Lecture 2: Basic Quantities and Circuit Elements

ELEC2501 Circuits and Signals

- SI Units
- Basic quantities
  - Current
  - Voltage
- Voltage-current relationship
- Power
- Examples

- Circuit elements
- Sources
  - Independent
  - Dependent
- Examples

SI Units

Base Units

unit	abbreviation	property
metre	m	length
kilogram	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	temperature
candela	cd	luminous intensity
mole	mol	amount of substance

Derived Units

Many exist. Some examples

unit	abbreviation	property
Watts	W	power
Volts	V	potential difference
Joules	J	energy
Ohms	Ω	electrical resistance

Supplementary Units

radian	rad	unit of angle
steradian	sr	unit of solid angle

Prefixes

Prefix	T	G	M	k	m	μ	n	p
Magnitude	10^{12}	10^{9}	10^{6}	10^{3}	10^{-3}	10^{-6}	10^{-9}	10^{-12}

Basic Quantities.

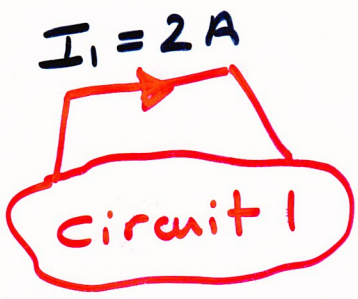
Let us focus on some terms we will regularly use when analysing electrical circuits.

Current.

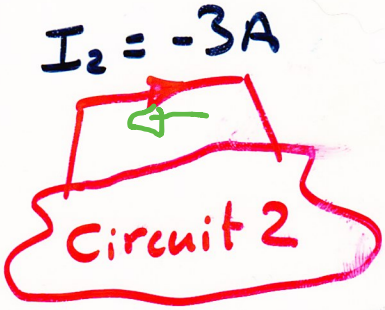
Rate of change of charge

$$i(t) = \frac{dq(t)}{dt} \quad \text{or} \quad q(t) = \int_{-\infty}^{t} i(x)\,dx$$

i - current (ampere)
q - charge (coulomb)
t - time



2C flowing L to R in 1s.



3C flowing R to L in 1s.

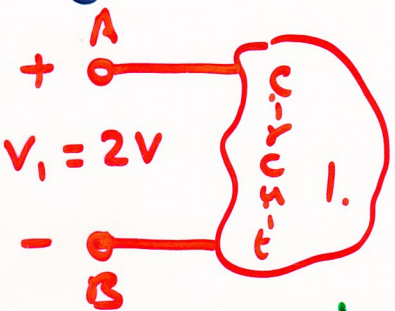
Voltage, electromotive force (EMF) or potential difference.

Charges in motion yield an energy transfer. Voltage between two points is defined as the difference in energy level of a unit charge located at each of the two points.

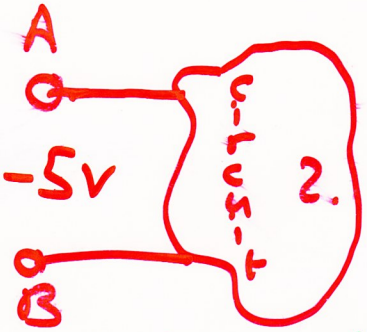
$$V = \frac{W}{Q}$$

V - potential difference (V)
W - energy change or work done (J)
Q - charge (C).

By implication from this definition one point has a higher potential w.r.t. the other. Represented by sign convention.

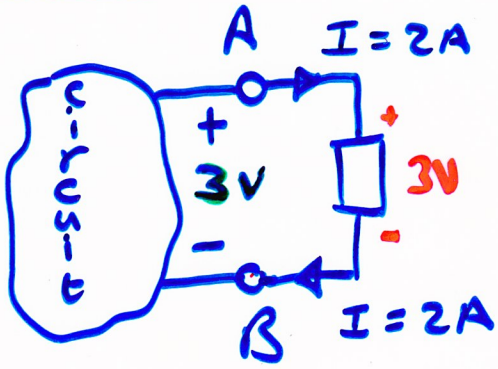


A has higher potential

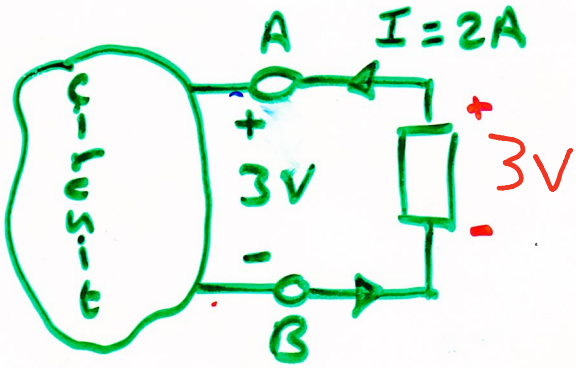


B has higher potential

Voltage - Current relationships.

