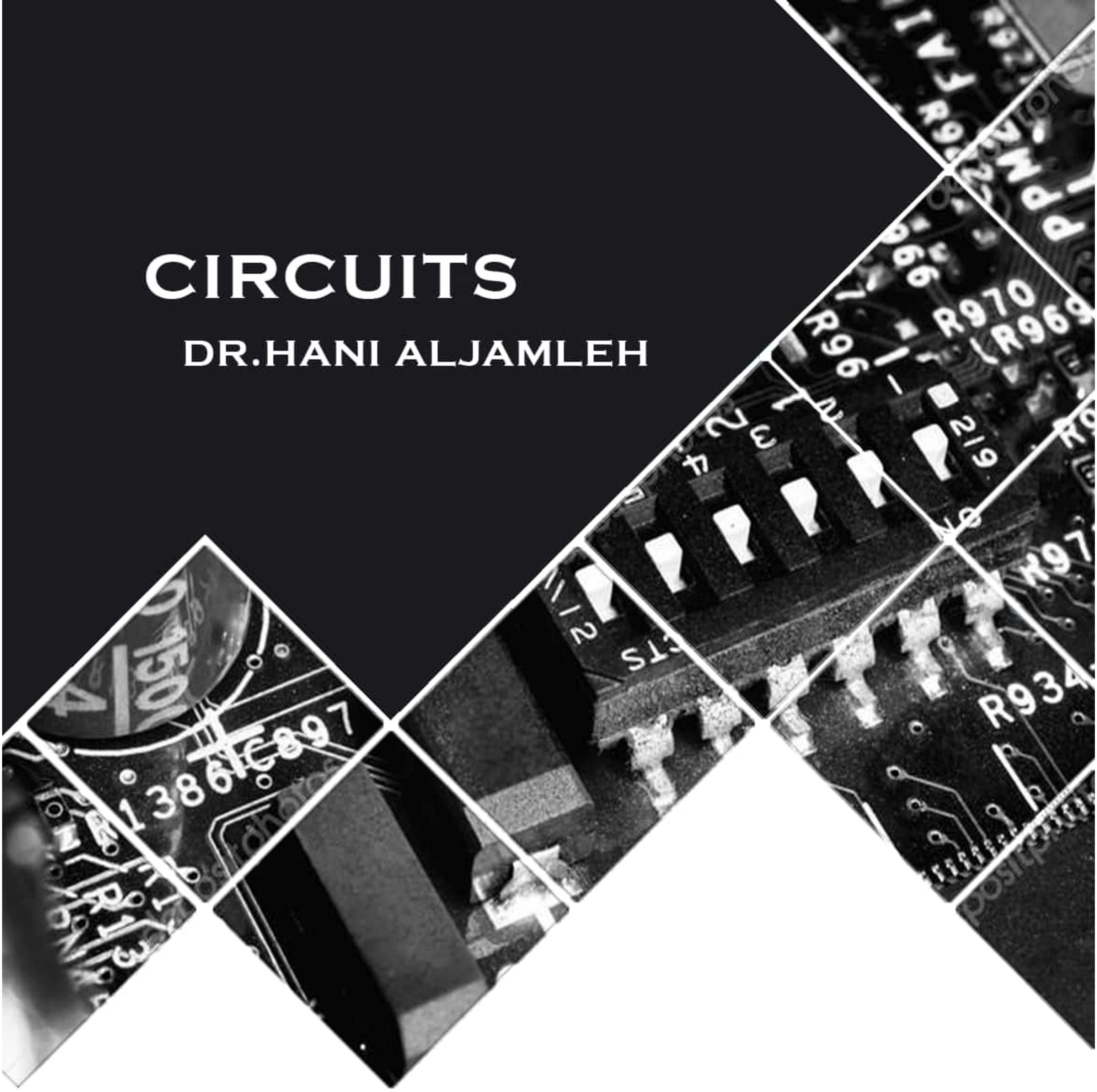
CIRCUITS

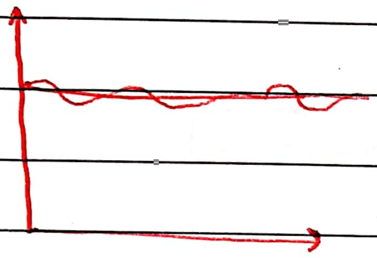
DR.HANI ALJAMLEH



BY:KHALID ALNASER

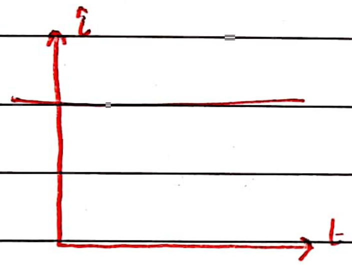
POWERUNIT

$$i = \frac{\partial Q}{\partial t} \longrightarrow \int_{t_0}^{t_1} i \, \partial t = Q$$



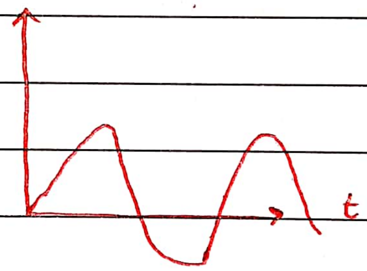
DC current

I



ac current

$i(t)$



يكون اتجاه التيار خارج البطارية من الموجب للسالب (عكس اتجاه $\bar{e}$)

Example 1.2:

$$q = 5t \sin(4\pi t) \text{ m C}$$

$$i = \frac{\partial q}{\partial t} = \left[5\underset{0.5}{t} \cdot (4\pi)\cos(4\pi \underset{0.5}{t}) + \sin(4\pi \underset{0.5}{t}) \cdot 5\right] \text{ mA}$$

$$= [2.5 * 4]\ \pi * 1 + 0$$

$$= \boxed{10\pi \text{ mA}}$$

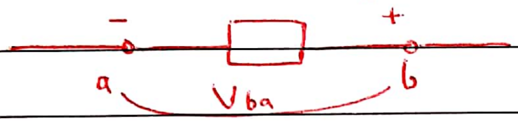
Example 1.3

$i = 3t^2 - t$

$$Q = \int_{t_1 = 1s}^{t_2 = 2s} 3t^2 - t \, \partial t$$

$$= t^3 - \frac{1}{2}t^2 \Big|_1^2 = [8-2] - [1 - \frac{1}{2}] = 6 - 0.5 = \boxed{5.5\ C}$$

* $\xleftarrow{I\ (\text{load})}$ ⟶ هيك بكون الـ load لأنه بدو يستهلك



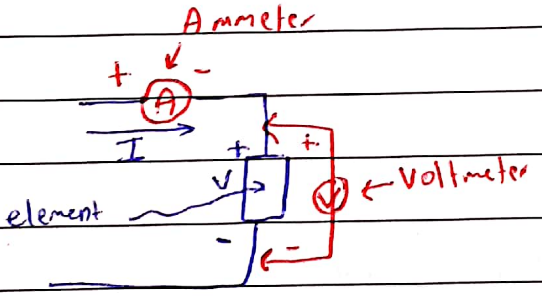
$V_{ba} = V_b - V_a$ $\xrightarrow{I}$ (Source)

