Solutions Manual

FUNDAMENTALS OF CIRCUITS, ELECTRONICS, AND SIGNAL ANALYSIS

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Georgia Institute of Technology

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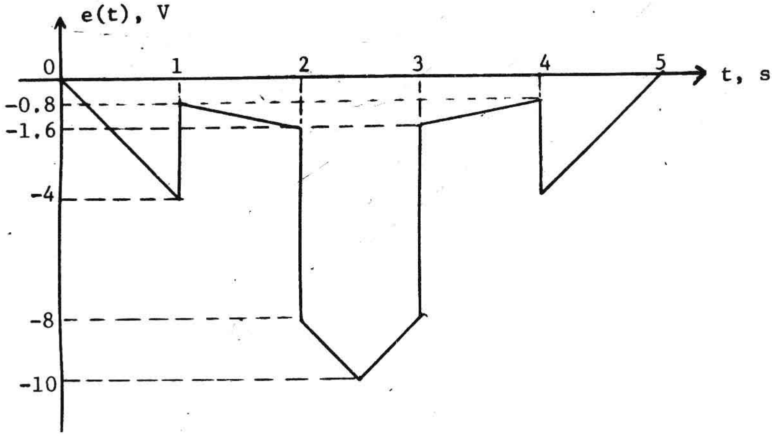
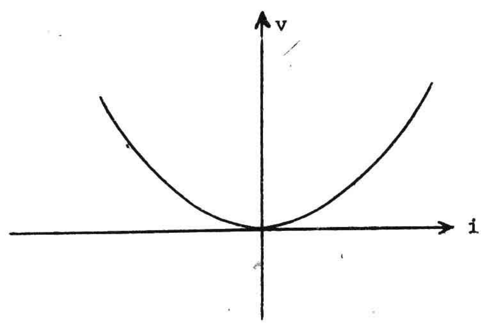
CONTENTS

1.1

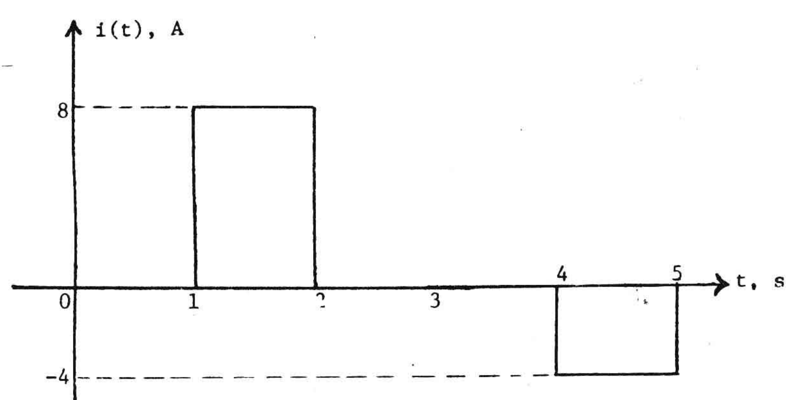


1.2 (a)



(b) $v(t) = i^2(t) = 1 + \sin 3t + \frac{1}{2}\cos 10\,t + \sin 13t - \frac{1}{2}\cos 16t$

1.3



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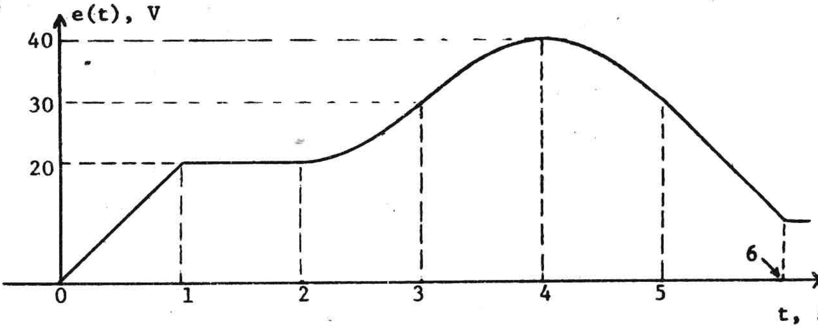
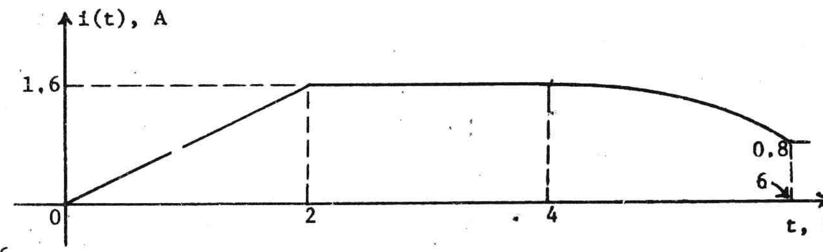
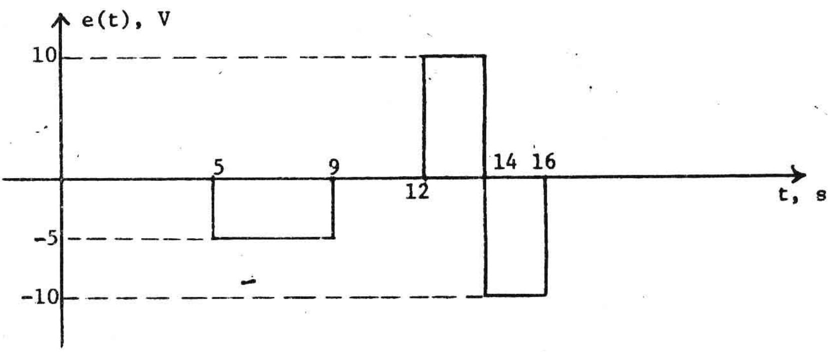

