UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	ELECTRICAL PRINCIPLES I
COURSE CODE	:	BNR 10203
PROGRAMME	:	1BND
EXAMINATION DATE	:	DECEMBER 2014 / JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TWENTY TWO (22)** PAGES

Q1 (a) (i) Define current and charge?

(3 marks)

(ii) Calculate the current flows when a charge of 2 C passes through a given point each second.

(1 mark)

(iii) Determine the total charge entering a terminal between t = 1 s and t = 2 s if the current passing the terminal is $i = (3t^2 - t)$ A.

(2 marks)

(iv) A current of 3.2A flows through a conductor. Calculate how much charge passes through any cross-section of the conductor in 20 s.

(2 marks)

(b) If the current flowing through an element is given by

$$i(t) = \begin{cases} 3t\text{A}, & 0 \le t < 6 \text{ s} \\ 18\text{A}, & 6 \le t < 10 \text{ s} \\ -12\text{A}, & 10 \le t < 15 \text{ s} \\ 0, & t \ge 15 \text{ s.} \end{cases}$$

Plot the charge stored in the element over $0 < t < 20$ s.

(8 marks)

(c) Compute the power absorbed or supplied by each component of the circuit in Figure 1(c).

(4 marks)

Q2 (a) Compute the current I_A, I_B, I_C and I_D in Figure **Q2(a)**.

(4 marks)

(b) The light bulb in Figure Q2(b) is rated 120 V, 0.75 A. Calculate V_s to make the light bulb operate at the rated conditions.

(6 marks)

(c) Compute the equivalent resistance for the circuit in Figure **Q2(c)** by using *delta* network to *wye* network transformation and use it to find current i.

(10 marks)

Q3 (a) Calculate the node voltages in the circuit of Figure **Q3(a)**.

(12 marks)

(b) By inspection, compute the mesh-current equations for the circuit in Figure **Q3(b)**.

(8 marks)

Q4 (a) Using superposition theorem, compute V_o in the circuit of Figure **Q4(a)**.

(6 marks)

(b) Determine v_x in the circuit of Figure **Q4(b)** using source transformation.

(7 marks)

(c) Calculate the Norton equivalent at terminals *a-b* of the circuit in Figure **Q4(c)**.

(7 marks)

Q5 (a) The voltage across a 4 μF capacitor is shown in Figure **Q5(a)**. Compute the current waveform.

(5 marks)

(b) Compute C_{eq} in the circuit of Figure **Q5(b)** if all capacitors are 4 μF.

(5 marks)

(c) If the voltage waveform in Figure **Q5(c)** is applied to a 50-mH inductor, compute the inductor current $i(t)$. Assume $i(0) = 0$.

(6 marks)

(d) Compute the equivalent inductance looking into the terminals of the circuit in Figure **Q5(d)**.

(4 marks)

Q6 (a) In the circuit shown in Figure **Q6(a)**.

$$v(t) = 56e^{-200t}\text{V}, \quad t > 0$$

$$i(t) = 8e^{-200t}\text{mA}, \quad t > 0$$

(i) Determine the values of R and C.

(ii) Compute the time constant τ.

(iii) Determine the time required for the voltage to decay half of its initial value at $t = 0$.

(5 marks)

(b) For the circuit in Figure **Q6(b)**, calculate i_o for $t > 0$.

(6 marks)

(c) Express the signals in Figure **Q6(c)** in terms of step functions.

(3 marks)

(d) Calculate v_o in the circuit of Figure **Q6(d)** when $v_s = 6u(t)$. Assume that $v_o(0) = 1V$.

(6 marks)

- END OF QUESTION –

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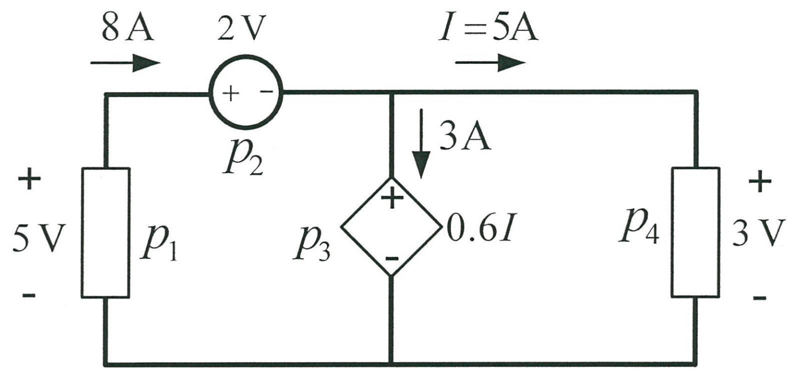