$V_{ba} = V_b - V_a > 0$

$V_{ab} = V_a - V_b$ ⟶ عكس بعض

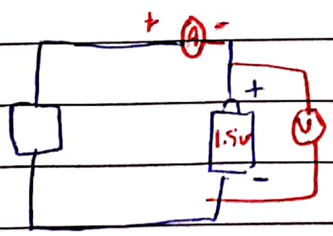
V

12/2/2020



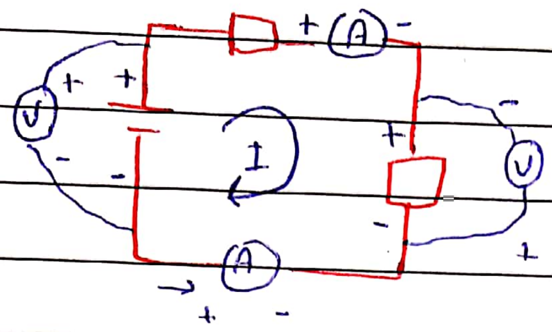
at t_0, t_1

$v(t_1) = 5V$
$i(t_1) = 3A$ } $P(t_1) = 5 * 3 = 15\ W > 0$ +ve absorbing



$V = 1.5\ V$
$A = -0.5\ A$ | $P = IV = 1.5 * -0.5 = -0.75\ W$ supplying

Voltage ⟶ Value + Polarity
Currents ⟶ Value + Direction



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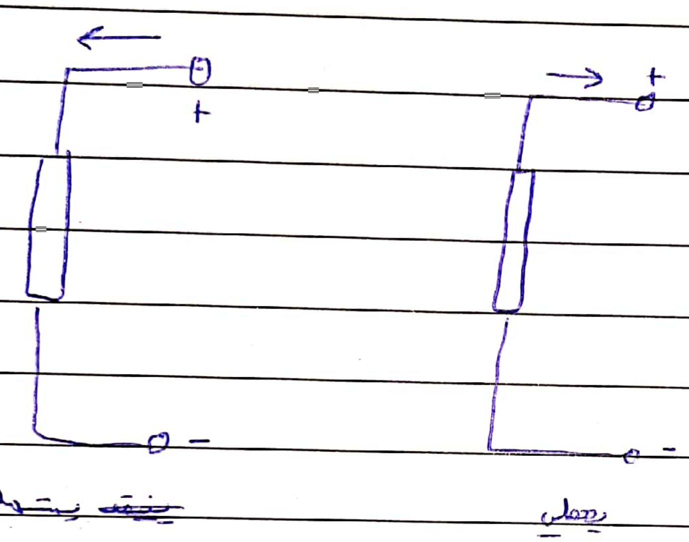
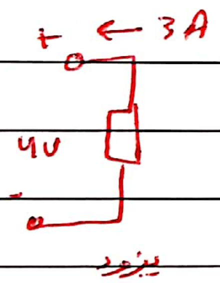


Figure 1.10



$P = 3 * 4 = -12$

يعطي

* $\boxed{1\,wh = 3.600\ J}$

Example 1.4 $\quad W = 2.3\ kJ$

$t = 10\ s$

$P = \frac{w}{t} = \frac{2.3}{10} = 0.23\ kw$

$= 230\ w$

$I = 2A$

$P = VI = \frac{230}{2} = V = \boxed{115\ V}$

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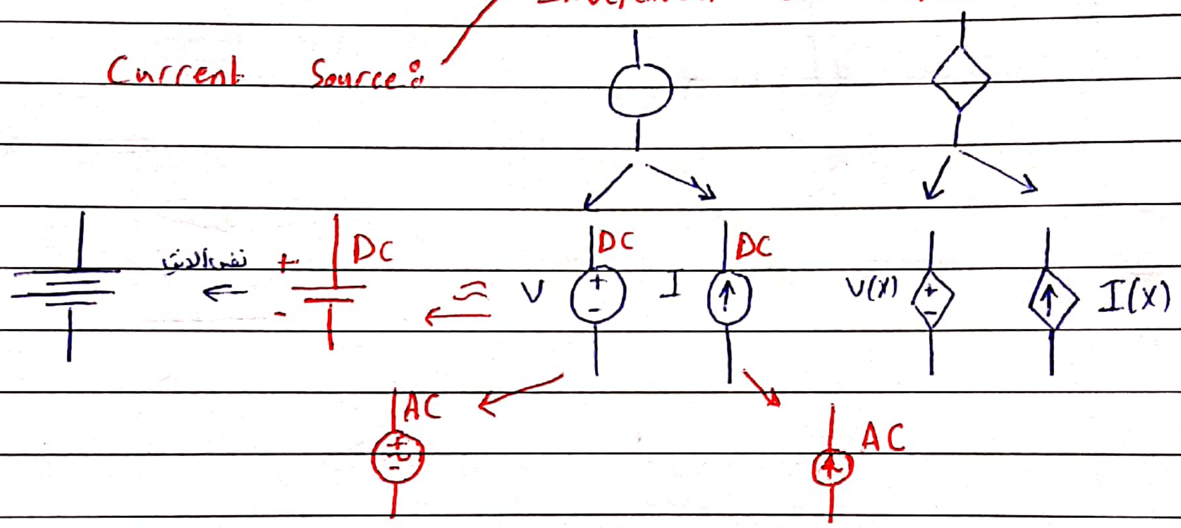
Example 1.5 →

Example 1.6 →

17/2/2020 :

Circuit Elements :

Voltage Source :
Current Source :
→ Independent oR Dependent



(*)

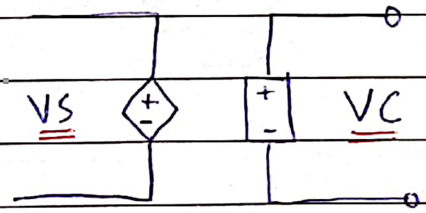
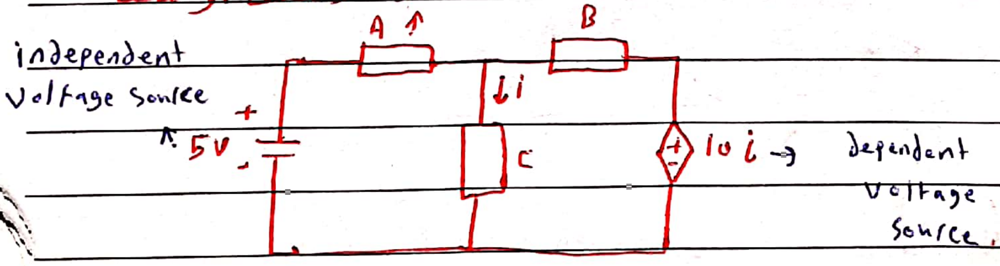


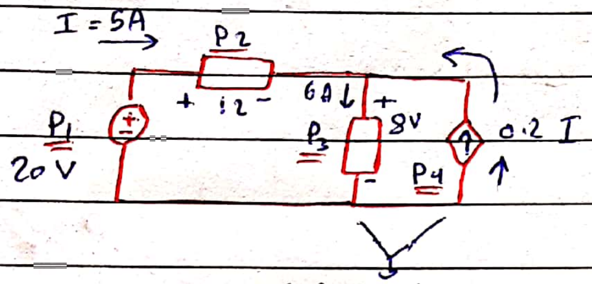
Figure 1.14

مقاومة او مكثف او محث

(*) في 5 Elements



Example 1.7:



نفس ال (V).

