Formulae in Circuit Theory

1. *Chapter 1*

$$i(t) = \frac{dq(t)}{dt},$$

i: the current in amperes (A),
q: the charges in coulombs (C),
t: the time in seconds **(s).**

$$v(t) = \frac{dw(t)}{dq}$$

v: the voltage in volts (V),
w: the energy in joules (J),
q: the charge in coulombs(C).

$$p(t) = \frac{dw(t)}{dt}$$

p: the power in watts (W),
w: the energy in joules (J),
t: the time in seconds **(s).**

$$p(t) = \frac{dw}{dt} = \left(\frac{dw}{dq}\right)\left(\frac{dq}{dt}\right) = v(t)i(t),$$

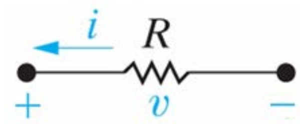
p: the power in watts (W),
v: the voltage in volts (V),
i: the current in amperes(A).

2. *Chapter 2*

Ohm's Law

$$v = iR$$

$$\boldsymbol{p = vi = \frac{v^2}{R} = i^2 R}$$



$$v = -iR$$

$$\boldsymbol{p = -vi = \frac{v^2}{R} = i^2 R}$$

Kirchhoff's Current Law (KCL)

$$\sum_{at\ any\ node} i = 0$$

$$or \sum i_{leaving} - \sum i_{entering} = 0\ at\ any\ nodes$$

$$or \sum i_{leaving} = \sum i_{entering}\ \ at\ any\ nodes$$

Kirchhoff's Voltage Law (KVL)

$$\sum_{along\ any\ closed\ loop} v = 0$$

$$or \sum v_{drop} - \sum v_{rise} = 0\ \ along\ any\ closed\ loops$$

$$or \sum v_{drop} = \sum v_{rise}\ \ along\ any\ closed\ loops$$

3. Chapter 3

n resistors in series connection

$$R_{eq} = R_1 + R_2 + \cdots + R_{n-1} + R_n$$

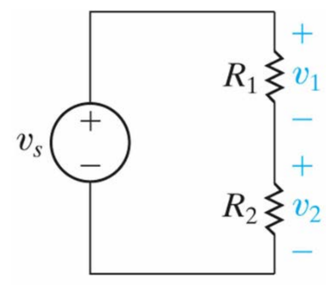
n resistors in parallel connection

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_{n-1}} + \frac{1}{R_n}$$

Voltage divider circuits

$$v_1 = R_1 i = \frac{R_1}{R_1+R_2} v_s$$

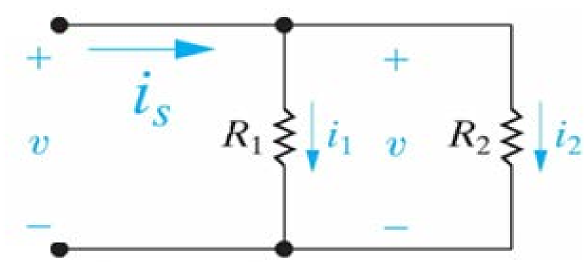
$$v_2 = R_2 i = \frac{R_2}{R_1+R_2} v_s$$



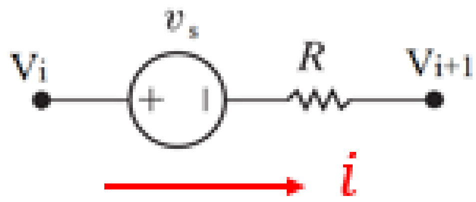
Current divider circuits

$$i_1 = \frac{v}{R_1} = \frac{R_2}{R_1+R_2} i_s$$

$$i_2 = \frac{v}{R_2} = \frac{R_1}{R_1+R_2} i_s$$

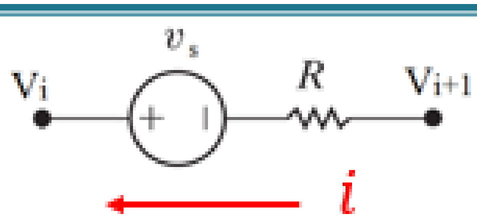


4. Chapter 4



In general, the current in the above branch can be found as

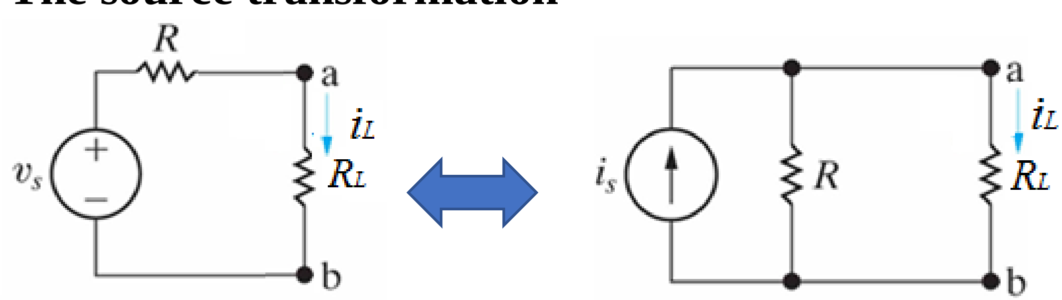
$$i = \frac{V_i - v_s - V_{i+1}}{R}$$



In general, the current in the above branch can be found as

$$i = \frac{V_{i+1} + v_s - V_i}{R}$$

The source transformation



$$v_s = Ri_s \qquad R_v = R_i$$

5. Chapter 5

For an ideal op-amp

$$v_p = v_n, \quad i_p = i_n = 0 \quad CMRR = \left|\frac{A_{dm}}{A_{cm}}\right|$$

6. Chapter 6

Inductors

$v = L\frac{di}{dt}$	(V)
$i = \frac{1}{L}\int_{t_0}^{t} v\,d\tau + i(t_0)$	(A)
$p = vi = Li\frac{di}{dt}$	(W)
$w = \frac{1}{2}Li^2$	(J)

Series-Connected

$$L_{eq} = L_1 + L_2 + \cdots + L_n$$

Parallel-Connected

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}$$

$$i(t_0) = i_1(t_0) + i_2(t_0) + \cdots + i_n(t_0)$$

Capacitors

$$v = \frac{1}{C}\int_{t_0}^{t} i \, d\tau + v(t_0) \qquad \text{(V)}$$

$$i = C\frac{dv}{dt} \qquad \text{(A)}$$

$$p = vi = Cv\frac{dv}{dt} \qquad \text{(W)}$$

$$w = \frac{1}{2}Cv^2 \qquad \text{(J)}$$

Series-Connected

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

$$v(t_0) = v_1(t_0) + v_2(t_0) + \cdots + v_n(t_0)$$

Parallel-Connected

$$C_{eq} = C_1 + C_2 + \cdots + C_n$$

7. Chapter 12

Table 1, 2 and 3. These tables will be given in quizzes and the final exam.

8. Chapter 13

If the source of the circuit is $x(t) = A\cos(\omega t + \phi)$, the steady-state response to the source is $y_{ss}(t)$, the transfer function is $H(s) = \frac{Y_{ss}(s)}{X(s)}$, then

$$y_{ss}(t) = A|H(j\omega)|\cos[\omega t + \phi + \theta(\omega)]$$

where $H(j\omega)$ is the transfer function, $H(s) = \frac{Y_{ss}(s)}{X(s)}$, of the circuit when $s = j\omega$. $H(j\omega) = |H(j\omega)|e^{j\theta(\omega)}$, where $|H(j\omega)|$ *and* $\theta(\omega) = \angle H(j\omega)$ is the magnitude and phase anlge of H(jω), respectively.