Lec 1

Electric Circuits

Definitions

1. Charge (Q)
2. voltage (V)
3. Current I

"The rate of charge flow"

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

Unit

(C/sec) or Amps (A)

- $Q = 1.6022 \times 10^{-19}$ Columbs

- voltage is the energy per unit charge, created by the separation. It is also known as the potential difference between the two points.

$$\boxed{V = \frac{dw}{dQ}}$$

W = energy

Quantity	symbol	Unit
voltage	V	volts
Energy	W or E	joules
charge	Q	C

4 Power [P]

$$\underset{\text{(power)}}{P} = Vi = \frac{dw}{\cancel{dQ}}\frac{\cancel{dQ}}{dt} = \frac{dw}{dt}$$

"watts"

5 Energy [E] or [W]

$$\boxed{W = E = \int p\,dt}$$

Recap

$$V = \frac{dw}{dQ}, \quad i = \frac{dQ}{dt}, \quad P = Vi = \frac{dw}{dt}$$

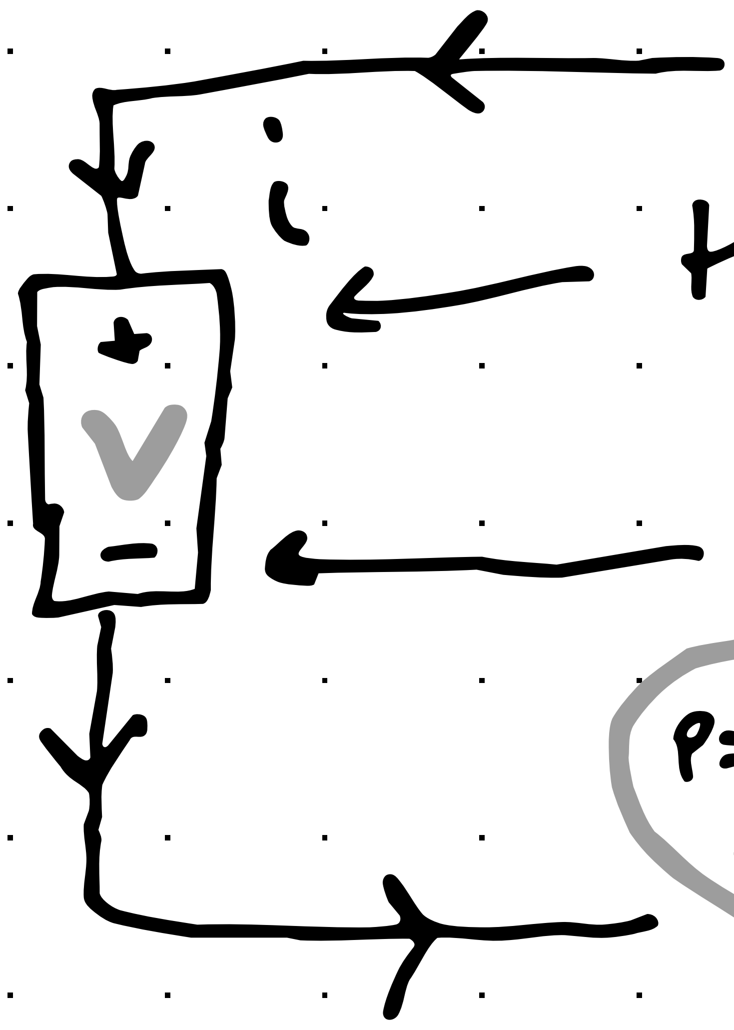
$$E = \int p\,dt$$

Power

If

$p = +vi$ — Power is absorbed

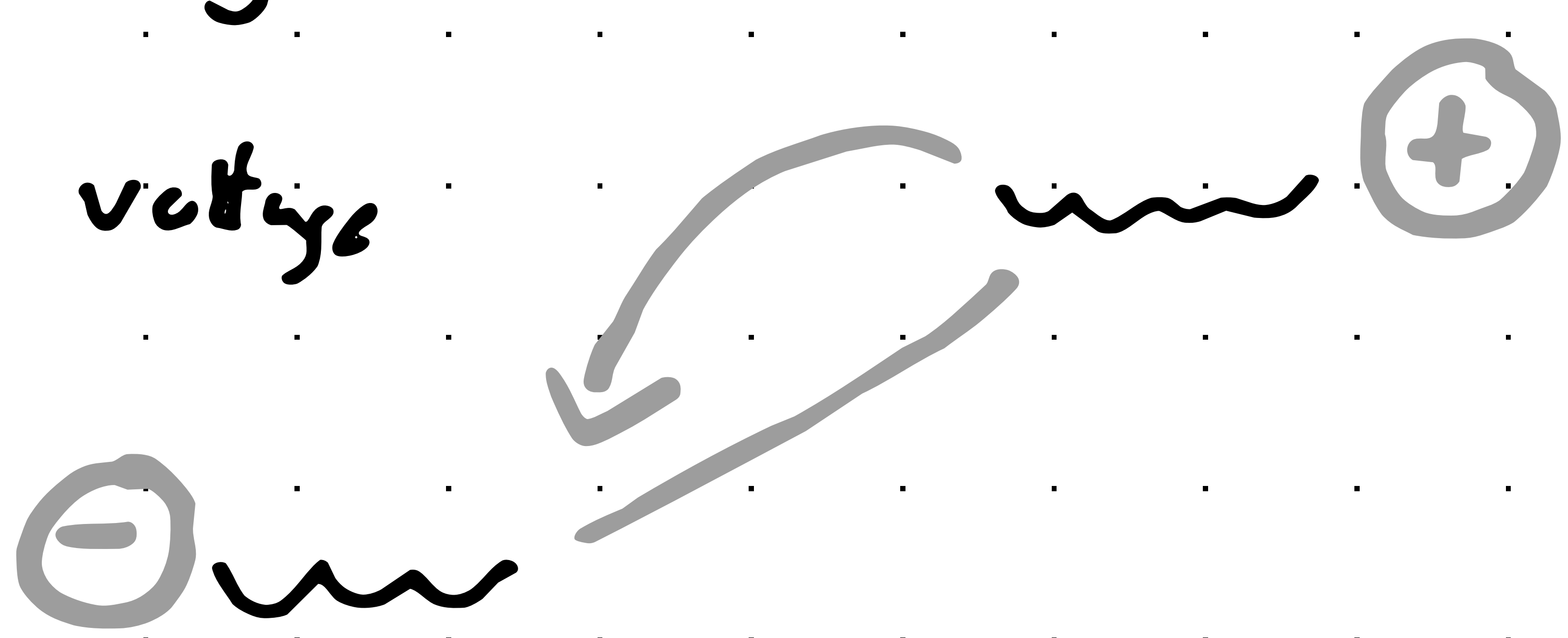
$p = -vi$ — Power is generated



Higher voltage

Lower voltage

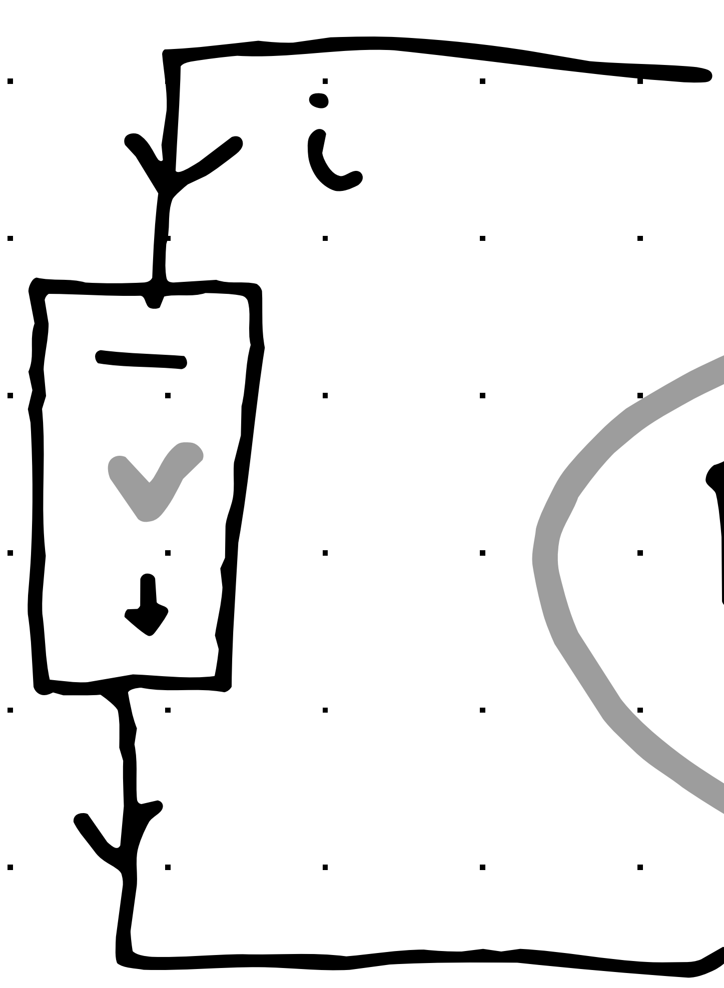
$p = +vi$, absorbed



This is probably a resistor!