FIGURE Q1(c)

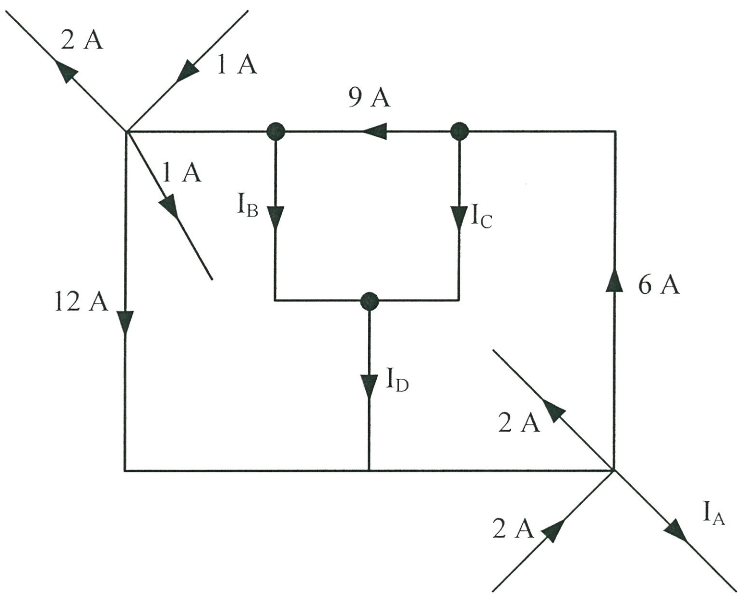

FIGURE Q2(a)

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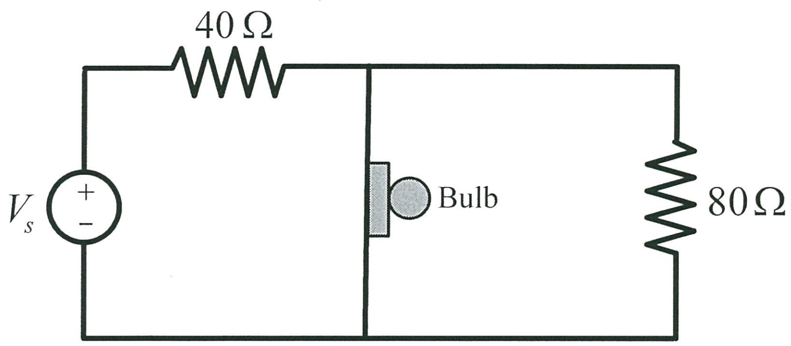

FIGURE Q2(b)

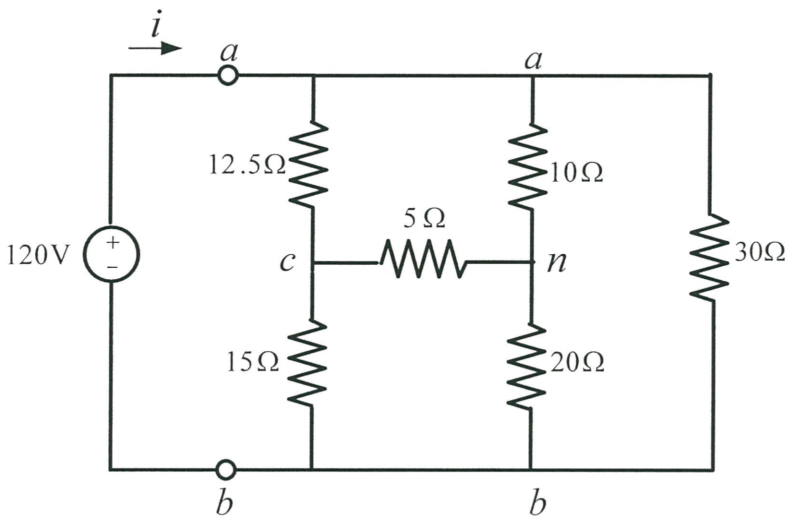

FIGURE Q2(c)