Sol:

$P_1 = I * V = -5 * 20 = -100\ W$

$P_2 = I * V = 5 * 12 = 60\ W$

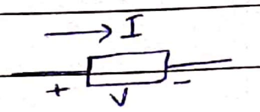
$P_3 = I * V = 6 * 8 = 48\ W$

$P_4 = I * V = -1 * 8 = -8\ W$

$\Rightarrow I = 0.2 * 5 = 1\ A$

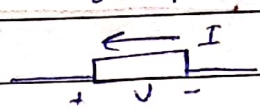
$V = 8\ V$

* Note:



(مستهلك) $P = IV$

dissipator



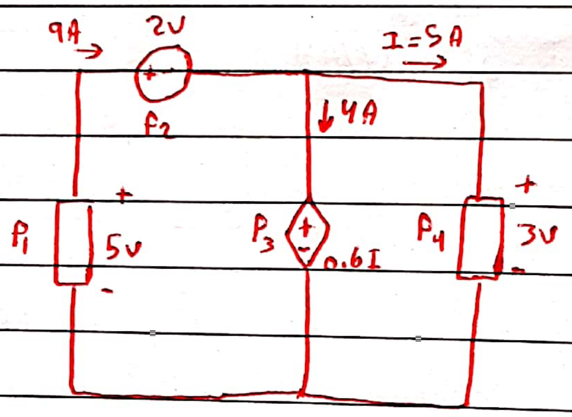
(مزود) $P = -IV$

Supplier

Check:

$P_1 + P_2 + P_3 + P_4 \overset{?}{=} \phi\ W$ هل مجموعهم بيساوي (zero)

Practice 1.7:



$P_1 = -5 * 9 = 45\ W$

$P_2 = 9 * 2 = 18\ W$

$P_3 = 4 * 3 = 12\ W$

$P_4 = 5 * 3 = 15\ W$

$\Sigma = 0$ ✓

Example 1.9:

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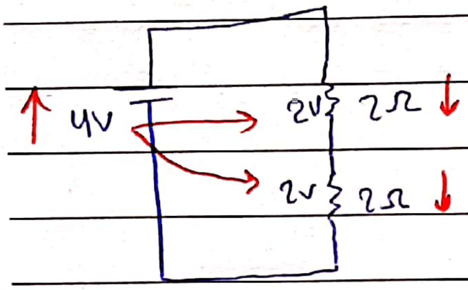
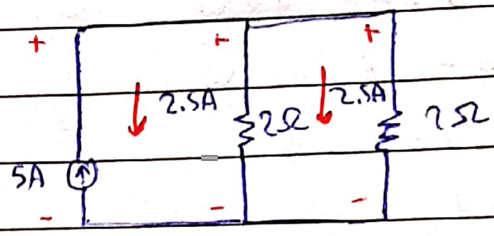
i.v characteristics اهم اشي

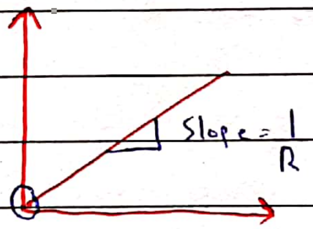
$R = \rho \frac{L}{A}$ (Ω.m)

Voltage Division



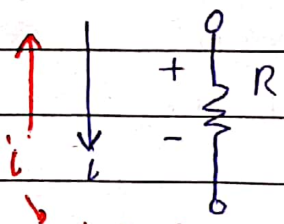
Current division





$\boxed{V = R \cdot I}$

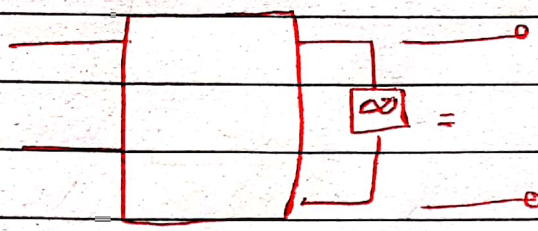
$R = \frac{V}{I} = \boxed{V/A}$



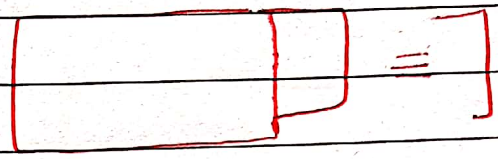
لو حطيناها
لازم اشارة سالبة

$R = \rho \frac{L}{A} \longrightarrow G = \frac{1}{R} = \frac{1}{\rho}\frac{A}{L} = \frac{i}{v}$

Conductance



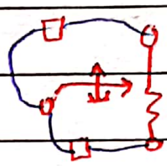
Open circuit ≡ No load



Short Circuit

Resistors → Fixed

Resistors → Variable



$P = i \cdot V$
$= i \cdot (i \cdot R)$
$= i^2 \cdot R$

$P = i \cdot V$
$= \frac{V}{R} \cdot V$
$= \frac{V^2}{R}$

always positive = passive element

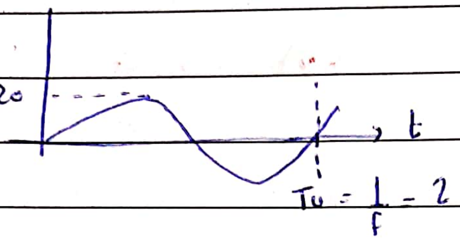
Example 2.1 →
Practice Problem 2.1 →
Example 2.2 →
Practice Problem 2.2 →

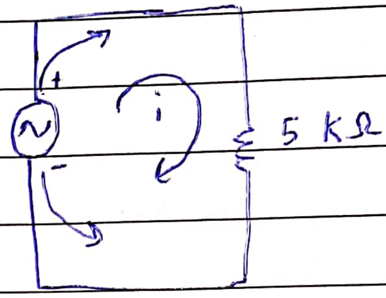
24/2/2020

Example 2.3:

$V_s = 20 \sin \pi t \rightarrow W = 2\pi f = \pi$

$f = \frac{1}{2} = 0.5\ Hz$





$$i = \frac{V}{R} = \frac{20 \sin \pi t\ V}{5\ K\Omega} = 4 \sin \pi t \quad mA$$

$$P = i * V \quad ?$$

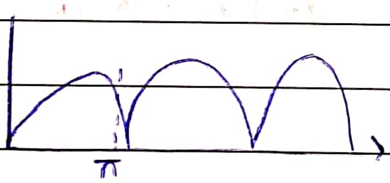
$$= \frac{V^2}{R} \qquad = 4\ mA * 20\ V\ (\sin \pi t)^2$$

$$= 80 \sin^2 \pi t \quad mW$$

$$= i^2 . R$$

Note: $Hz = \frac{1}{s}$

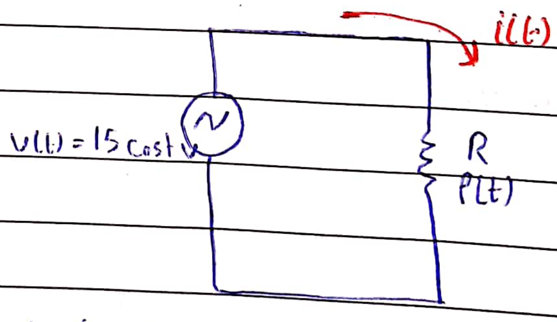
Power



Practice Problem 2.3:

$P(t) = 30 \cos^2 t\ (mW)$

$V = 15 \cos t\ (V)$



$$i(t) = \frac{P}{V} = \frac{30 \cos^2 t\ mW}{15 \cos t\ V} = 2 \cos t\ (mA)$$

$$R = \frac{V}{i} = \frac{V^2}{P} = \frac{(15)^2 (\cos t)^2\ V^2}{30 (\cos t)^2\ mW} = 7.5\ K\Omega$$

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الـ network ممكن يكون فيها اكتر من Circuit
والـ Circuit لازم تكون مغلقة بس الـ network مش شرط
* كل branch بمثل Element

Figure 2.10

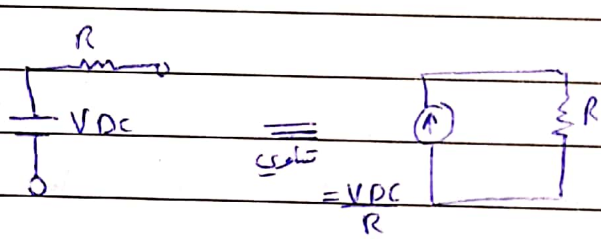
5 branches

3 nodes

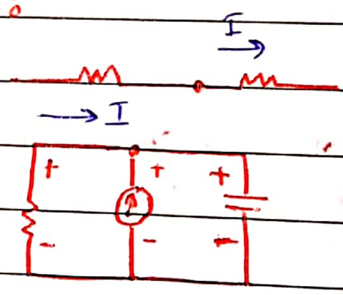
3 loops

$$\boxed{b = l + n - 1}$$

*Notes:



Note:



→ Same Current

→ Same Voltage

Example 2.4

4 branches

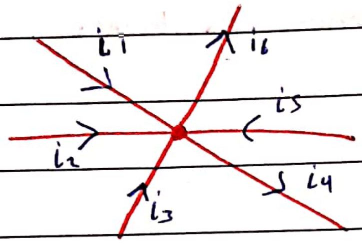
3 nodes

Practice Problem 2.4

5 branches

3 nodes

26/2/2020

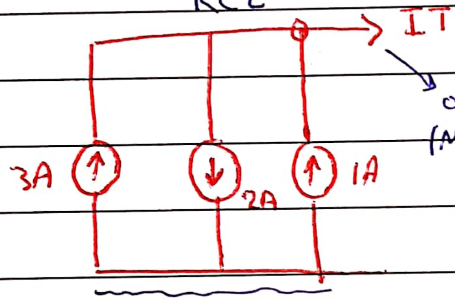


inward : +ve ≡ entering

outward : −ve ≡ leaving

$$+i_1 + i_2 + i_3 - i_4 + i_5 - i_6 = 0$$

KCL

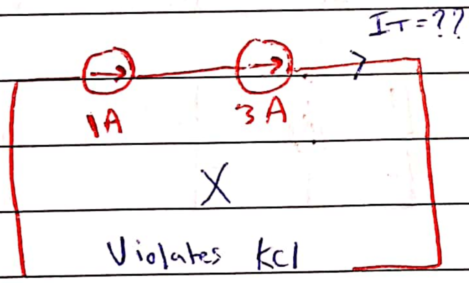


Parallel

Out = IN

$I_T + 2 = 3A + 1A$

$I_T = 3 + 1 - 2 = \boxed{2A}$

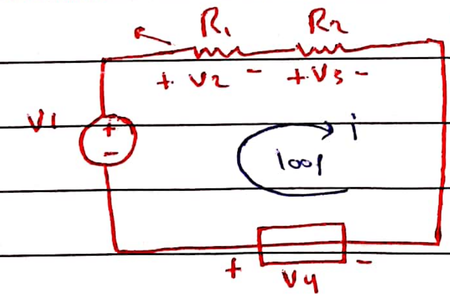


* ما بصير نحط ، two different currents على التوالي

* بنقدر نجمعهم مع بعض فقط اذا كان Parallel

terminal

KVL



مع عقارب الساعة

CW

عكس عقارب الساعة CCW

KVL : $-V_1 + V_2 + V_3 - V_4 = 0$

KVL : $V_1 - V_2 - V_3 + V_4 = 0$

$$\boxed{\sum_{m=1}^{M} V_m = 0}$$

كل element ال 2 terminal

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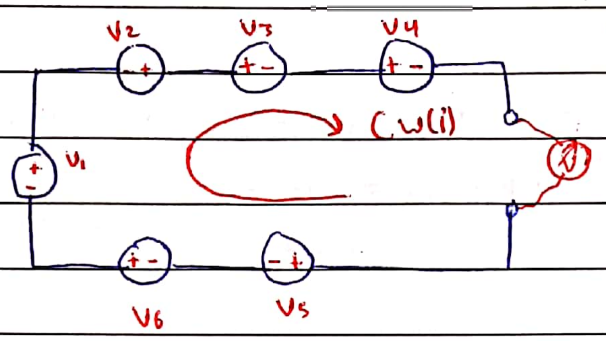
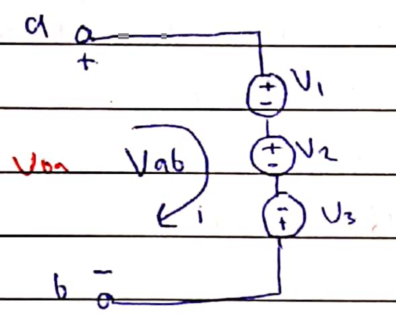
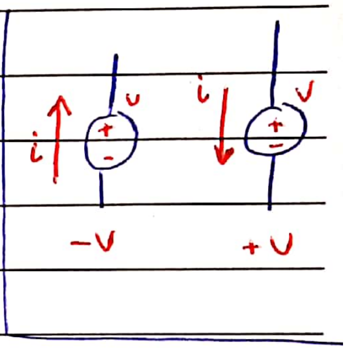