Water will naturally flow down the hill!

To get water to the top of the hill again, you need a pump!



$p = -vi$, generated

Battery

Generally Speaking....

If the direction of the current is from positive (high) voltage to negative (low) voltage, then this element is absorbing power

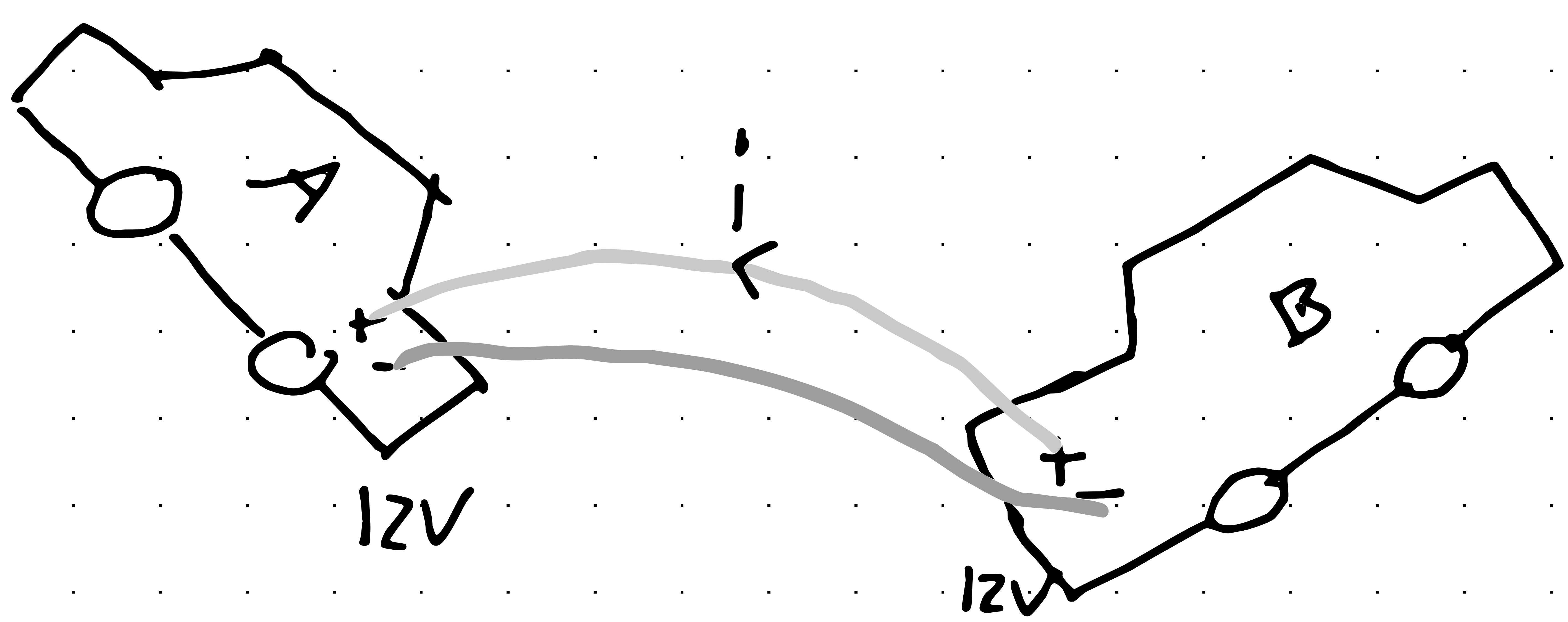
$\boxed{6}$ The Conservation of Power law

For any closed loop...

$$\sum |P_{gen}| = \sum |P_{abs}|$$

(Power Generated) (Power Absorbed)

Ex When a car has a dead battery, it can often be started by connecting the battery from another car. The positive terminals are connected, as are the negative terminals. The connection is as shown



i) Which car has the dead battery?

A), Because the current is flowing from A, to B!

ii) If this inter battery equation is maintained for *one minute* how much energy is transferred?

