Note Title 9/9/2007

Lecture 2

From Section 2.2 of Textbook

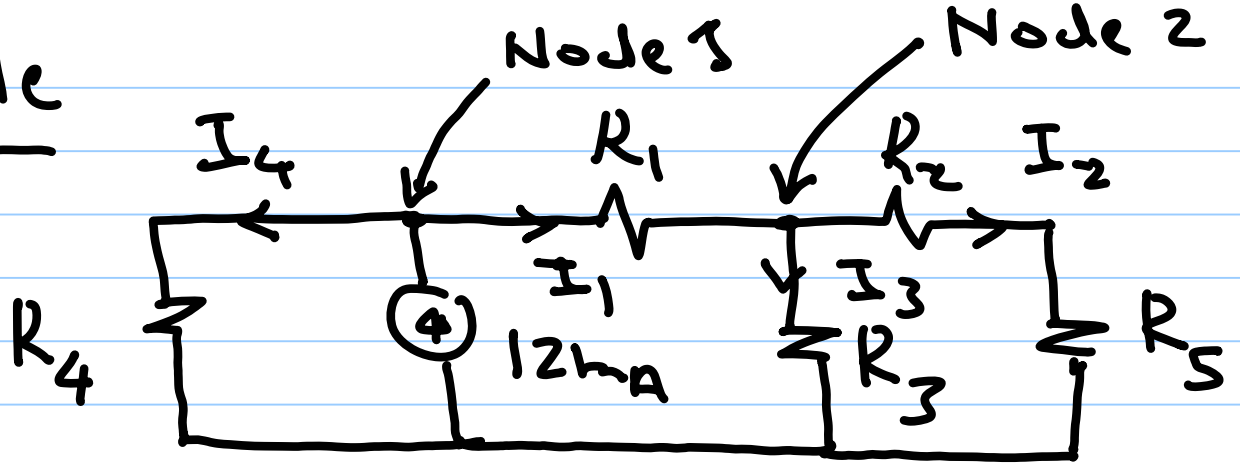
Solve E2.2 – E2.7, 2.11, 2.14,

2.16, 2.18, 2.20

Kirchhoff's Current Law

* The sum of currents entering a node is zero
* The sum of currents leaving a node is zero
* The sum of currents entering a node is equal to the sum of currents leaving the node

Example



at Node 1

$$12\times10^{-3} - I_1 - I_4 = 0$$

or

$$I_1 + I_4 - 12\times10^{-3} = 0$$

or

$$12\times10^{-3} = I_1 + I_4$$

at Node 2

$$I_1 - I_2 - I_3 = 0$$

or

$$I_3 + I_2 - I_1 = 0$$

or

$$I_1 = I_2 + I_3$$

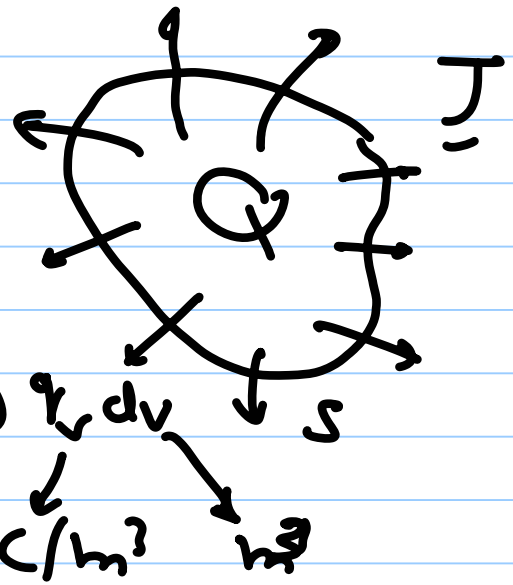
* Currents flowing In are +ve and currents flowing out are -ve !

