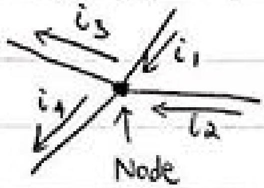
EE2005 Electronic Devices and Circuits

Review on Ch.1-3 (Part I)

Ch.1

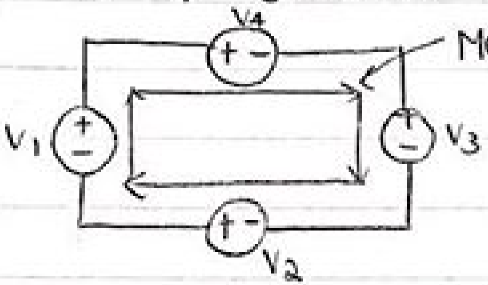
#cityueenotes @ig

- KCL $i_1 + i_2 = i_3 + i_4$



- Entering +ve
- Leaving -ve

- KVL $v_1 - v_4 - v_3 + v_2 = 0$ $\boxed{\text{OR}}$ $-v_1 + v_4 + v_3 - v_2 = 0$



- Rise: +ve → Generating Power
- Drop: -ve → Consuming Power

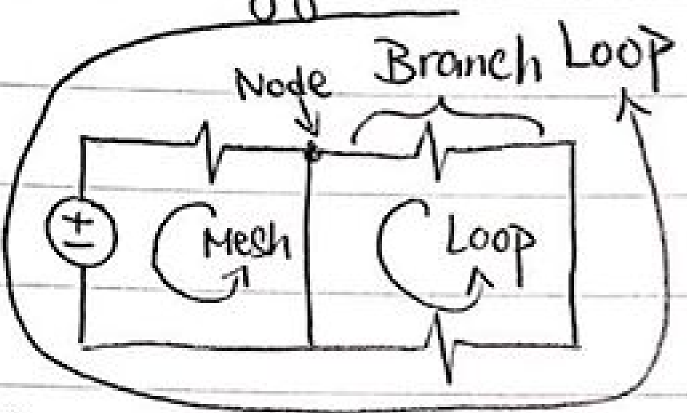
* Both sign and direction can be inter-changed. (I used to think in reverse)
Just keep your thought unchanged throughout calculation,
such that everything keeps in the same manner.

- Resistance (Ω)
- Ohm's Law $V = IR$
- Power $P = VI$
  - $P = I^2 R$
  - $P = \frac{V^2}{R}$

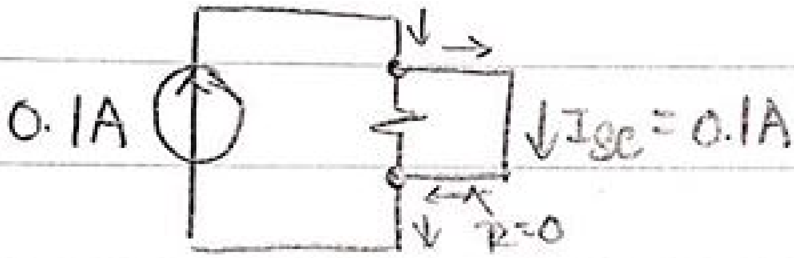
- Resistance (Ω)
- Ohm's Law $V = IR$
- Power $P = VI$
  - $P = I^2 R$
  - $P = \frac{V^2}{R}$