$V = 12\ V$ $\quad$ $i = 30A$

Need P first!

$P = vi, \quad P = (12)(30) \quad P = 360W$

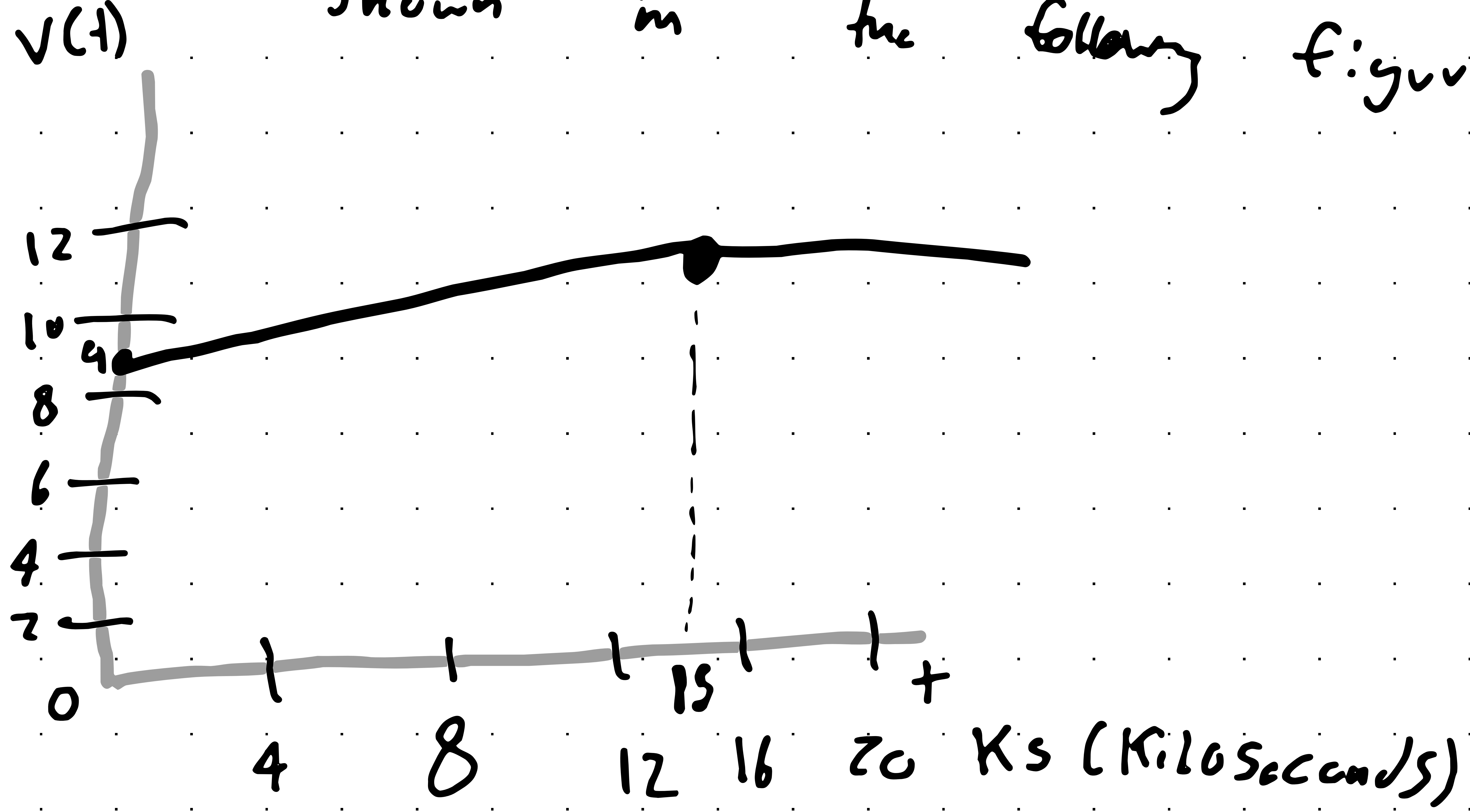
$$W = \int p\,dt$$

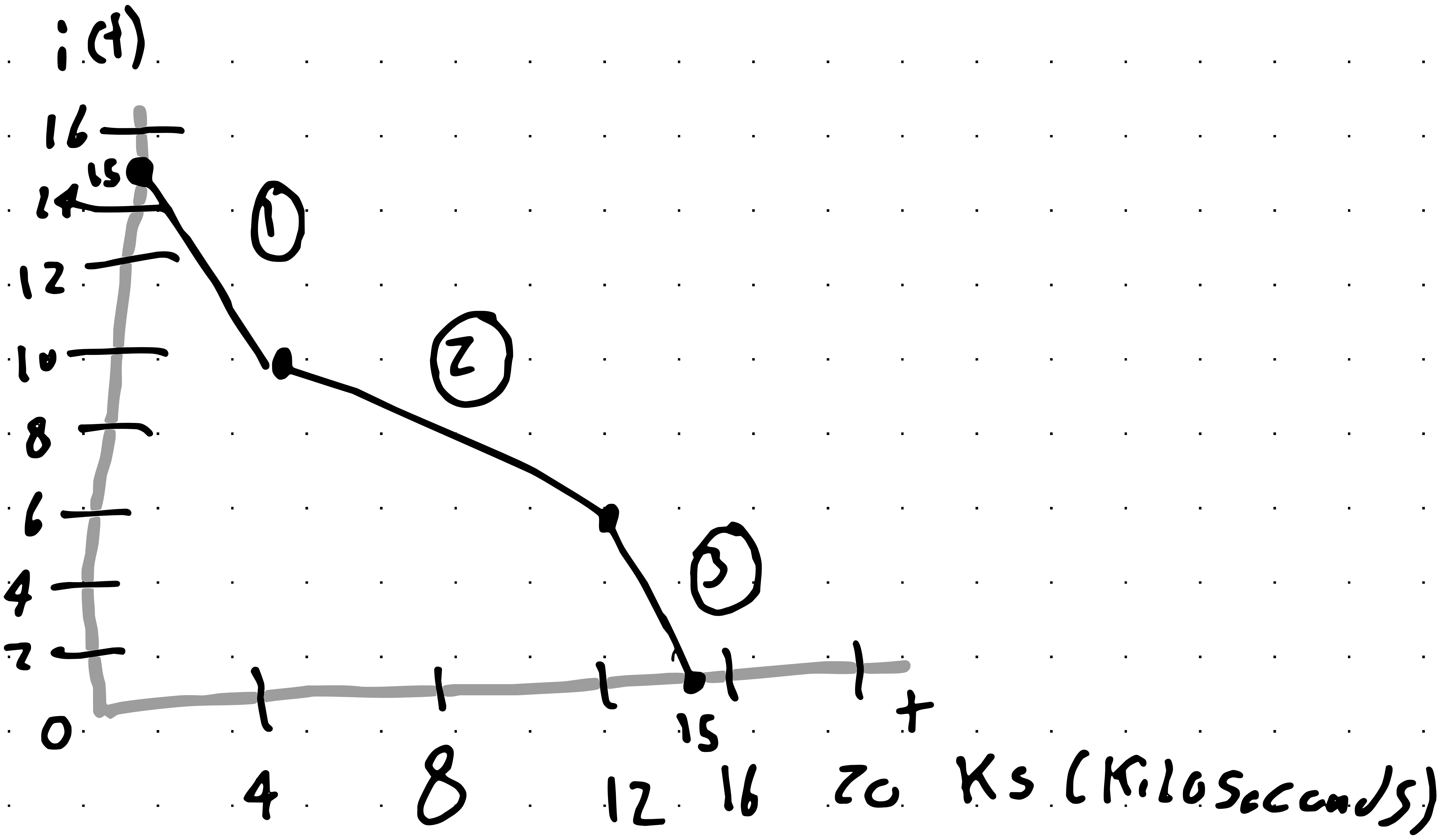
$$w(t) = \int_0^{60} 360\,dt = 360t \Big|_0^{60}$$

$$360(60-0)$$

$$21600J$$

EX The voltage and current at the "terminals" of a certain car battery during a charge cycle are shown in the following figures





a) Calculate the total charge transferred to the battery

We know that

$$i = \frac{dQ}{dt}, \text{ so } Q = \int i\,dt \, !$$

$Q = \int i\,dt$, or just the area under the curve... right?