Origin of KCL

* The Charge Continuity equation of electromagnetics states that

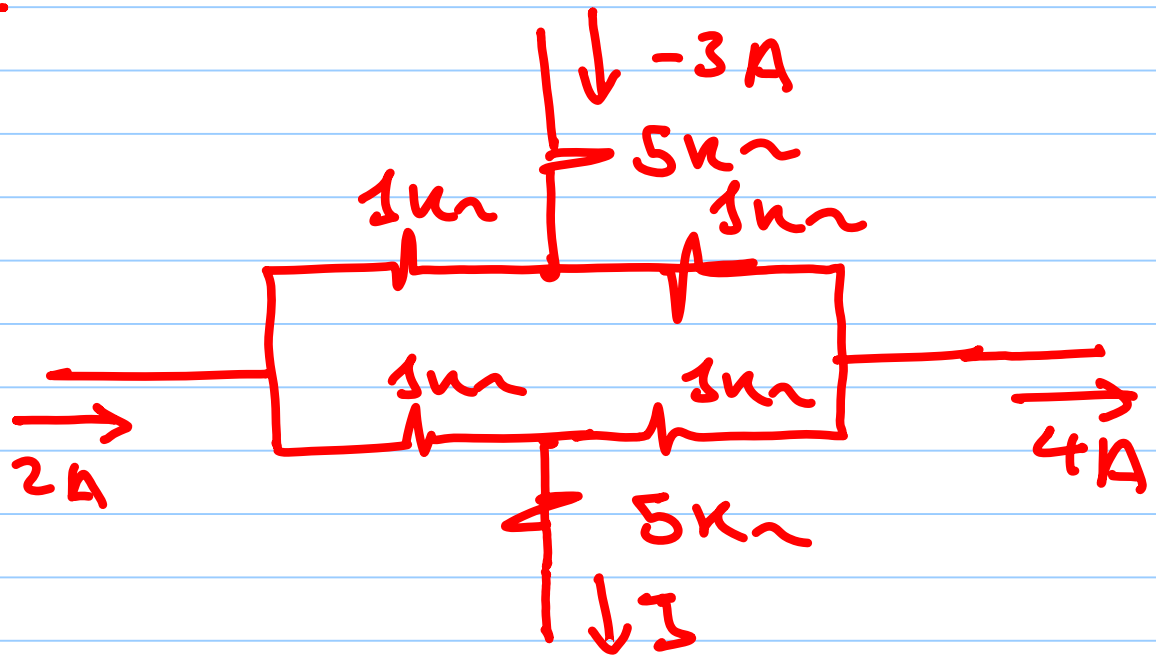
$$\oint_S \underline{J} \cdot d\underline{s} = -\frac{d}{dt}\iiint q_v \, dv$$

$\underline{J}$: A/m^2, $d\underline{s}$: m^2, q_v: C/m^3, dv: m^3



* at sufficiently low frequencies, the RHS is negligible $\Rightarrow \oint_S \underline{J} \cdot d\underline{s} = 0 \Rightarrow$ Sum of currents leaving $S = 0$

Example

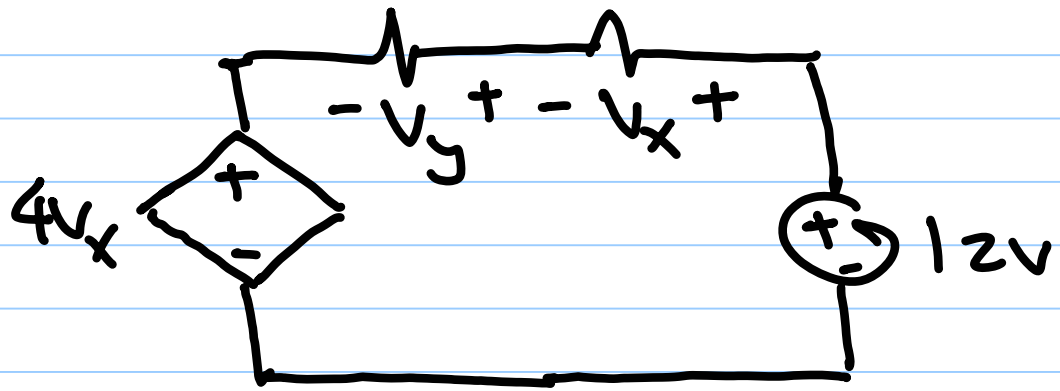


Find the current I in the shown Circuit

Kirchhoff's Voltage Law (KVL)

* The algebraic sum of the voltages in the Clockwise direction of a loop is Zero
* The algebraic sum of the voltages in Counter Clockwise direction of a loop is Zero
* The algebraic sum of voltages in the CW direction equals the algebraic sum in the CCW direction

Example



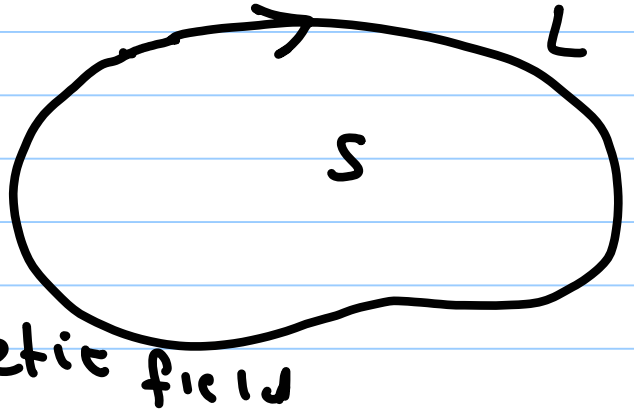
* CW direction: $V_y + V_x - 12 + 4V_x = 0$
* CCW direction: $12 - V_x - V_y - 4V_x = 0$
* Third formulation: $V_x + V_y + 4V_x = 12$
* A voltage is given a the sign if you encounter its low terminal first in that direction!