#cityueenotes@ig

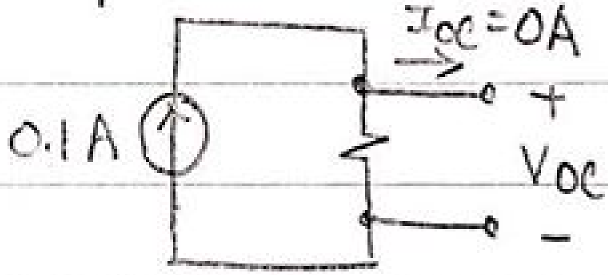
- Terminology



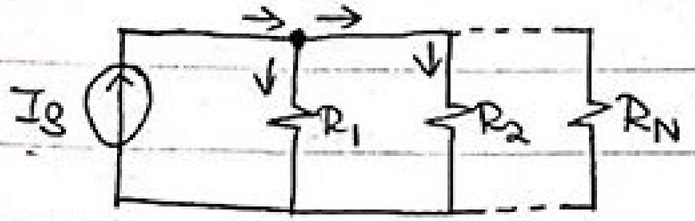
- Short Circuit



- Open Circuit



- Parallel Network → Current Divider



- Equivalent Resistance R_P

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

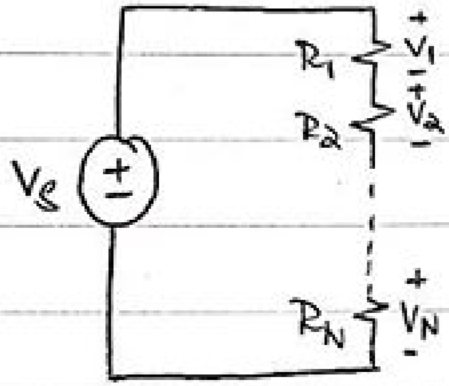
*Alternative Method:

except R_K.

- Current Divider Rule

$$I_K = \frac{R_P}{R_K} I_S = \frac{R_1 + R_2 + \cdots + R_{K-1} + R_{K+1} + \cdots + R_N}{R_P} I_S$$

- Series Network → Voltage Divider



#cityueenotes@ig

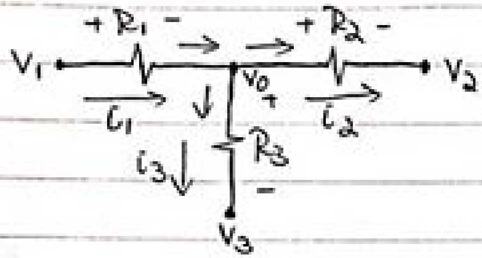
- Equivalent Resistance R_S

$$R_S = R_1 + R_2 + R_3 + \cdots + R_N$$

- Voltage Divider Rule

$$V_K = \frac{R_K}{R_S} V_S$$

• Nodal Voltage Analysis (NVA) ← KCL



$$\frac{V_1 - V_0}{R_1} = \frac{V_0 - V_2}{R_2} + \frac{V_0 - V_3}{R_3}$$

$$\downarrow \qquad \downarrow \qquad \downarrow$$

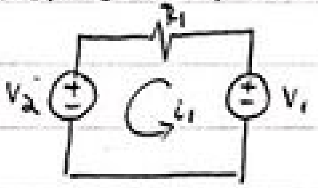
$$i_1 = i_2 + i_3$$

• For 2 nodes V_1 and V_2,

1. Apply KCL at V_1 – ①
2. Apply KCL at V_2 – ②
3. Solve equations ① and ②

citynee notes@ig

• Mesh Current Analysis (MCA) ← KVL



Resistor always +ve

$$-V_1 + i_1 R_1 + V_2 = 0$$

-ve go first so -ve

☆ Direction can be interchanged.
But all meshes need to be kept in the same direction.

• For 2 meshes i_1 and i_2,

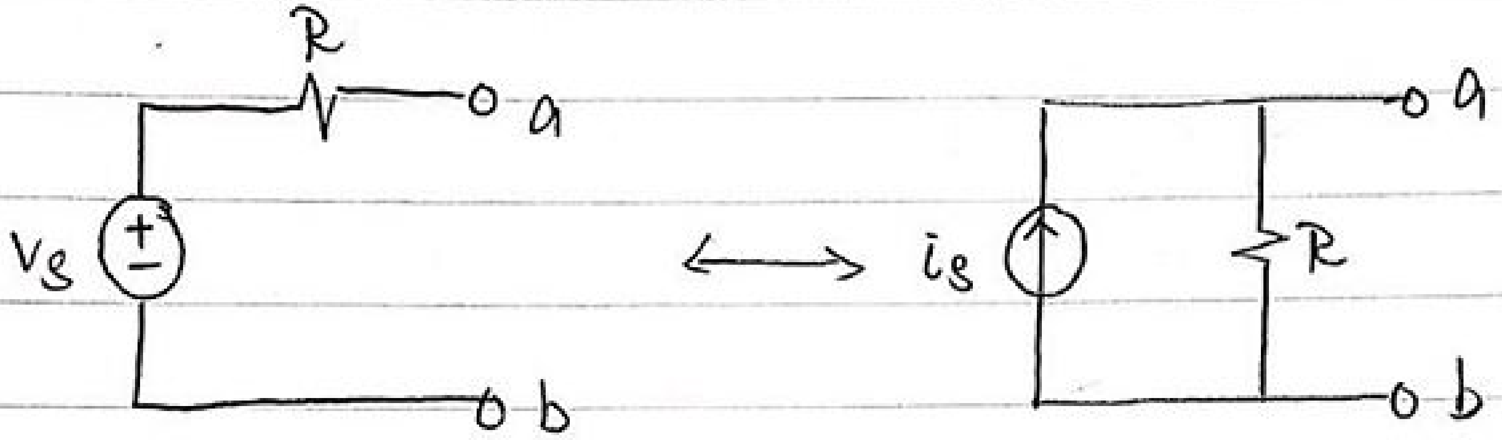
1. Apply KVL at mesh 1 – ① [if R_{12} in between, $+R_{12}(i_1 - i_2)$.]
2. Apply KVL at mesh 2 – ② [if R_{12} in between, $+R_{12}(i_2 - i_1)$.]
3. Solve equations ① and ②