$-V_1 - V_2 + V_3 + V_4 + V_5 - V_6 = 0 \Rightarrow V_1 + V_2 - V_3 - V_4 - V_5 + V_6$

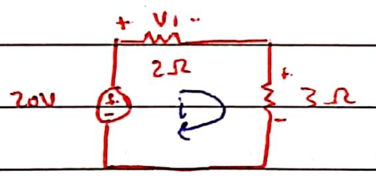


$-V_{ab} + V_1 + V_2 - V_3 = 0$

$V_{ab} = V_1 + V_2 - V_3$



Example 2.5:



KVL: $-20 + V_1 + V_2 = 0$

ohm's law: $V_1 = 2 * i$

$V_2 = 3 * i$

$= -20 + 2i + 3i = 0$

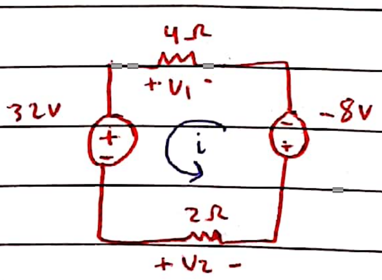
$5i = 20$

$\boxed{i = 4A}$

$V_1 = 2 * 4 = 8\ V$

$V_2 = 3 * 4 = 12\ V$

Practice Problem 2.5:



KVL: $-8 - V_1 + 32 + V_2 = 0$

ohm's law: $V_1 = -4i = -4 * -4 = 16\ V$

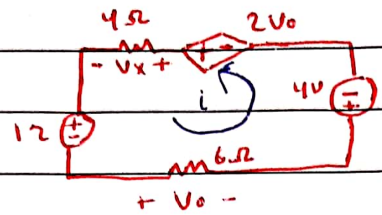
$V_2 = +2i = 2 * -4 = -8\ V$

$= -8 + 4i + 32 + 2i = 0$

$+6i = -24$

$\boxed{i = -4A}$

Example 2.6:



① — KVL: $+12 + V_o + 4 - 2V_o + V_x = 0$

But $V_o = i * 6$ — ②

$V_x = i * 4$ — ③

Let ③ & ② in ① $\rightarrow$ $16 + i*6 - 2*(i*6) + i*4 = 0$

$i(6 - 12 + 4) = -16$

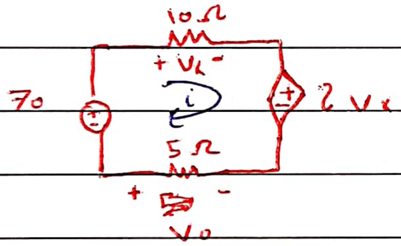
$i(-2) = -16 \rightarrow \boxed{i = 8A}$

$V_o = 8*6 = 48 \ V$

$V_x = 8*4 = 32 \ V$

للتأكد $12 + 48 + 4 - 96 + 32 = 0$

Practice Problem 2.6:



KVL: $-70 + V_x + 2V_x - V_o = 0$

$V_x = 10i = 20V$

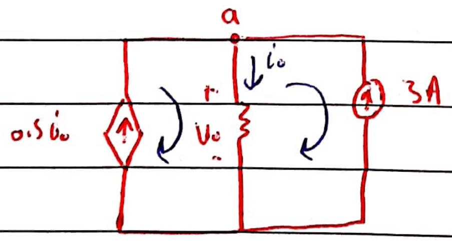
$V_o = -5i = -10 \ V$

$-70 + 10i + 2*10i - (-5i) = 0$

$i(10 + 20 + 5) = 70$

$i = \frac{70}{35} = 2$

Example 2.7:



KCL: $+0.5 i_o - i_o + 3 = 0$

$i_o(0.5 - 1) = -3$

$i_o = \frac{-3}{-0.5} = 6A$

$V_o = 4 * i_o = 4*6 = 24 \ V$

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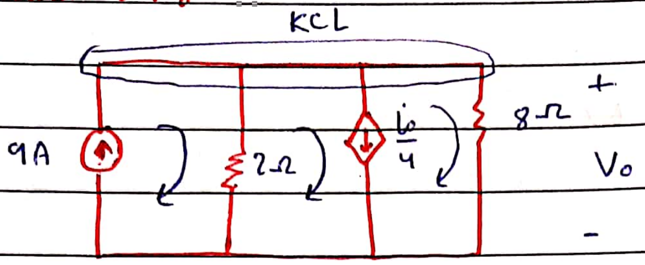
Practice Problem 2.7:



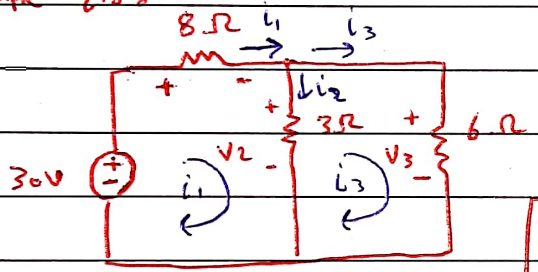
$9 - i_o - \frac{i_o}{4} - \frac{V_o}{8} = 0 \rightarrow i_o(-1 - \frac{1}{4} - \frac{1}{4}) = -9 \rightarrow i_o(-1.5) = -9$

$i_o = \frac{9}{1.5} = \boxed{6A}$

But: $V_o = 2 * i_o = 2*6 = 12\ V$

2/13/2020

Example 2.8:



① KVL1: $-30 + 8i_1 + 3i_2 = 0$

② KVL2: $6i_3 - 3i_2 = 0$

③ KCL: $i_1 - i_2 - i_3 = 0 \rightarrow i_2 = i_1 - i_3$

$8i_1 + 3i_2 + 0i_3 = 30 \rightarrow 8i_1 + 3(i_1 - i_3) = 30$

$11i_1 - 3i_3 = 30$

$0i_1 - 3i_2 + 6i_3 = 0$

$= -3(i_1 - i_3) + 6i_3 = 0$

$= -3i_1 + 9i_3 = 0$

$\boxed{i_1 = 3i_3}$

$11(3i_3) - 3i_3 = 30 \rightarrow i_3 = \frac{30}{30} = 1A$

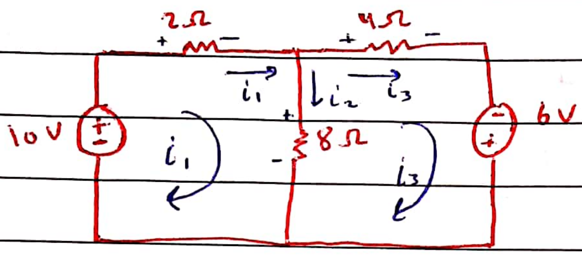
$\therefore\ i_1 = 3i_3 = 3A$

$\therefore\ i_2 = i_1 - i_3 = 3 - 1 = 2A$

Voltages: $V_1 = 8i_1 = 8*3 = 24V$

$V_2 = 3i_2 = 3*2 = 6V$

Practice Problem 2.8



KVL1: $-10+2i_1+8(i_1-i_3)=0 \rightarrow i_1(2+8)-i_3(8)=10 \rightarrow (10i_1-8i_3=10)\times\frac{8}{10}$ — ①