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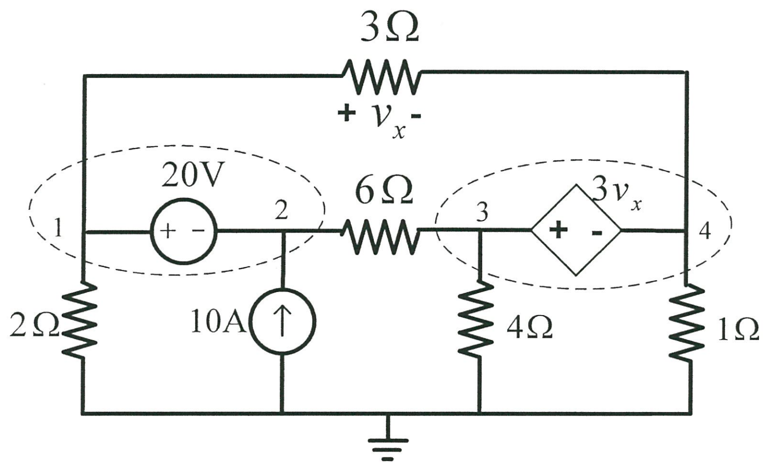

FIGURE Q3(a)

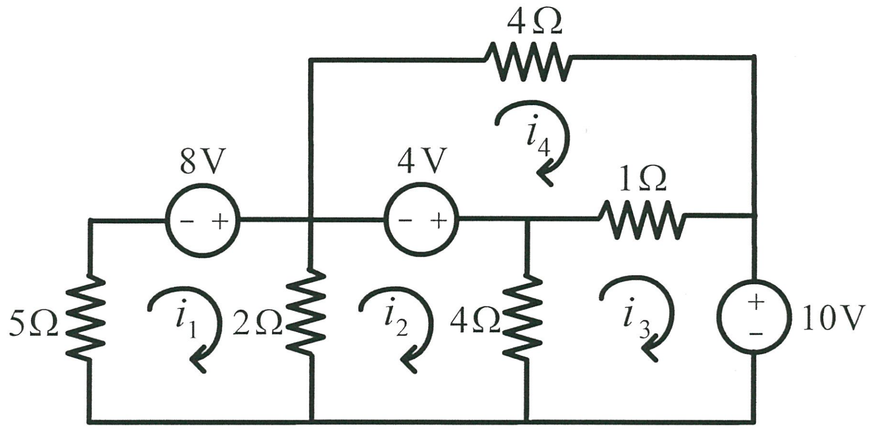

FIGURE Q3(b)

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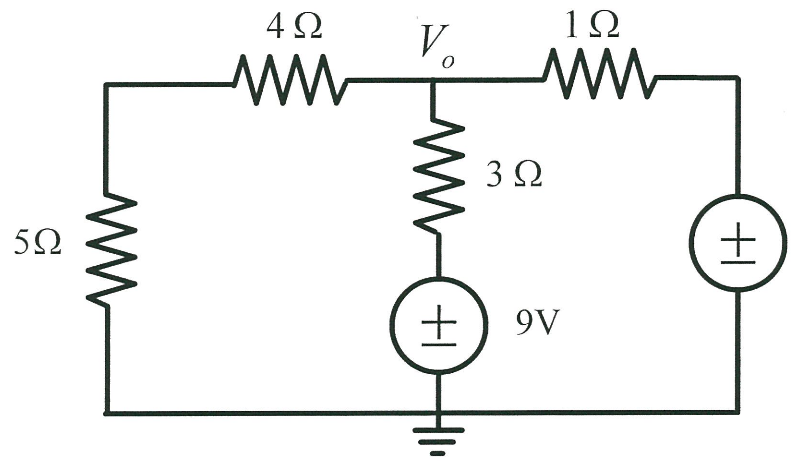

FIGURE Q4(a)

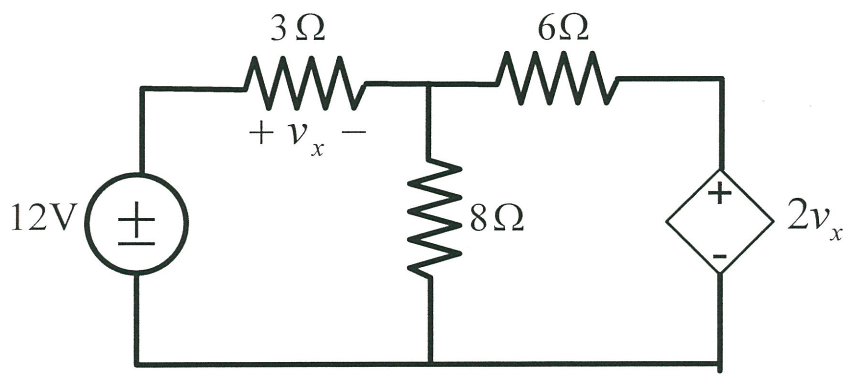

FIGURE Q4(b)