- Superposition
  - Voltage Source → Short Circuit
  - Current Source → Open Circuit

- One port network #cityueenotes@ig
  - Thevenin equivalent circuit (Voltage)
    1. Remove the load.
    2. Find the equivalent resistance R_{Th}.
       a) Voltage Source → Short Circuit
       b) Current Source → Open Circuit
    3. Find the Thevenin voltage source V_{Th}.

  - Norton equivalent circuit (Current)
    1. Remove the load.
    2. Find the equivalent resistance R_N.
       a) Voltage Source → Short Circuit
       b) Current Source → Open Circuit
    3. Find the Norton current source I_N.

- Source Transformation



Voltage in series with R $\longleftrightarrow$ Current in parallel with R

- Maximum Power Transfer

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = 4I_N^2 R_N$$

$(R_{Load} = R_{Th} = R_N)$ #cityueenotes@ig

Ch.2

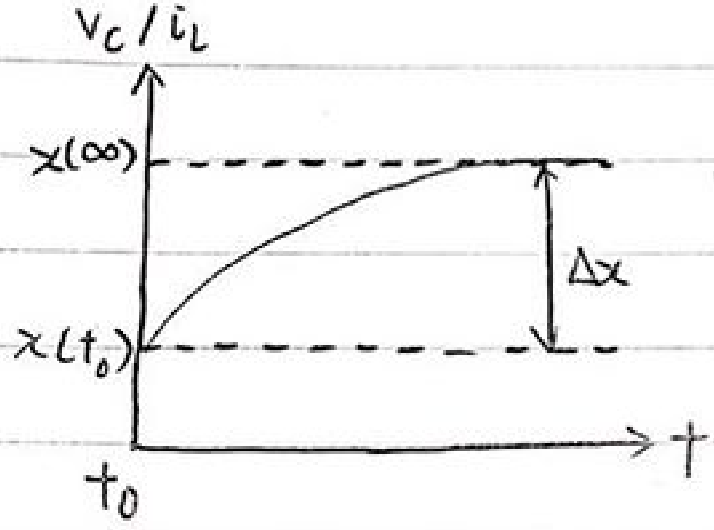
- Capacitors
- Inductors

} Please refer to Ch.3.(Part2)

- Transient

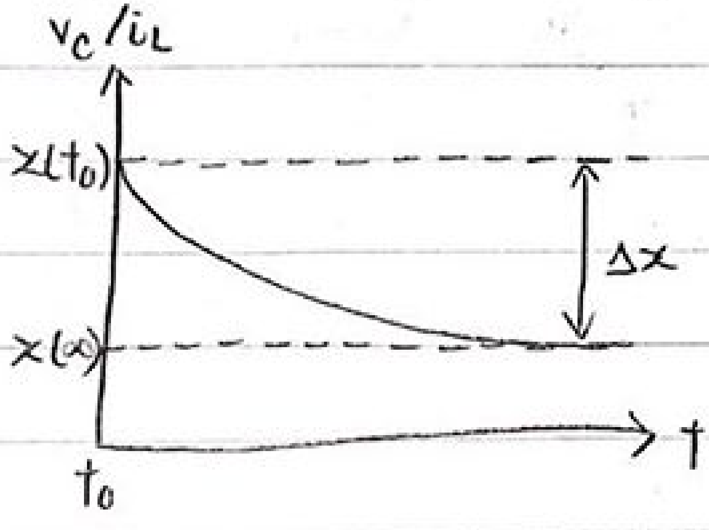
#cityueenotes@ig

  - Time constant
    - RC circuit $\tau = CR$
    - RL circuit $\tau = \frac{L}{R}$
  - First order expression (suggest to use <u>case B</u> only.)