$-8(i_1-i_3)+4i_3-6=0 \rightarrow -i_1(8)+i_3(4+8)=6 \rightarrow -8i_1+12i_3=6$ ②

$8i_1-6.4i_3=8$

$5.6\, i_3=14$

$i_3=\frac{14}{5.6}=2.5\,A$

From ① $\rightarrow 10i_1=8i_3+10 = 8\times 2.5+10=30 \rightarrow i_1=\frac{30}{10}=3A$

KCL: $i_1=i_3+i_2$

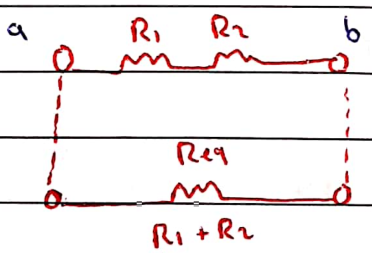
$\therefore i_2=i_1-i_3 = 3-2.5=0.5\,A$

$V_1=2i_1=6V$

$V_2=8i_2=4V$

$V_3=4i_3=10V$

Resistors in Series:



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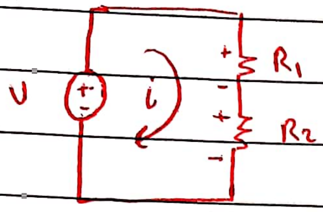
Voltage Divider Network:

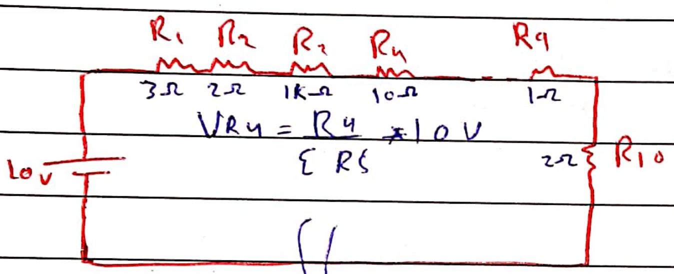


KVL: $-V + iR_1 + iR_2 = 0$

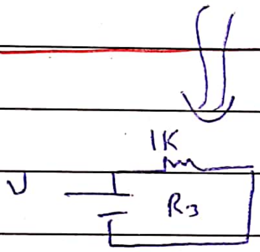
$$i = \frac{V}{R_1+R_2}$$

$$V_{R_1} = i * R_1 = \frac{R_1}{R_1+R_2} V$$

$$V_{R_2} = i * R_2 = \frac{R_2}{R_1+R_2} V$$



$$V_{R_4} = \frac{R_4}{\Sigma R_S} * 10V$$



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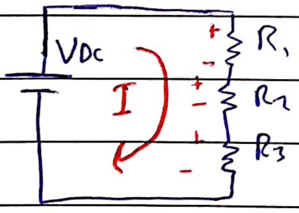


$$V_{R_1} = V_{DC} \frac{R_1}{R_1+R_2+R_3}$$

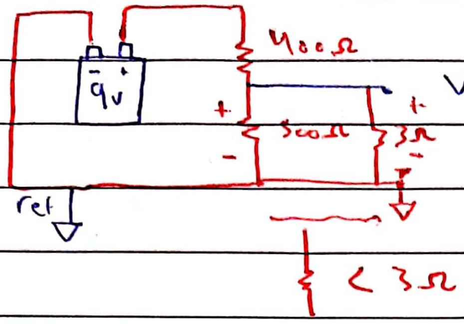
$$V_{R_2} = V_{DC} \frac{R_2}{R_1+R_2+R_3}$$

$$V_{R_3} = V_{DC} \frac{R_3}{R_1+R_2+R_3}$$

$$V_{R_{23}} = V_{DC} \frac{R_2+R_3}{R_1+R_2+R_3}$$

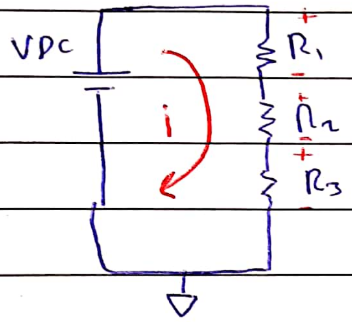
$$= V_{R_2} + V_{R_3}$$

$$I = V_{DC} \frac{1}{\underbrace{R_1+R_2+R_3}_{R_{eq}}}$$



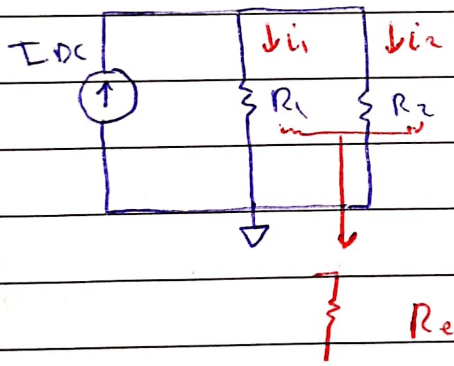
$V = 9 * \frac{500}{900} = 5V$

Voltage Division:



$V_{R\#} = V_{DC} \frac{R_\#}{R_1 + R_2 + R_3}$

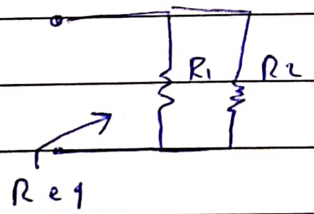
Current Division:



$i_{R_1} = I_{DC} \frac{R_2}{R_1 + R_2}$

$i_{R_2} = I_{DC} \frac{R_1}{R_1 + R_2}$

$R_{eq} = R_{\parallel} = \frac{R_1 R_2}{R_1 + R_2}$



$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

$G_{eq} = G_1 + G_2$

$\frac{1}{R_{eq}} = \frac{R_1 + R_2}{R_1 R_2} \rightarrow R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

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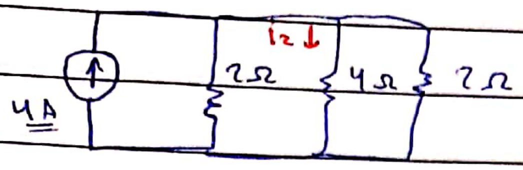
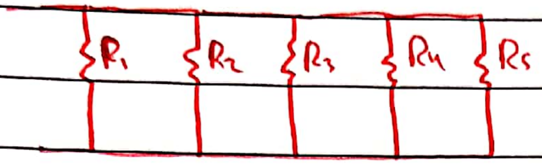