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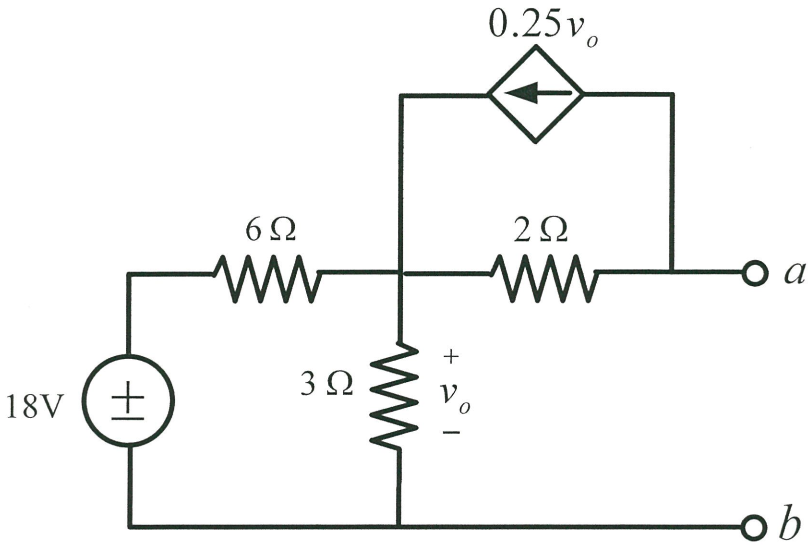

FIGURE Q4(c)

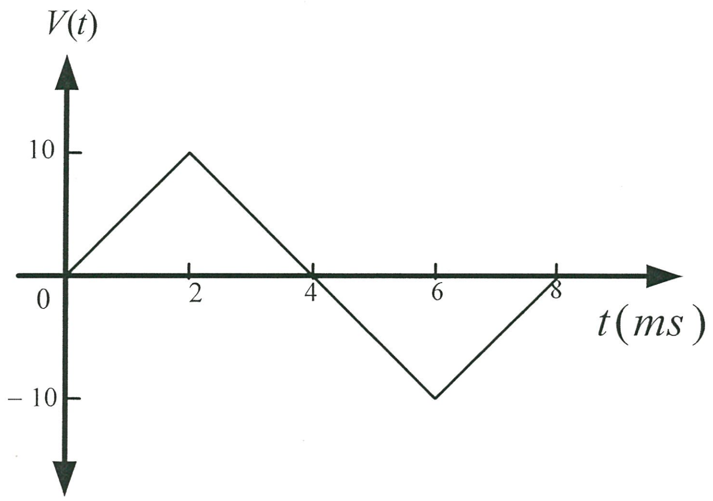

FIGURE Q5(a)

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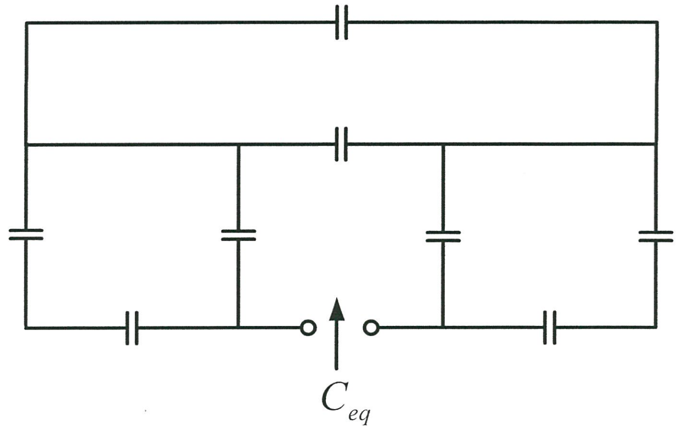

FIGURE Q5(b)

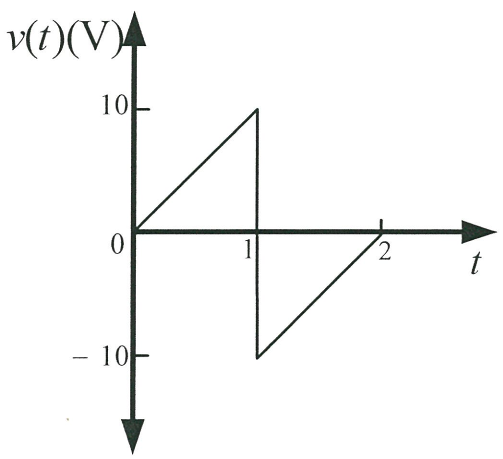

FIGURE Q5(c)