Case A

$x(t) = x(t_0) + \Delta x (1 - e^{(-t-t_0)/\tau})$



Case B

$x(t) = x(\infty) + \Delta x e^{(-t-t_0)/\tau}$

EE2005 Electronic Devices and Circuits

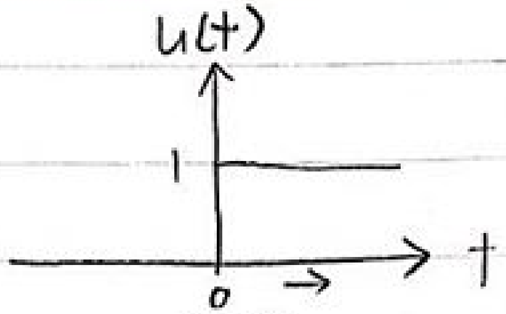
Review on Ch.1-3 (Part 2)

Ch.2 (Cont.)

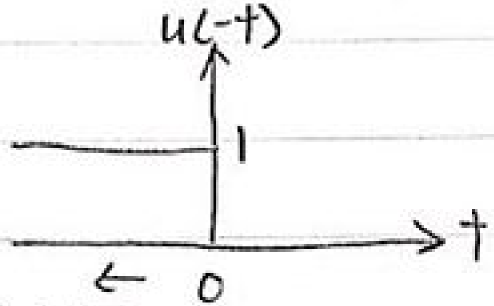
(Sth. not taught in lecture but must know)

!! • Unit-step function

$$u(t) = \begin{cases} 1 & n \geq 0 \\ 0 & n < 0 \end{cases}$$



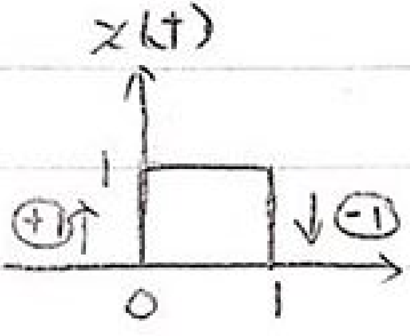
$$u(-t) = \begin{cases} 1 & n \leq 0 \\ 0 & n > 0 \end{cases}$$