Origin of KVL

* $V_{ab} = V_a - V_b = \int_a^b \underline{E} \cdot d\underline{\ell}$ ($\underline{E}$ is electric field V/m)

* From Faraday's Law

$$\oint_L \underline{E} \cdot d\underline{\ell} = -\frac{d}{dt} \iint_S \underline{B} \cdot d\underline{s}$$

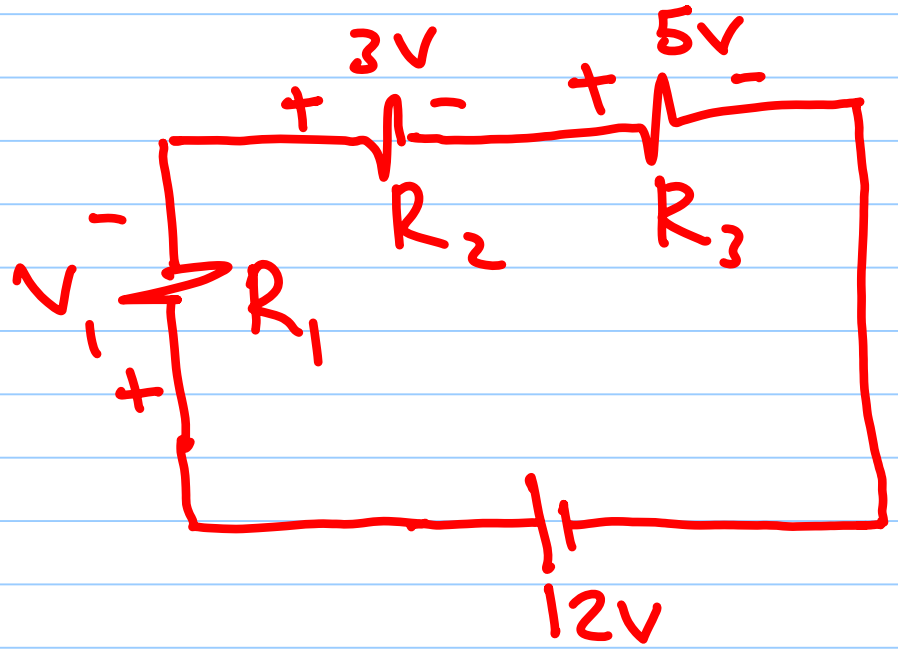


$\underline{B}$: magnetic field

* at sufficiently low frequency RHS is negligible

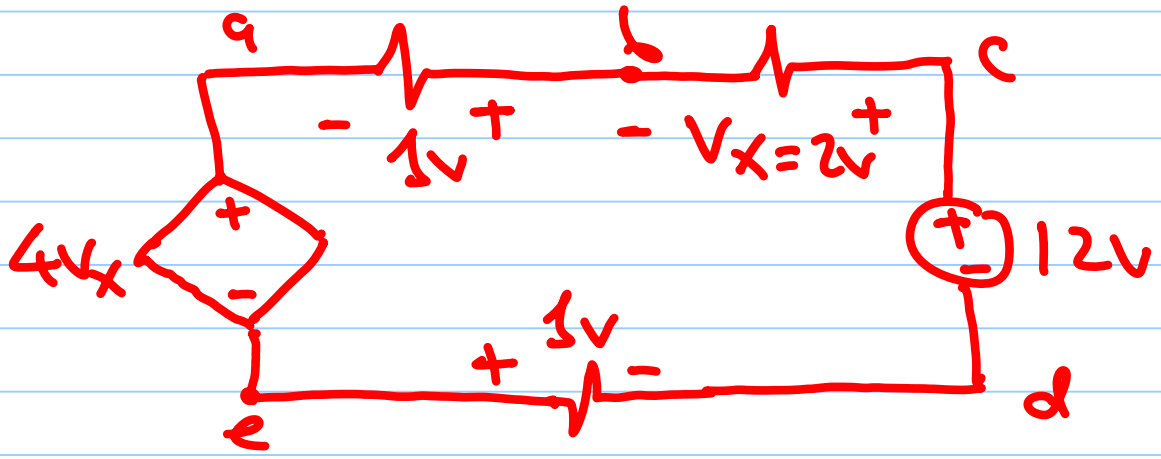
$\Rightarrow \oint_L \underline{E} \cdot d\underline{\ell} = 0 \Rightarrow$ sum of voltages is zero

Example



Find the voltage V_1 using KVL

Example



Using KVL find V_{da} and V_{be}

Example

Use ohm's law, KCL and KVL

to find the equivalent resistance of the shown series resistances