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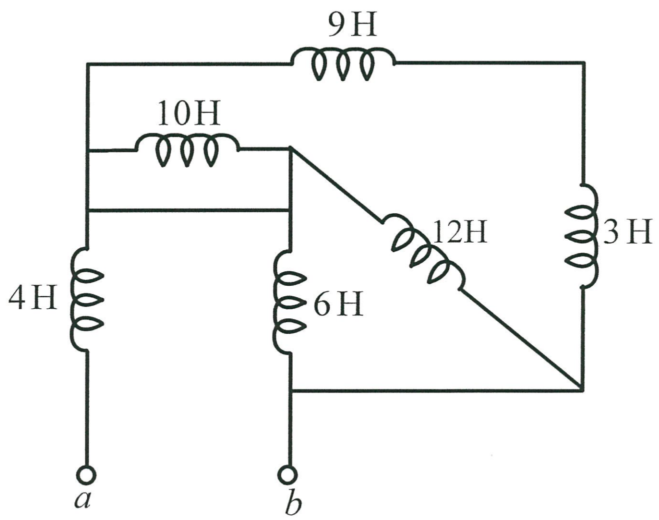

FIGURE Q5(d)

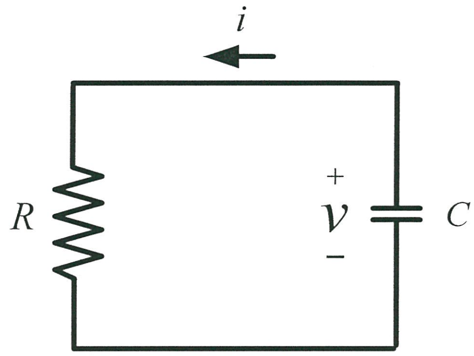

FIGURE Q6(a)

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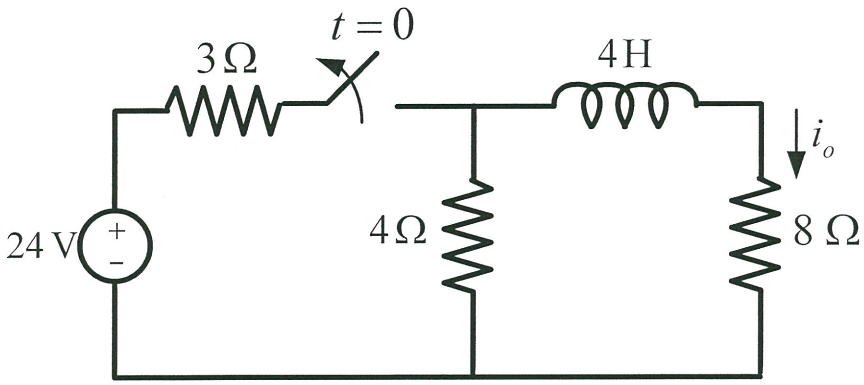

FIGURE Q6(b)

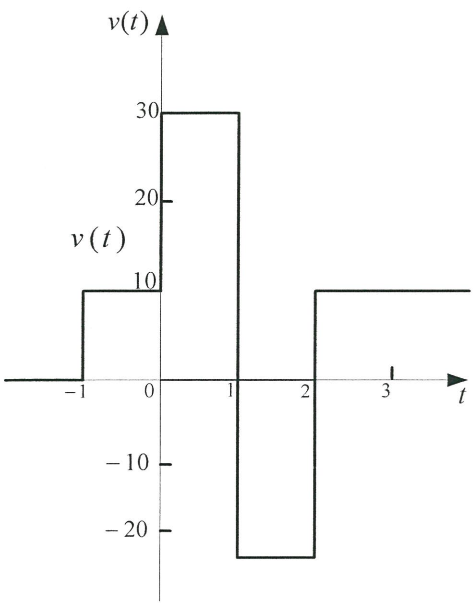

FIGURE Q6(c)