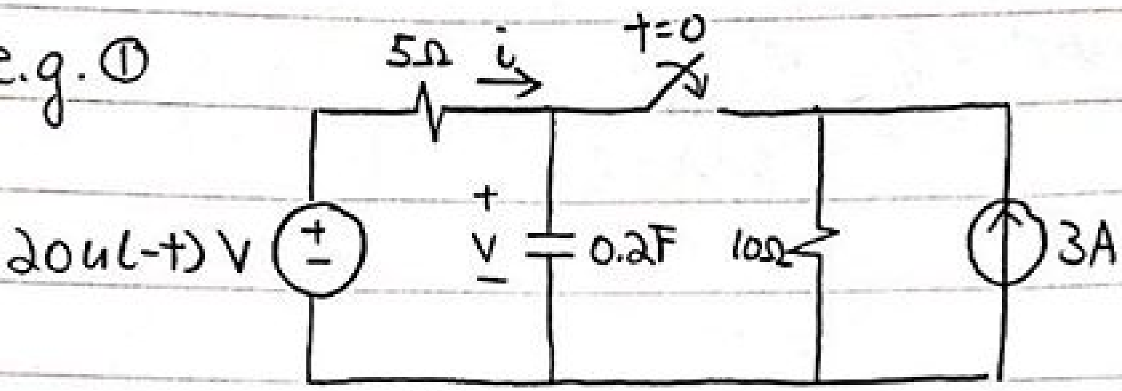
$t=0$ $t-1=0 \rightarrow t=1$

e.g. $x(t) = u(t) - u(t-1)$

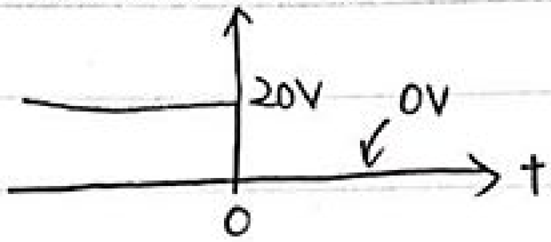
// cityueenotes@ig



e.g. ①



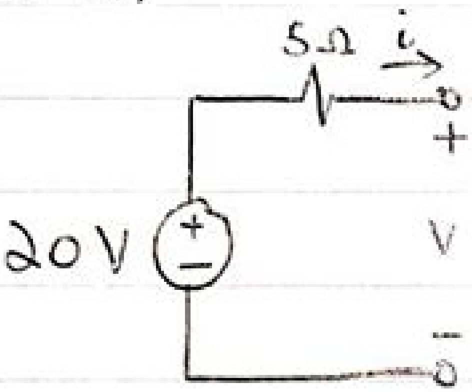
Unit Step Function 20u(-t)



$$20u(-t) = \begin{cases} 20 & t \le 0 \\ 0 & t > 0 \end{cases}$$

For $t<0$,

#cityueenotes@ig

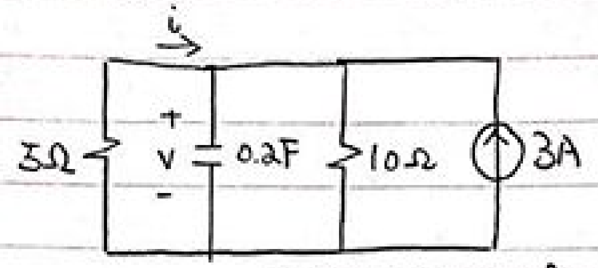


$i(t) = 0A$

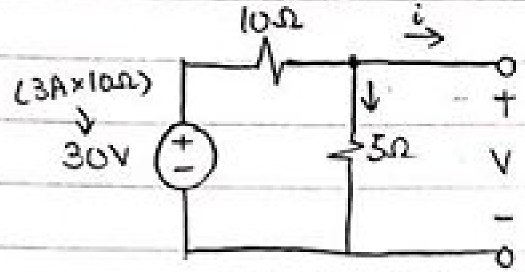
$v(t) = 20V.$

e.g. ① (Cont.)

For $t>0$,



⇓ Source Transformation



$v(0) = 20V$

Voltage Divider

$v(\infty) = 30 \times \frac{5}{10+5}$

$= 10V$

#cityueenotes@ig

$\tau = R_{Th}C$

$= (10\Omega \parallel 5\Omega)(0.2)$

$= \frac{2}{3}s$

$v(t) = v(\infty) + [v(0) - v(\infty)]e^{-t/\tau}$

$= 10 + (20-10)e^{-t(\frac{3}{2})}$

$= 10 + 10e^{-1.5t}$

$= 10(1+e^{-1.5t})\ V$

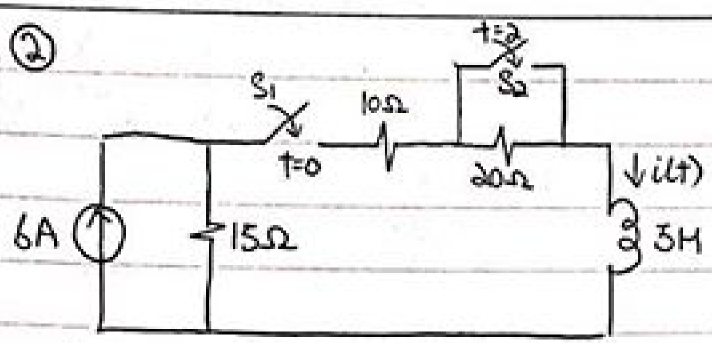
$i(t) = \frac{-v(t)}{3\Omega}$ Note that v and i go in different direction.