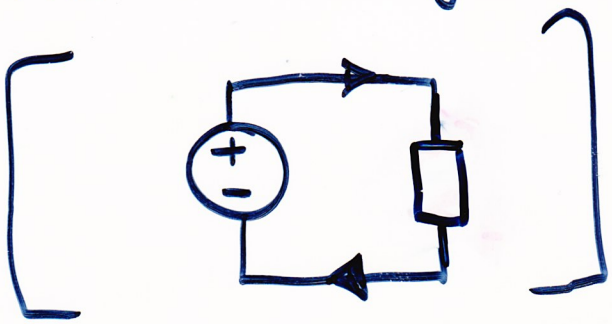


Energy absorbed.



Energy supplied

Note the current flow convention



Current direction is + → − .

Opposite of actual electron flow.

Considering the potential difference in terms of energy and charge changes.

$$V = \frac{dW}{dq}$$

V - potential diff.

dW - energy change with charge change, dq.

But $i = dq/dt$

So $Vi = \frac{dW}{dq}\frac{dq}{dt} = \frac{dW}{dt} = P$

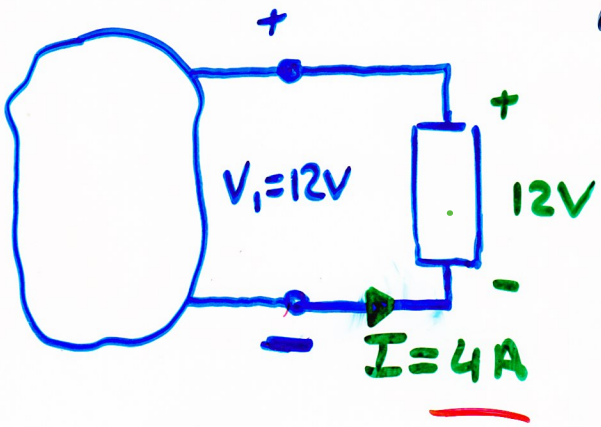
P is power.

Alternatively $\Delta W = \int_{t_1}^{t_2} v\,i\,dt$

$$P = iV$$

Examples

(1) (Irwin El.1 a)



Determine the amount of power absorbed or supplied by the element.

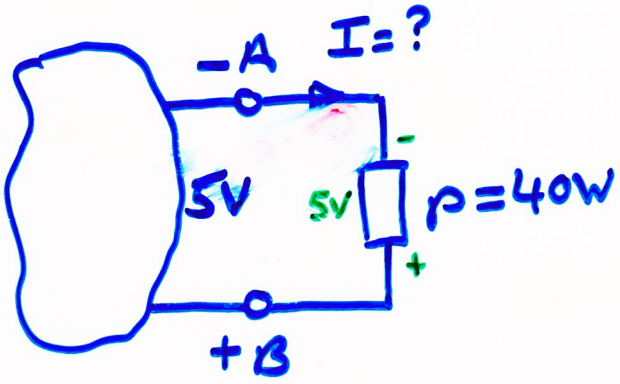
$V = 12V$

$I = -4A$

$\therefore \quad p = -48W$

48W supplied.

(2) (Irwin 1.36)



Determine the current

$p = 40W$ (absorbing)

$V_{AB} = -5V$

Now $P = IV$

$$I = \frac{P}{V}$$

$$I = \frac{40}{-5} = -8A$$

Circuit Elements

Circuit elements classified by the current through it and the voltage (or p.d.) across it.

Two types: active and passive

ACTIVE - generates energy e.g. batteries, transistor devices.

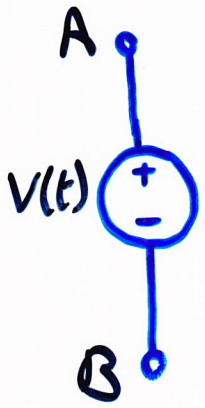
PASSIVE - no energy generation e.g. resistors, capacitors & inductors.

Deal with passive components later.
Consider ACTIVE elements now.

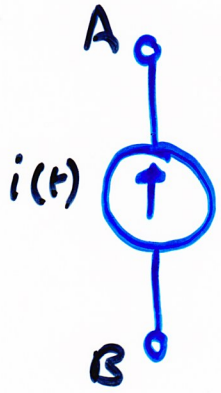
4 active sources

1. Independent voltage source
2. " current "
3. Dependent voltage source
4. " current "

Independent Sources.