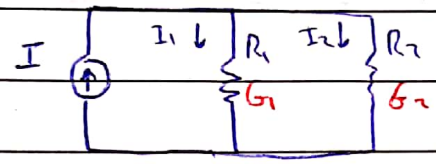
$$i_2 = 4 \cdot \frac{1}{1+4} = \frac{4}{5}\,A$$

$$i_2 = I\,\frac{R_1 // R_3}{R_1 // R_3 + R_2}$$



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

$$G_{eq} = G_1 + G_2 + G_3 + G_4 + G_5$$



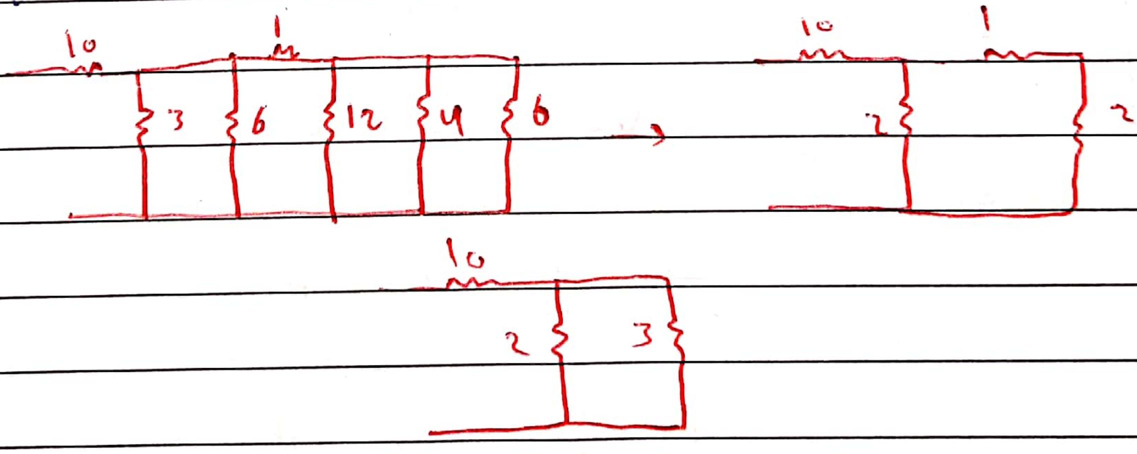
$$I_1 = \frac{R_2}{R_1+R_2}\,I \qquad I_1 = \frac{G_1}{G_1+G_2}\,I$$

$$I_2 = \frac{R_1}{R_1+R_2}\,I \qquad I_2 = \frac{G_2}{G_1+G_2}\,I$$

Example 2.9:

Practice Problem 2.9:

Example 2.10:



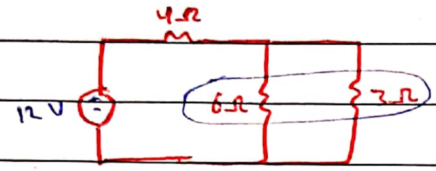
Practice ~~Example~~ Problem 2.10:

Example 2.11:

$S = \mho = \Omega^{-1} = mho$

Practice Problem 2.11:

Example 2.12:



$6\Omega \parallel 3\Omega = 2\Omega$

$V_o = 12 \frac{2}{2+4} = 4V$

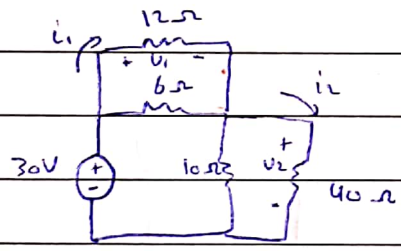
$i_o = \frac{4V}{3\Omega}$

$P_{3\Omega} = i_o * V_o = \frac{4}{3} * 4 = \frac{16}{3} W$

$= i_o^2 * R$

$= \frac{V_o^2}{R}$

Practice Problem 2.12:



$V_1 = 30 * \frac{4}{4+8} = 30 * \frac{4}{12} = 10V$

$V_2 = 30 - V_1 = 20V$

$i_1 = \frac{V_1}{12} = \frac{10}{12} = \frac{5}{6} A$

$i_2 = \frac{V_2}{40} = \frac{20}{40} = \frac{1}{2} A$

Example 2.13

Practice Problem

$R_{eq} = 6k$

$V_2 = 6k * 30m = 180V$

$V_1 = V_2 \frac{9k}{9k+3k}$

$= 180 * \frac{9}{12} = \boxed{135 V}$

$i_o = 30mA$

$i_1 = i_o \frac{18k}{27k} = 30m * \frac{6}{9} = 20mA$

$i_2 = i_o - i_1 = 30m - 20m = 10mA$

Five App

Chapter 3:

Voltage Nodes KCL → Nodal equations

Current Loops KVL → Mesh equations

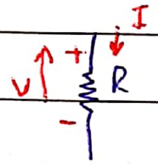
nodal analysis:

(a)

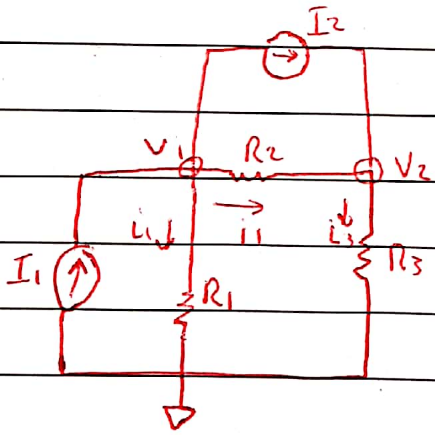
n = 3 → common Ref ground

→ (n-1) = 2 : Nodal voltages

Voltage rise



(1d)



KCL ① @ V_1: $I_1 - I_2 - i_1 - i_2 = 0$

$\therefore I_1 = I_2 + i_1 + i_2$

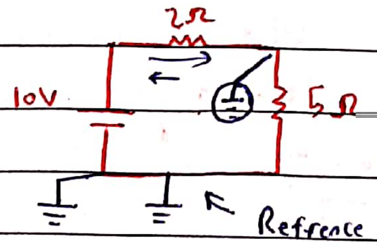
KCL ② @ V_2: $I_2 + i_2 - i_3 = 0$

$\therefore i_3 = I_2 + i_2$

$$I_1 = I_2 + \frac{V_1 - 0}{R_1} + \frac{V_1 - V_2}{R_2} = 0$$

$$I = \frac{V_2 - 0}{R_3} = I_2 + \frac{V_1 - V_2}{R_2} = 0$$

11/3/2020



Refrence

Zero potential

Earth

ground

Figure 3.2

KCl @ n1 : $I_1 - i_2 - i_1 = 0$

$I_n = out$

$I_1 = i_2 + i_1 + I_2$

KCl @ n2 : $I_2 + i_2 = i_3$

$i_1 = \frac{V_1 - 0}{R_1}$

$i_2 = \frac{V_1 - V_2}{R_2}$ Ohm's law

$i_3 = \frac{V_2 - 0}{R_3}$

(1) → $I_1 = \frac{V_1 - V_2}{R_2} + \frac{V_1}{R_1} + I_2$

$\left[\frac{1}{R_1} + \frac{1}{R_2}\right] V_1 + \left[-\frac{1}{R_2}\right] V_2 = I_1 - I_2$