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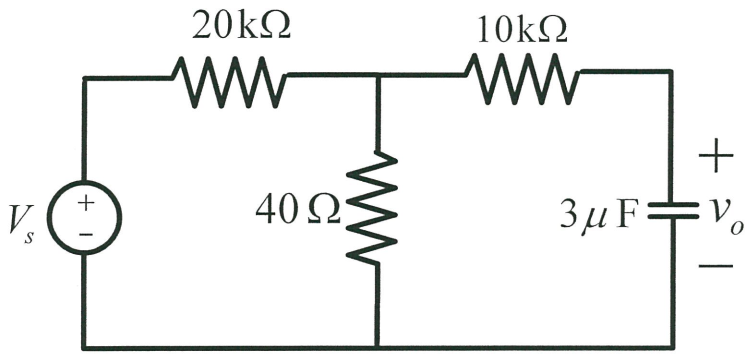

FIGURE Q6(d)

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FORMULAS

The voltage division principle for two resistors in series is

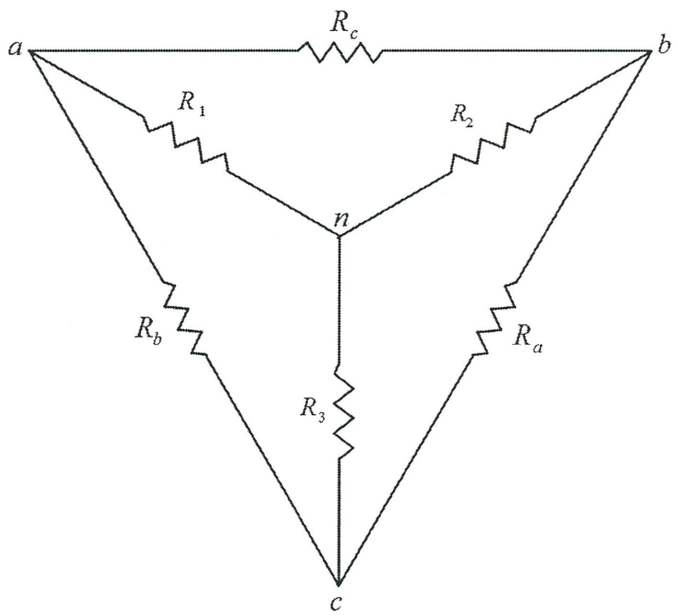
$$v_1 = \frac{R_1}{R_1 + R_2} v$$

$$v_2 = \frac{R_2}{R_1 + R_2} v$$

The current division principle for two resistors in parallel is

$$i_1 = \frac{R_2}{R_1 + R_2} i$$

$$i_2 = \frac{R_1}{R_1 + R_2} i$$



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Delta to Wye-Conversion

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

Wye to Delta Conversion

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

$$R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

The number of branches b, the number of nodes n, and the number of independent loops l ina network are related as

$b = l + n - 1$

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The power delivered to the load is:

$$P = i^2 R_L = \left(\frac{V_{Th}}{R_{Th} + R_L} \right)^2 R_L$$

For maximum power dissipated in R_L, P_{max}, for a given R_{TH}, and V_{TH},

$$R_L = R_{TH} \quad \Rightarrow \quad P_{max} = \frac{{V_{Th}}^2}{4R_L}$$

CAPACITORS

The current-voltage relationship of capacitor according to above convention is

$$i = C \frac{dv}{dt}$$

$$v = \frac{1}{C} \int_{t_0}^{t} i \, dt + v(t_0)$$

The energy, *w*, stored in the capacitor is

$$w = \frac{1}{2} C v^2$$

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INDUCTORS

The current-voltage relationship of an inductor:

$$i = \frac{1}{L}\int_{t_0}^{t} v(t)\,dt + i(t_0)$$

The energy, *w*, stored by an inductor:

$$w = \frac{1}{2} L i^2$$

Current and voltage relationship for R, L, C

Circuit element	Units	Voltage	Current	Power
 Resistance	ohms (Ω)	$v = Ri$ (Ohm's law)	$i = \frac{v}{R}$	$p = vi = i^2R$
 Inductance	henries (H)	$v = L\frac{di}{dt}$	$i = \frac{1}{L}\int v\,dt + k_1$	$p = vi = Li\frac{di}{dt}$
 Capacitance	farads (F)	$v = \frac{1}{C}\int i\,dt + k_2$	$i = C\frac{dv}{dt}$	$p = vi = Cv\frac{dv}{dt}$

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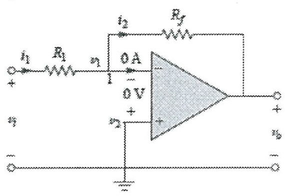
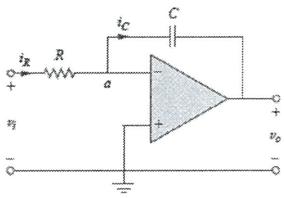
Important characteristics of the basic elements.