voltage source

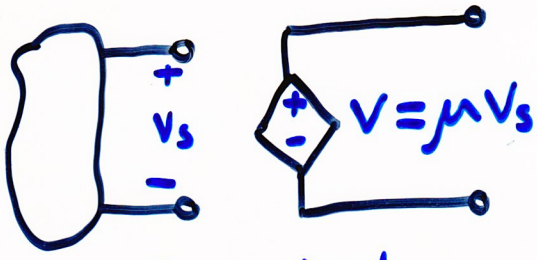


current source

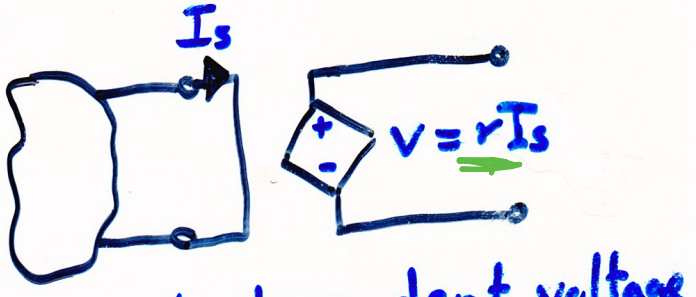
voltage source – voltage maintained independent of current through it.

current source – current maintained independent of voltage across it.

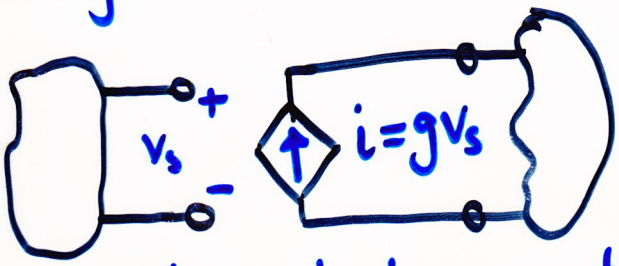
Dependent Sources.



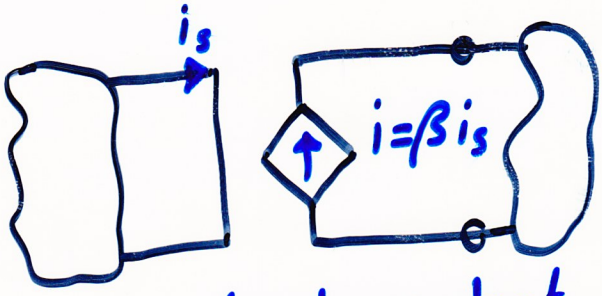
voltage dependent voltage source



current dependent voltage source



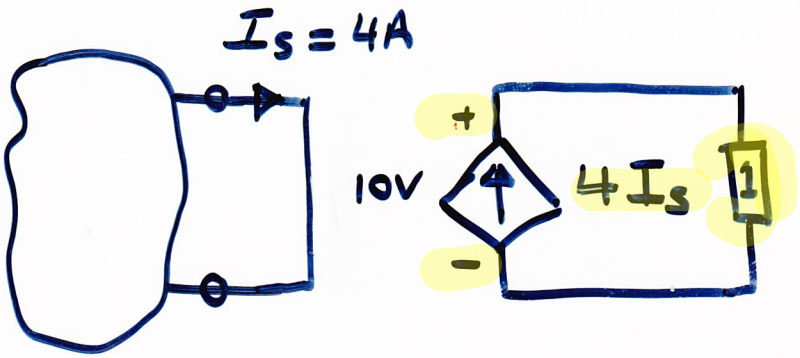
voltage dependent current source



current dependent current source.

Examples

(1) (Irwin Ext. 1.4b)



Power supplied to element 1?

$I_s = 4A$

$\therefore$ Current source produces, $I = 4I_s$

$= 4 \times 4$

$= \underline{16A}$

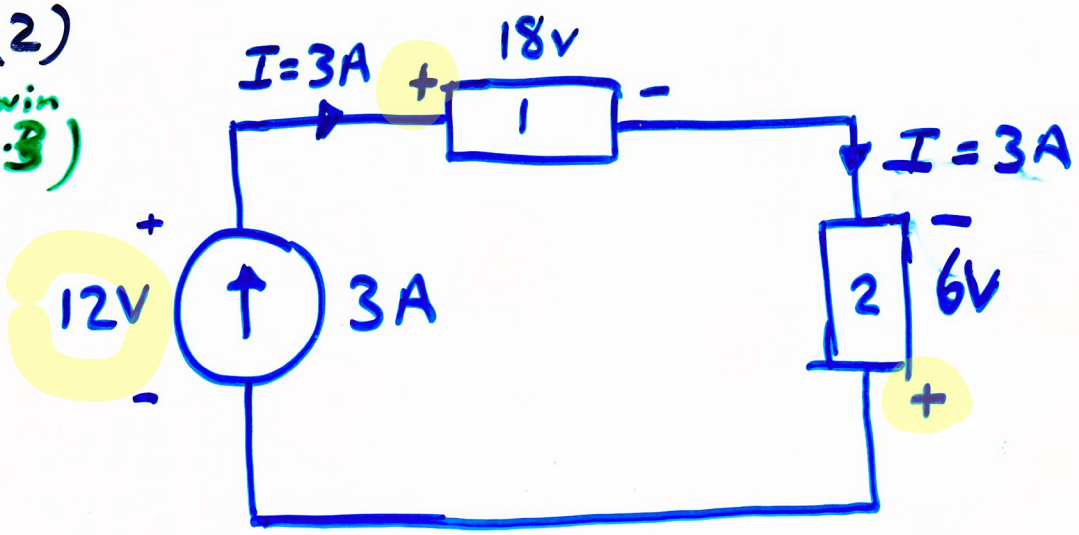
Potential across the element is 10V.

