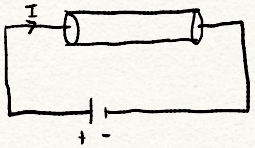
CHARGE & CURRENT

CHARGE is an electrical property of atoms, measured in Coulombs (C)

- the charge of an electron is negative and has magnitude 1.602×10^{-19} C
- proton is positive & carries the same charge

- 1 C = 1/1.602E-19 = 6.24×10^{18} electrons (know #!)
- experimentally, all charges in nature are multiples of $e = -1.602 \times 10^{-19}$ C
- charge cannot be created or destroyed



- in presence of electromotive force (i.e. battery) positive charges move in one direction, negative in other
- convention to take current flow as movement of (+) charges

CURRENT is rate of change of charge, measured in Amperes (A)

↳ 1 amp = 1 C/s

$$i \triangleq \frac{dq}{dt}$$

(i: current; dq: charge; dt: time)

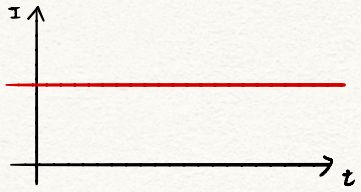
$$Q \triangleq \int_{t_0}^{t} i \, dt$$

(Q: charge transferred)

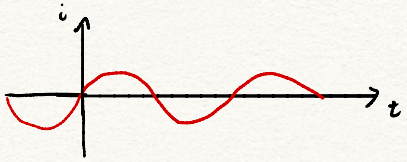
ALTERNATING VS. DIRECT

- there are 2 ways current can flow

direct: flows in 1 direction. Can be constant or time varying



alternating: changes direction w/ respect to time



ex. air cond., fridge, washing machine, other electrical appliances

- we I if constant current; i if variable

ex:

a) total charge entering a terminal is given by $q = 5t \sin 4\pi t$ mC
calculate current at $t = 0.5$ sec.

$i(t) = 5\sin(4\pi t) + 20\pi t \cos(4\pi t)$
$i(0.5) = 31.41$ C

b) if $q = (10 - 10e^{-2t})$ mC, find current @ 1.0s.
$i(t) = 20\, e^{-2t}$
$i(1) = 20e^{-2} = 2.707$ mC

ex: determine total charge passing thru terminal btw. $t = 1$s and $t = 2$s if current passing thru is $i = (3t^2 - t)$ A

$$Q = \int_1^2 3t^2 - t \, dt = t^3 - \tfrac{1}{2}t^2 \Big|_1^2 = 7 - \tfrac{1}{2}(3) = 11/2 = 5.5 \text{ C}$$

what if $i = \begin{cases} 4\text{ A}, & 0 < t < 1 \\ 4t^2\text{ A}, & t > 1 \end{cases}$ and $0 < t < 2$?

$$Q = \int_0^1 4 \, dt + \int_1^2 4t^2 \, dt = 4t \Big|_0^1 + \tfrac{4}{3}t^3 \Big|_1^2 = \tfrac{12}{8} + \tfrac{28}{3} = \tfrac{40}{3} = 13.\overline{3} \text{ C}$$

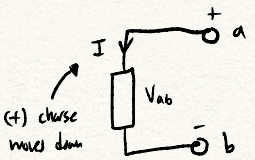
VOLTAGE

- **electromotive force (emf)** is what moves electrons in a particular direction
  - ↳ known as **voltage** or **potential difference**

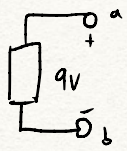
$$V_{ab} \triangleq \frac{dW}{dq}$$

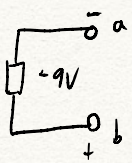
V_{ab}: voltage btw. pts. a & b. dW: work. dq: charge.

voltage is the energy required to move a unit charge from a ref. pt. (-) to another pt. (+).



$V_{ab} = -V_{ba} \Rightarrow$

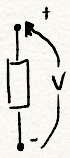




$V_{ab} = 9V$

constant voltage / DC voltage is denoted by V

variable voltage / AC voltage is denoted by v



signal is an electric quantity such as current or voltage

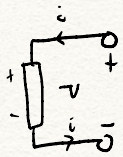
POWER / ENERGY

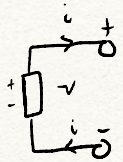
Power is the rate of expending or absorbing energy, measured in watts (W)

$$p = \frac{dW}{dt} = \frac{dW}{dq} \cdot \frac{dq}{dt} = vi$$

p: instantaneous power, func. of time

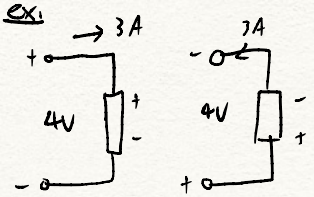
- if $p > 0$, power is being absorbed by the element
- if $p < 0$, power is being supplied by the element





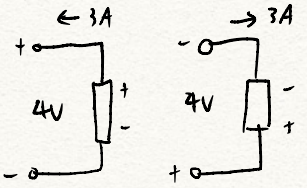
Passive sign convention is when current enter positive terminal and $p = +vi$. If enters through negatie terminal, $p = -vi$

ex.



both elements have absorbing power of +12 W.

ex.



both elements have supplying power of +12 V

$\sum p = 0$ i.e. + power supplied = − power supplied

$$w = \int_{t_0}^{t} p\,dt = \int_{t_0}^{t} vi\,dt$$

A watt-hour is another measure of energy.

1 wh = 3600 J

ex. current of 2A flows thru bulb for 10s. If 2.3kJ given off, calculate voltage drop.

$$p = vi \Rightarrow v = \frac{p}{i} = \frac{w}{iz} = \frac{2300}{2(10)} = 115\ V$$

$q = 2 \times 10 = 20\ C$