Relation	**Resistor (*R*)**	**Capacitor (*C*)**	**Inductor (*L*)**
v-i:	$v = iR$	$v = \frac{1}{C}\int_{t_o}^{t} i dt + v(t_o)$	$v = L\frac{di}{dt}$
i-v:	$i = \frac{v}{R}$	$i = C\frac{dv}{dt}$	$i = \frac{1}{L}\int_{t_o}^{t} v dt + i(t_o)$
p or w	$p = i^2 R = \frac{v^2}{R}$	$w = \frac{1}{2}Cv^2$	$w = \frac{1}{2}Li^2$
Series	$R_{eq} = R_1 + R_2$	$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$	$L_{eq} = L_1 + L_2$
Parallel	$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$	$C_{eq} = C_1 + C_2$	$L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$
At dc:	**Same**	**Open circuit**	**Short circuit**
Circuit variable that cannot change abruptly:	**Not applicable**	*v*	*i*

An op amp integrator



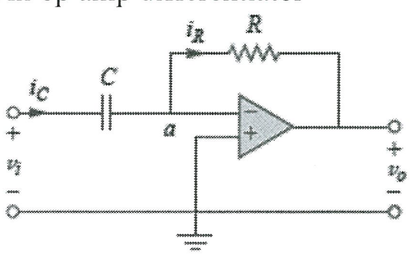
(a)



(b)

$$v_o = -\frac{1}{RC}\int_0^t v_i(t)\, dt$$

An op amp differentiator



$$v_o = -RC\frac{dv_i}{dt}$$

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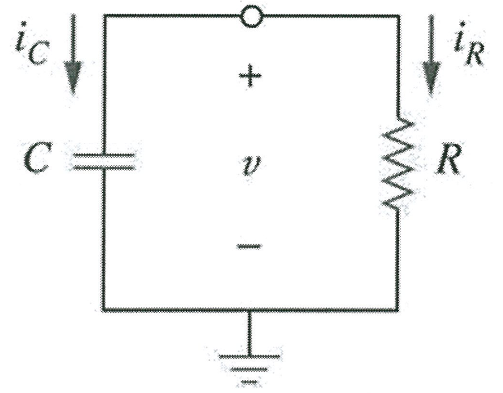
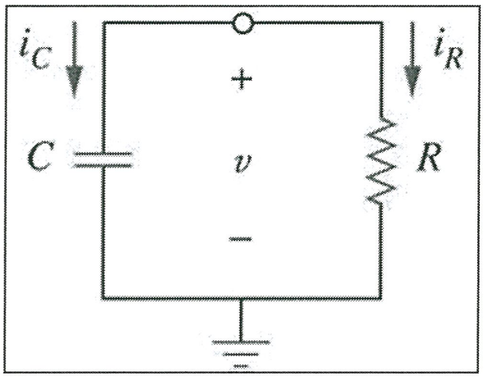
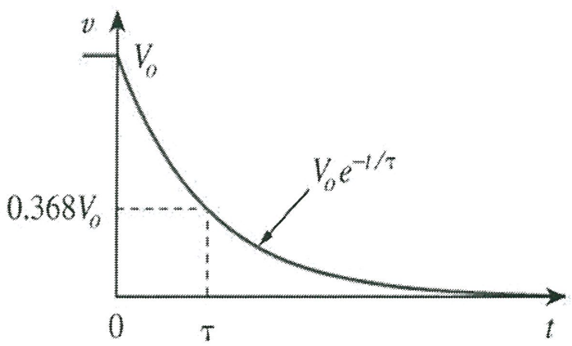