So, power $= I \times V$

$= 16 \times 10$

$= \underline{160W}$

(2)
(Irwin E1.3)



What are the power levels absorbed or supplied by elements 1 & 2?

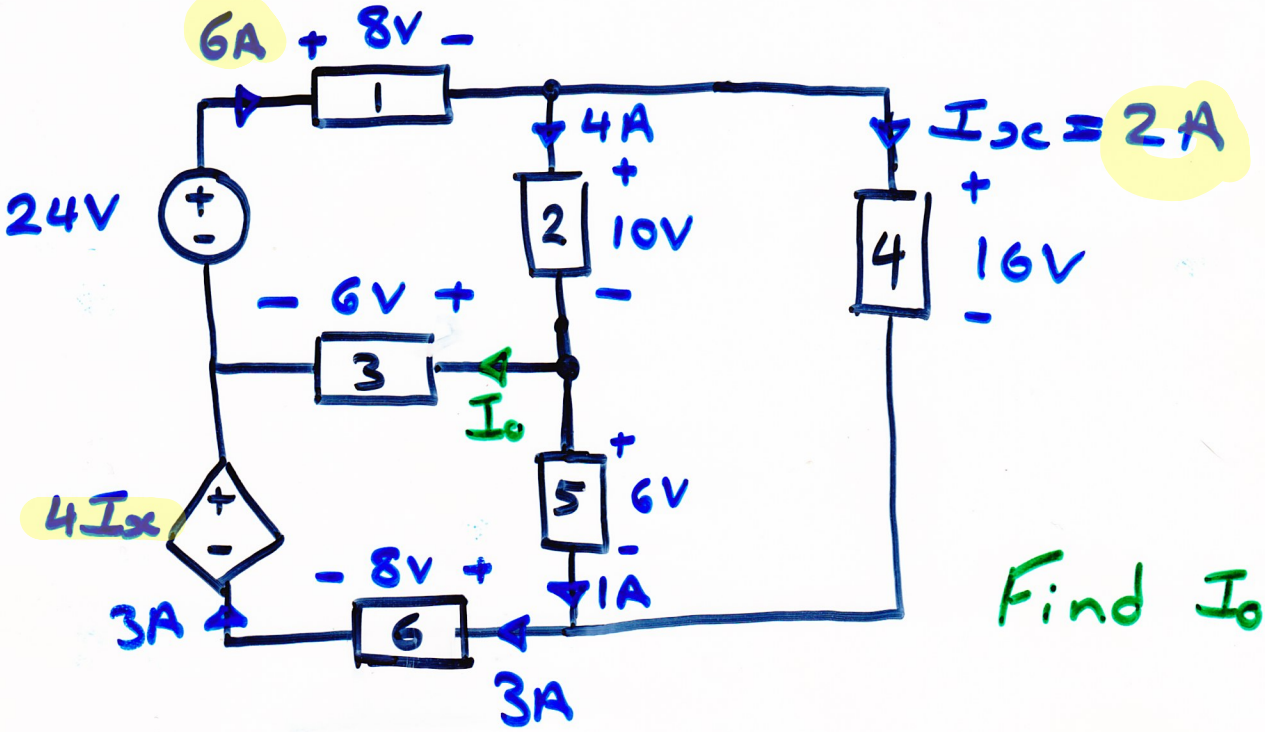
Current source, $P_{source} = 12 \times -3 = -36\,W$
SUPPLIED!

Element 1, $P_1 = 3 \times 18 = 54\,W$
ABSORBED

Element 2, $P_2 = 3 \times -6 = -18\,W$
18W SUPPLIED.

1.43

(3) Problem ~~1.39~~ from Irwin.



Find I_o

Voltage of dependent source, $V_{DS} = 4 \times 2 = 8V$.

$P_{DS} = 8 \times -3 = -24W$

$P_{24V} = 24 \times -6 = -144W$

$P_1 = 8 \times (6) = 48W$

$P_2 = 10 \times (4) = 40W$

$P_4 = 16 \times (2) = 32W$

$P_5 = 6 \times (1) = 6W$

$P_6 = 8 \times (3) = 24W$

Total = 18 W

So element 3 must absorb 18W. Potential diff across is 6V so current is 18/6 = 3A