$= -2(1+e^{-1.5t})\ A$

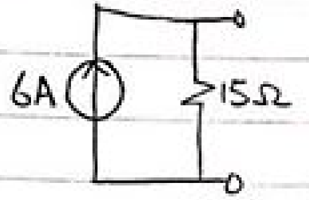
$\therefore v(t) = \begin{cases} 20 & t<0 \\ 10(1+e^{-1.5t}) & t>0 \end{cases}$

$i(t) = \begin{cases} 0 & t<0 \\ -2(1+e^{-1.5t}) & t>0 \end{cases}$

e.g. ②



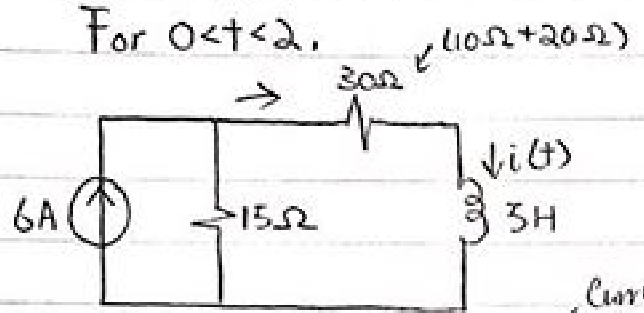
For t<0,



↓i(t) ?!

$i(t) = 0\,A$

For 0<t<2,



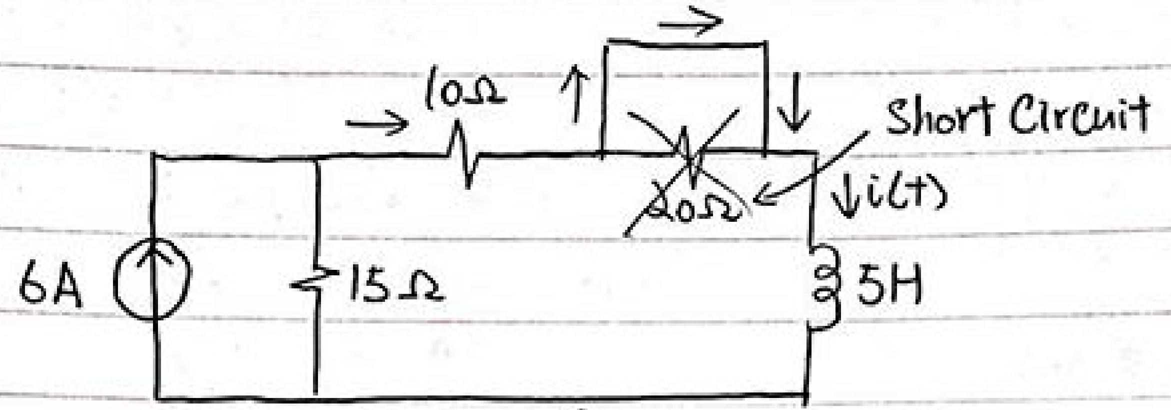
#cityqueenotes @ig

Current Divider

$$i(\infty) = 6 \times \frac{15}{15+10+20}$$
$$= 2A$$
$$\tau = \frac{L}{R_{Th}}$$
$$= \frac{5}{15+10+20}$$
$$= \frac{5}{45}$$
$$= \frac{1}{9}s$$
$$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$$
$$= 2 + (0-2)e^{-9t}$$
$$= 2 - 2e^{-9t}$$
$$= 2(1-e^{-9t})\,A$$
$$\therefore i(1) = 2(1-e^{-9(1)})$$
$$= 1.9998\,A$$

e.g. 2 (Cont.)

For $t>2$,



$$i(\infty) = 6 \times \frac{15}{15+10} \leftarrow \text{Current Divider}$$

$$= 3.6A$$

$$\tau = \frac{L}{R_{Th}}$$

#cityueenotes@ig

$$= \frac{5}{15+10}$$

$$= 0.2s$$

Starting from 2

$$i(t) = i(\infty) + [i(2) - i(\infty)]\, e^{-(t-2)/\tau}$$

$$= 3.6 + (2 - 3.6)e^{-5(t-2)}$$

$$= 3.6 - 1.6e^{-5(t-2)} \text{ A}$$

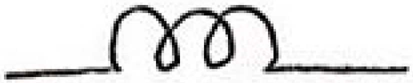
$$\therefore i(3) = 3.6 - 1.6e^{-5(3-2)}$$

$$= 3.5892 \text{ A}$$

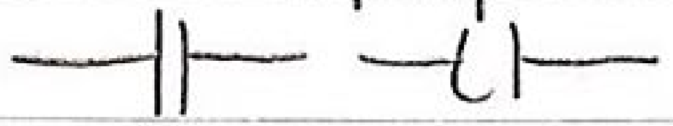
$$\therefore i(t) = \begin{cases} 0 & t<0 \\ 2(1-e^{-9t}) & 0<t<2 \\ 3.6-1.6e^{-5(t-2)} & t>2 \end{cases}$$

