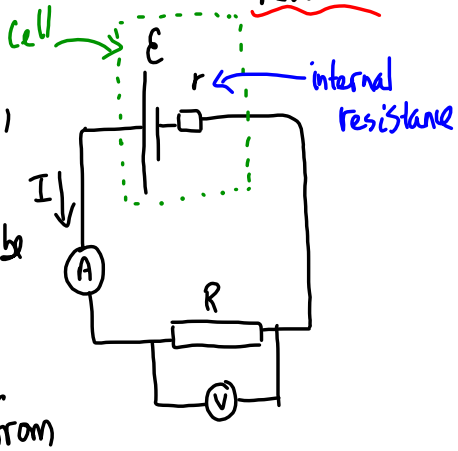

Difference between a battery and a cell:



## Internal Resistance

The resistance of a cell or a battery is called its internal resistance

- the internal resistance acts like a resistance, r, in series with the rest of the circuit, but cannot be separated from the cell.




- some of the energy in a cell in converted from electrical energy to thermal energy. due to internal resistance
- this means that there is less energy available to the external circuit and $V < \varepsilon$

## The circuit equation:

- a small + test charge
- the current is I
- the test charge gains $\varepsilon$ joules of electrical energy per coulomb in the cell and then it loses
  - → V joules of electrical energy per coulomb of external resistance.
  - → Ir joules of electrical energy per coulomb of internal resistance in the cell.

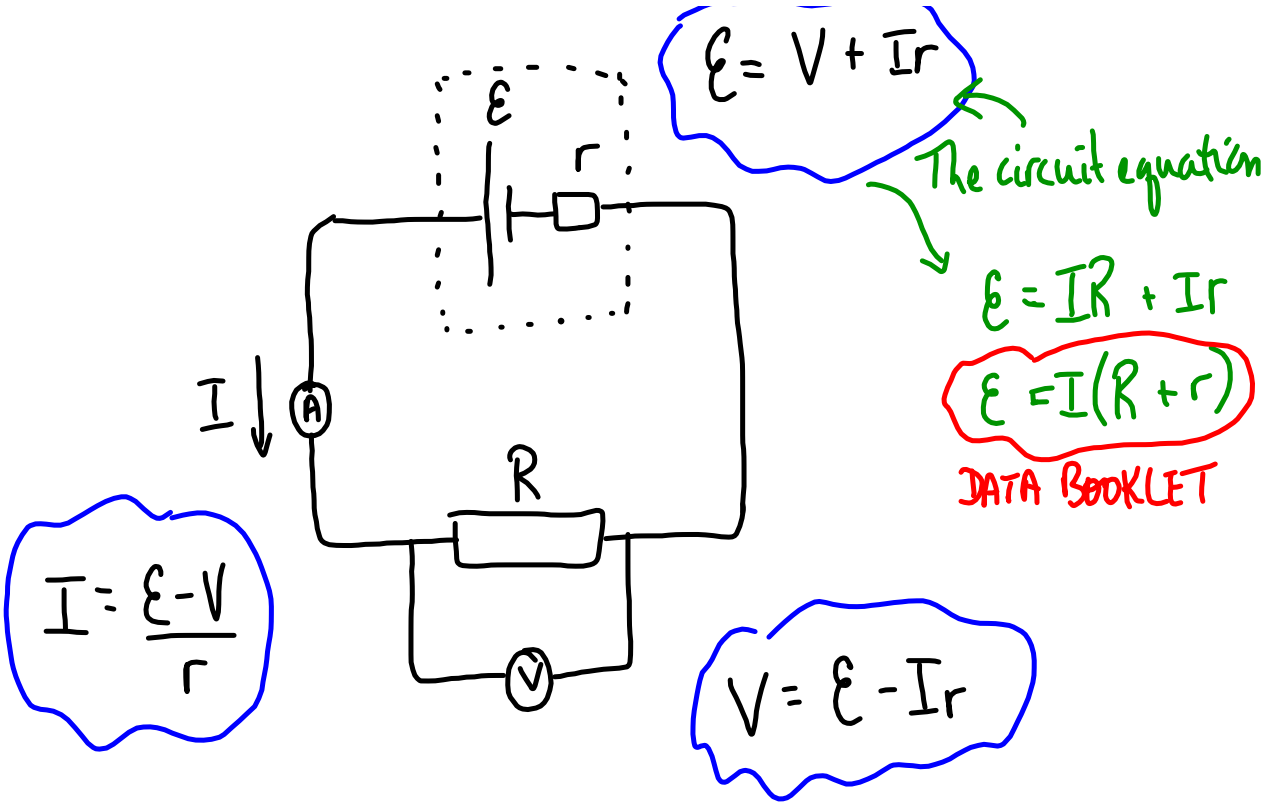
- Since energy is conserved:

$$\varepsilon = V + Ir \quad \rightarrow \quad V = IR$$

The circuit equation

$$\varepsilon = IR + Ir$$

$$\varepsilon = I(R + r)$$ DATA BOOKLET


ε = V + Ir
The circuit equation
ε = IR + Ir
ε = I(R + r)
DATA BOOKLET
ε
r
I
A
R
V
I = (ε - V) / r
V = ε - Ir