KCL=> $i_R + i_C = 0 \rightarrow \frac{v}{R} + C\frac{dv}{dt} = 0$

A RC source-free circuit

$v(t) = V_0\, e^{-t/\tau} \rightarrow \tau = R\,C$





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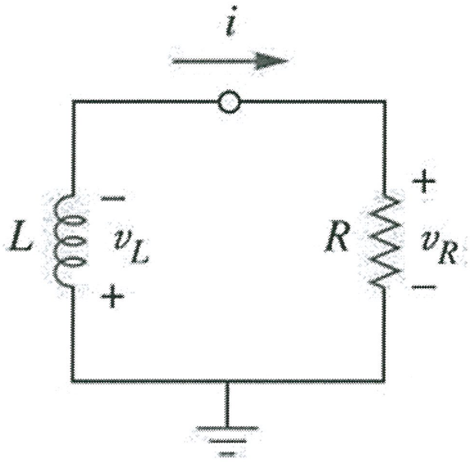
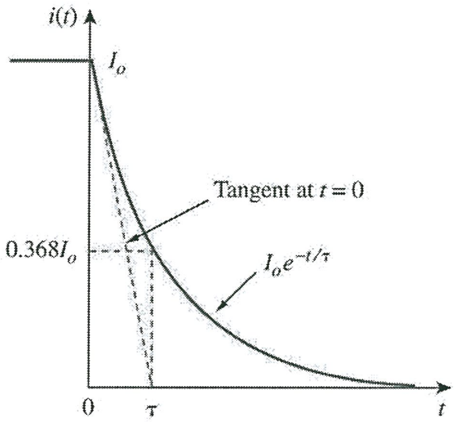
A first-order RL circuit consists of a inductor L (or its equivalent) and a resistor or its equivalent





$$v_L + v_R = 0$$

$$L\frac{di}{dt} + iR = 0$$

Inductors law Ohms law

A RL source-free circuit

$$i(t) = I_0\, e^{-t/\tau}$$

$$\text{where } \tau = \frac{L}{R}$$

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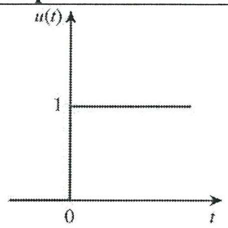
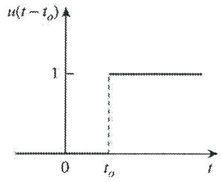
The unit step function $u(t)$ is 0 for negative values of t and 1 for positive values of t.

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

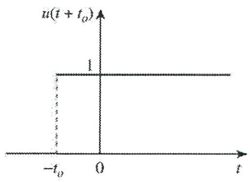


$$u(t-t_o)=\begin{cases}0, & t<t_o\\ 1, & t>t_o\end{cases}$$



(a)

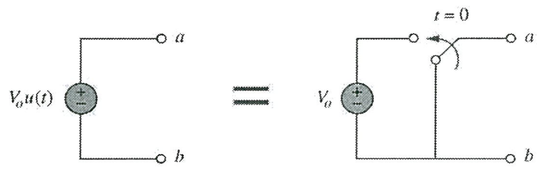
$$u(t+t_o)=\begin{cases}0, & t<-t_o\\ 1, & t>-t_o\end{cases}$$



(b)

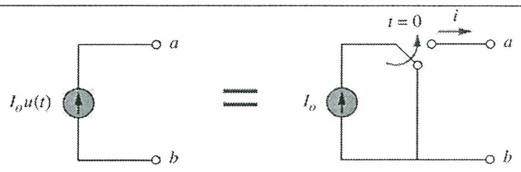
Represent an abrupt change for:

1. voltage source.



(a) (b)

2. for current source:



(a) (b)

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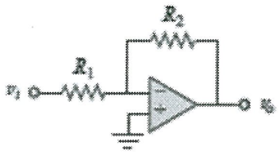
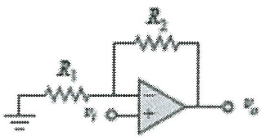
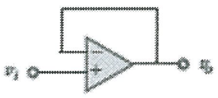
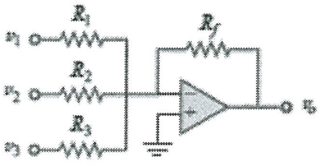
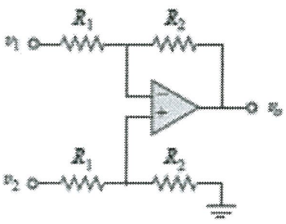
Summary of basic op amp circuits.

Op amp circuit	Name/output-input relationship
	Inverting amplifier $v_o = -\frac{R_2}{R_1} v_i$
	Noninverting amplifier $v_o = \left(1 + \frac{R_2}{R_1}\right) v_i$
	Voltage follower $v_o = v_i$
	Summer $v_o = -\left(\frac{R_f}{R_1} v_1 + \frac{R_f}{R_2} v_2 + \frac{R_f}{R_3} v_3\right)$
	Difference amplifier $v_o = \frac{R_2}{R_1}(v_2 - v_1)$