Ch.3 #cityueenotes@ig

- AC Circuit ($V = IZ$)
  - Impedance Z/X (Ω)
    - Resistor 

      $Z_R = R \leftarrow (\Omega)$
    - Inductor 

      $Z_L = j\omega L \leftarrow (H)$

      → Short Circuit in Superposition
    - Capacitor 

      $Z_C = \frac{1}{j\omega C} \leftarrow (F)$

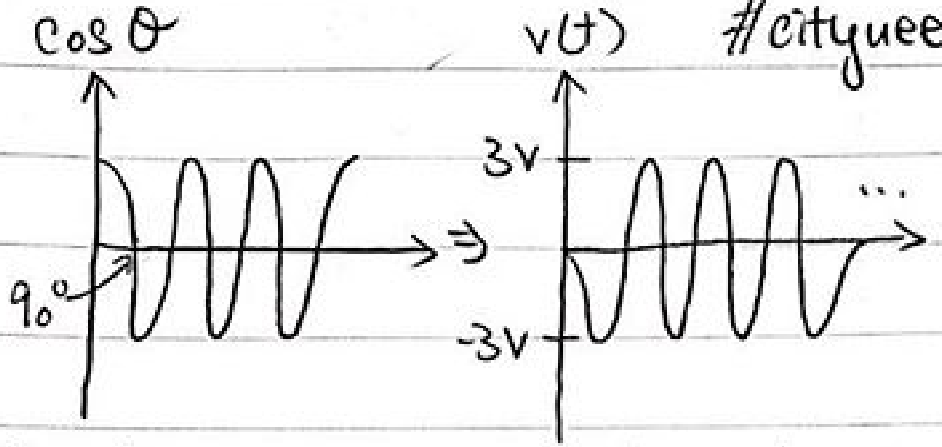
      → Open Circuit in Superposition

- Sinusoid
  - Reading AC values.