If we section up the graph..

$$= \left[\frac{1}{2}(9)(5) + (9)(10) + \frac{1}{2}(8)(4) + (6)(8) + \frac{1}{2}(3)(6)\right] \times 10^3$$

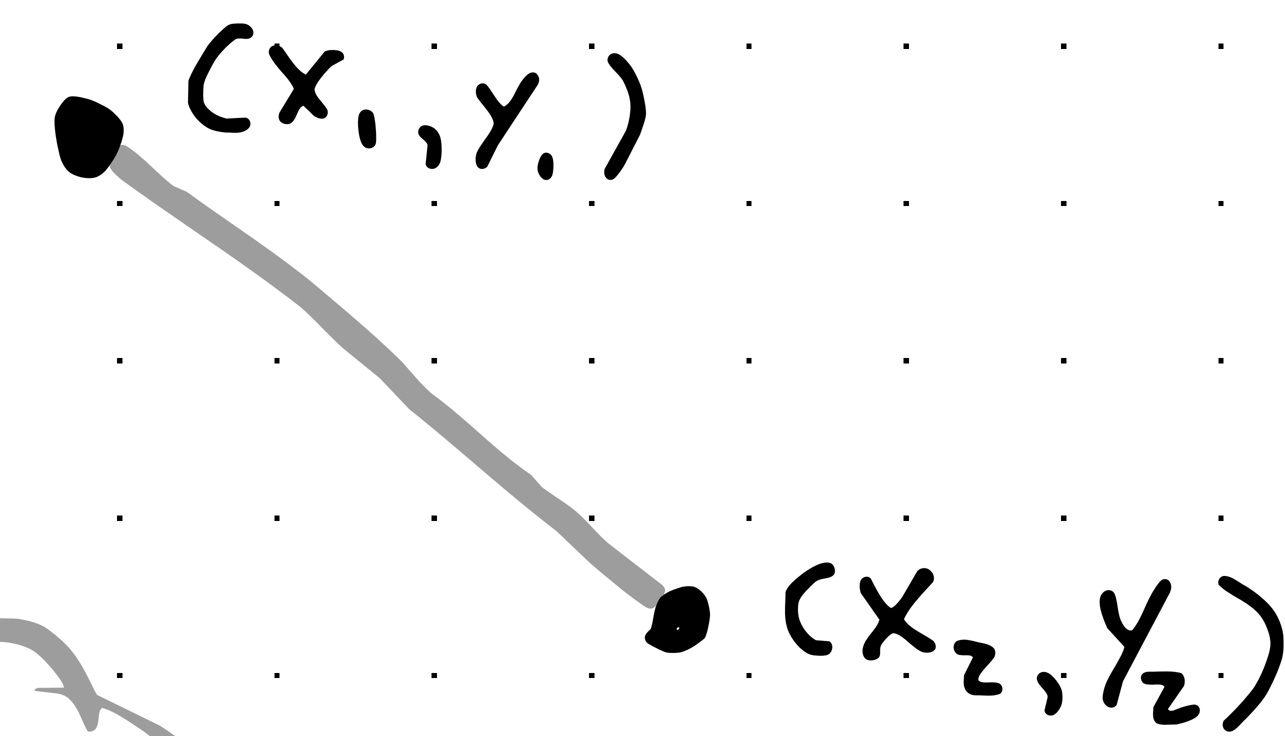
To get us out of kiloseconds

$$= 123000\,e$$

b) Calculate the total energy transferred to the battery

Equation of a straight line... Reminder!

$$\boxed{\frac{y-y_1}{x-x_1} = \frac{y_2-y_1}{x_2-x_1}}$$



Initial Term

M

For line 1!

$$\frac{i-15}{t-0} = \frac{10-15}{4-0}$$

i = Initial Term - Slope

$$\dot{i}_1 = 15 - 1.25\times10^{-3}t \qquad 0 \le t \le 15\,ks$$

$$\dot{i}_2 = 12 - 0.5\times10^{-3}t \qquad 4\,ks \le t \le 12\,ks$$

$$\dot{i}_3 = 30 - 2\times10^{-3}t \qquad 12\,ks \le t \le 15\,ks$$

Voltage

$$v_{(t)} = 0.2\times10^{-3}t + 9 \qquad 0 \le t \le 15\,ks$$

Now, we need to calculate the power for each period

$0 < t < 4ks$

$P_1 = i_1 V$

$$W_1 = \int_0^{4ks} P_1 \, dt$$

$4ks < t < 12ks$

$P_2 = i_2 V$

$$W_2 = \int_{4ks}^{12ks} P_2 \, dt$$

$12ks < t < 15ks$

$P_3 = i_3 V$

$$W_3 = \int_{12ks}^{15ks} P_3 \, dt$$

$$\text{Energy}_{\text{Total}} = W_1 + W_2 + W_3$$