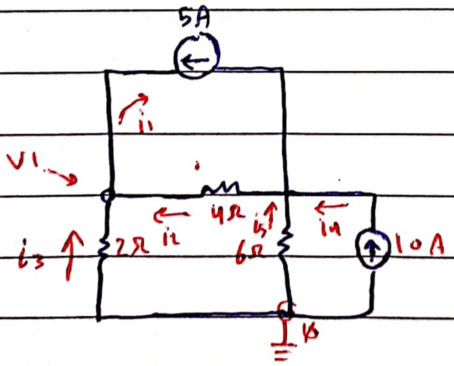
Matrix

(2) → $I_2 + \frac{V_1 - V_2}{R_2} = \frac{V_2}{R_3}$

$\left[\frac{1}{R_2}\right] V_1 + \left[-\frac{1}{R_2} - \frac{1}{R_3}\right] V_2 = -I_2$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_2} = -\frac{1}{R_2} \\ -\frac{1}{R_2} \quad +\frac{1}{R_2} \quad -\frac{1}{R_3} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 - I_2 \\ +I_2 \end{bmatrix}$$

Example 3.1 :



(1) KCl @ node 1: $i_2 + i_3 - i_1 = 0$ — (1)

Ohm's law

$i_1 = -5$

$i_2 = \frac{V_2 - V_1}{4} = \frac{20 - \frac{40}{3}}{4} = 1.6668A$

$i_5 = \frac{0 - V_2}{6}$

$i_3 = \frac{0 - V_1}{2}$

$i_3 = 10$

in (A) $\frac{V_2-V_1}{4} + \frac{-V_1}{2} - (-5) = 0$

$$\left[\left[\frac{-1}{4}-\frac{1}{2}\right]V_1 + \left[\frac{1}{4}\right]V_2 = -5\right] \times 4$$

$$-3V_1 + V_2 = -20 \quad \ldots (1)$$

KCL @ node (2) $i_1 + i_4 + i_5 - i_2 = 0$

$$-5 + 10 - \frac{V_2}{6} - \frac{(V_2-V_1)}{4} = 0$$

$$\left[\left[\frac{1}{4}\right]V_1 + \left[-\frac{1}{6}-\frac{1}{4}\right]V_2 = -5\right] \times 12$$

$$3V_1 + [-5]V_2 = -60$$

$$3V_1 - 5V_2 = -60 \quad \ldots (2)$$

let (1)+(2) $\rightarrow$ $-4V_2 = -80$

$$\boxed{V_2 = 20\ V}$$

In (1) $\rightarrow$ $\cancel{-60 + V_2 = -20}$

$$-3V_1 + 20 = -20 \rightarrow \boxed{V_1 = \frac{40}{3}}$$

* $\begin{bmatrix} -3 & 1 \\ 3 & -5 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} -20 \\ -60 \end{bmatrix}$

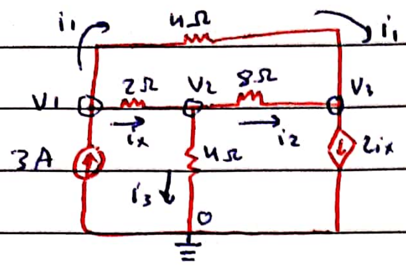
* $V_1 = \frac{\Delta_1}{\Delta} = \frac{160}{12} = \frac{40}{3}$ | $V_2 = \frac{\Delta_2}{\Delta} = \frac{240}{12} = 20$

$\Delta = \begin{vmatrix} -3 & 1 \\ 3 & -5 \end{vmatrix} = 15 - 3 = 12$ $\quad \Delta_1 = \begin{vmatrix} -20 & 1 \\ -60 & -5 \end{vmatrix} = 100 - (-60) = 160$

$\Delta_2 = \begin{vmatrix} -3 & -20 \\ 3 & -60 \end{vmatrix} = 180 - (-60)$

$= 240$

Example 3.2:



By ohm's law:

$$i_1 = \frac{V_1 - V_3}{4}$$

$$i_2 = \frac{V_2 - V_3}{8}$$

$$i_3 = \frac{V_2}{4}$$

$$i_x = \frac{V_1 - V_2}{2}$$

By KCl

@ n1: In = out

$$3 = i_1 + i_x$$

$$3 = \frac{V_1 - V_3}{4} + \frac{V_1 - V_2}{2}$$

$$4\times\left[\left[\frac{1}{4}+\frac{1}{2}\right]V_1 + \left[-\frac{1}{2}\right]V_2 + \left[-\frac{1}{4}\right]V_3 = 3 \right]$$

$$3V_1 - 2V_2 - 1V_3 = 12 \quad (1)$$

@ n2: In = out

$$i_x = i_3 + i_2$$

$$\frac{V_1 - V_2}{2} = \frac{V_2}{4} + \frac{V_2 - V_3}{8}$$

$$8\times\left[\left[\frac{1}{2}\right]V_1 + \left[-\frac{1}{2}-\frac{1}{4}-\frac{1}{8}\right]V_2 + \left[\frac{1}{8}\right]V_3 = 0 \right]$$

$$4V_1 - 7V_2 + V_3 = 0 \;---\; (2)$$

@ n3: In = out

$$i_1 + i_2 - 2i_x = 0$$

$$\frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} - \frac{2(V_1 - V_2)}{2} = 0$$

$$8\times\left[\left[\frac{1}{4}-1\right] + \left[\frac{1}{8}+1\right]V_2 + \left[-\frac{1}{4}-\frac{1}{8}\right]V_3 = 0 \right]$$

$$-\frac{6}{3}V_1 + \frac{9}{3}V_2 - \frac{3}{3}V_3 = 0$$

$$-2V_1 + 3V_2 - V_3 = 0$$

$$\underbrace{\begin{bmatrix}3 & -2 & -1\\ 4 & -7 & 1\\ -2 & 3 & -1\end{bmatrix}}_{A}\underbrace{\begin{bmatrix}v_1\\ v_2\\ v_3\end{bmatrix}}_{\vec{v}} \underset{=}{=} \underset{b}{\begin{bmatrix}12\\ 0\\ \end{bmatrix}}$$

$$\vec{V} = \mathrm{Inv}(A) * b$$

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