$v(t) = 3\cos(6t + 90^\circ)$ → angular frequency ω

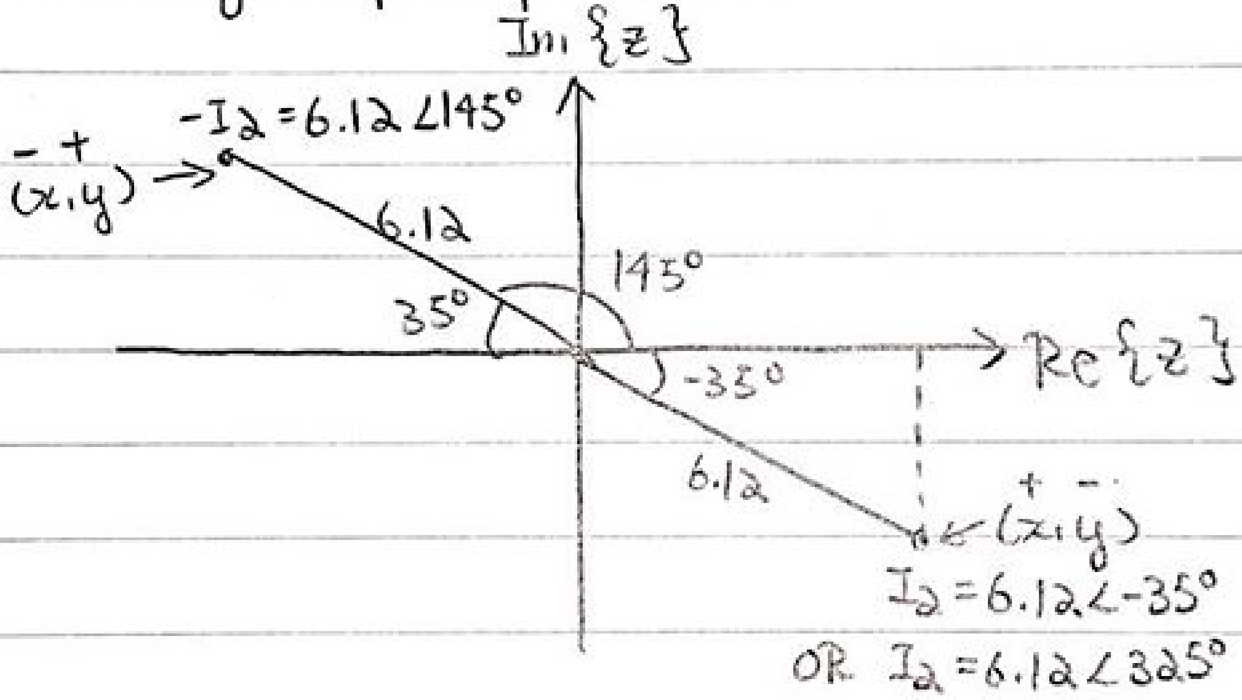
$= 3\angle 90^\circ$

amplitude   shifted angle



#cityueenotes@ig

- Reading complex polar coordinates



- AC Circuit Analysis
  - KVL
  - KCL
  - Voltage Divider Rule
  - Current Divider Rule
  - Nodal Voltage Analysis
  - Mesh Current Analysis

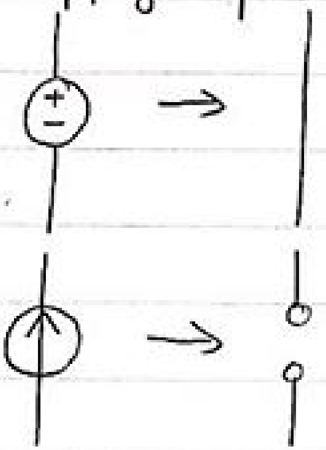
Please refer to Ch.1.(Part 1)

#cityueenotes@ig

- Superposition (apply respectively for DC/AC in different ω source)

Voltage Source → Short Circuit

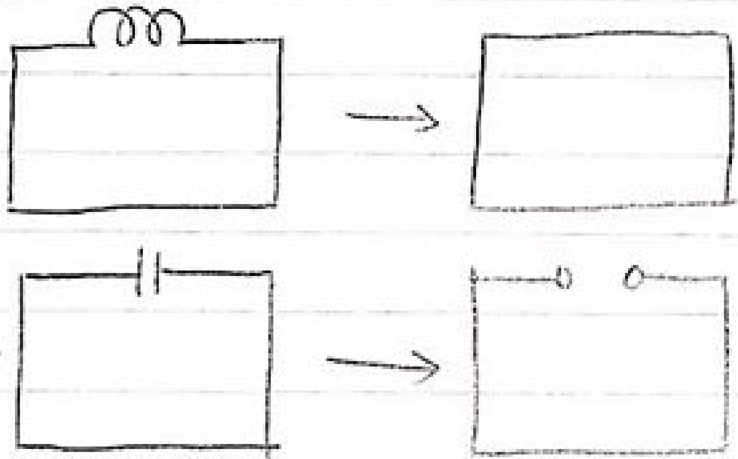
Current Source → Open Circuit



- DC Source:

Inductor → Short Circuit

Capacitor → Open Circuit



- Average power / current / voltage = DC offset
  (Note that average of $\sin\theta$ and $\cos\theta$ must be 0.)

! Use $\boxed{\text{Calculator}}$ to do ALL calculations.

- COMPLEX Mode : $\boxed{\text{MODE}}$ + $\boxed{2}$ (all keys in PURPLE)
- Phasor $\boxed{\angle}$: $\boxed{\text{SHIFT}}$ + $\boxed{(-)}$
- Imaginary j = $\boxed{i}$: $\boxed{\text{ENG}}$ #cityueenotes@ig
- Degree : $\boxed{\text{SHIFT}}$ + $\boxed{\text{MODE}}$ + $\boxed{1}$
- Radians: $\boxed{\text{SHIFT}}$ + $\boxed{\text{MODE}}$ + $\boxed{2}$
- Cartesian Form → Phasor Form : $\boxed{\text{SHIFT}}$ + $\boxed{+}$
- Phasor Form → Cartesian Form : $\boxed{\text{SHIFT}}$ + $\boxed{-}$
- Displaying Re ↔ Im / Magnitude ↔ Phasor : $\boxed{\text{SHIFT}}$ + $\boxed{\text{EXE}}$