e(t), V
40
30
20
0
1
2
3
4
5
6
t, s

1.5

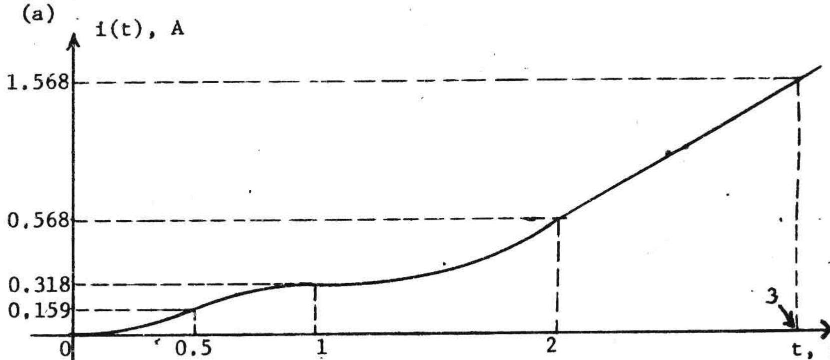

i(t), A
1.6
0.8
0
2
4
6
t, s

1.6

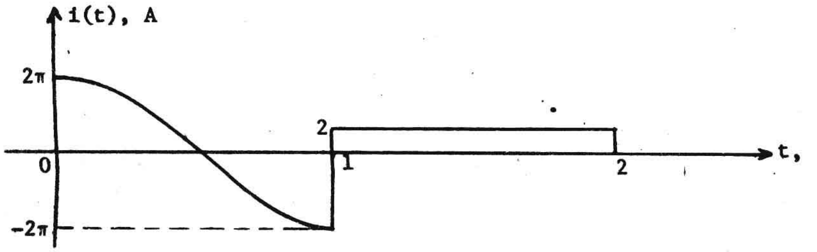

e(t), V
10
-5
-10
5
9
12
14
16
t, s

1.7

(a)

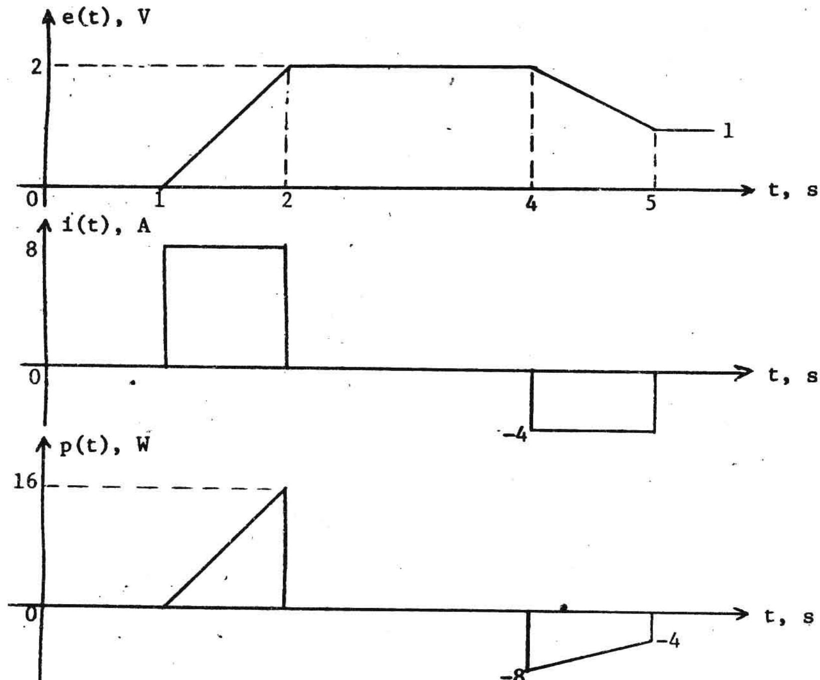

i(t), A
1.568
0.568
0.318
0.159
0
0.5
1
2
3
t, s

1.7 (b)



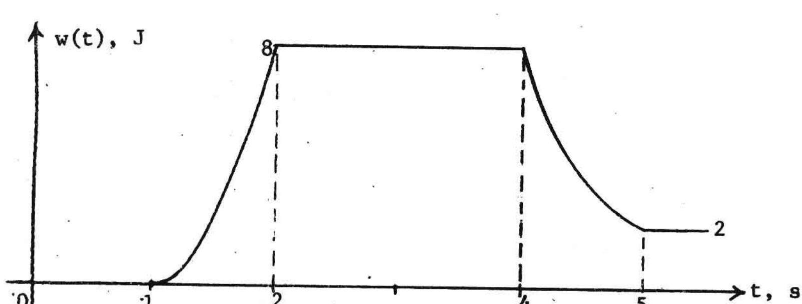
i(t), A
2π
2
0
1
2
t, s
-2π

1.8 (a)



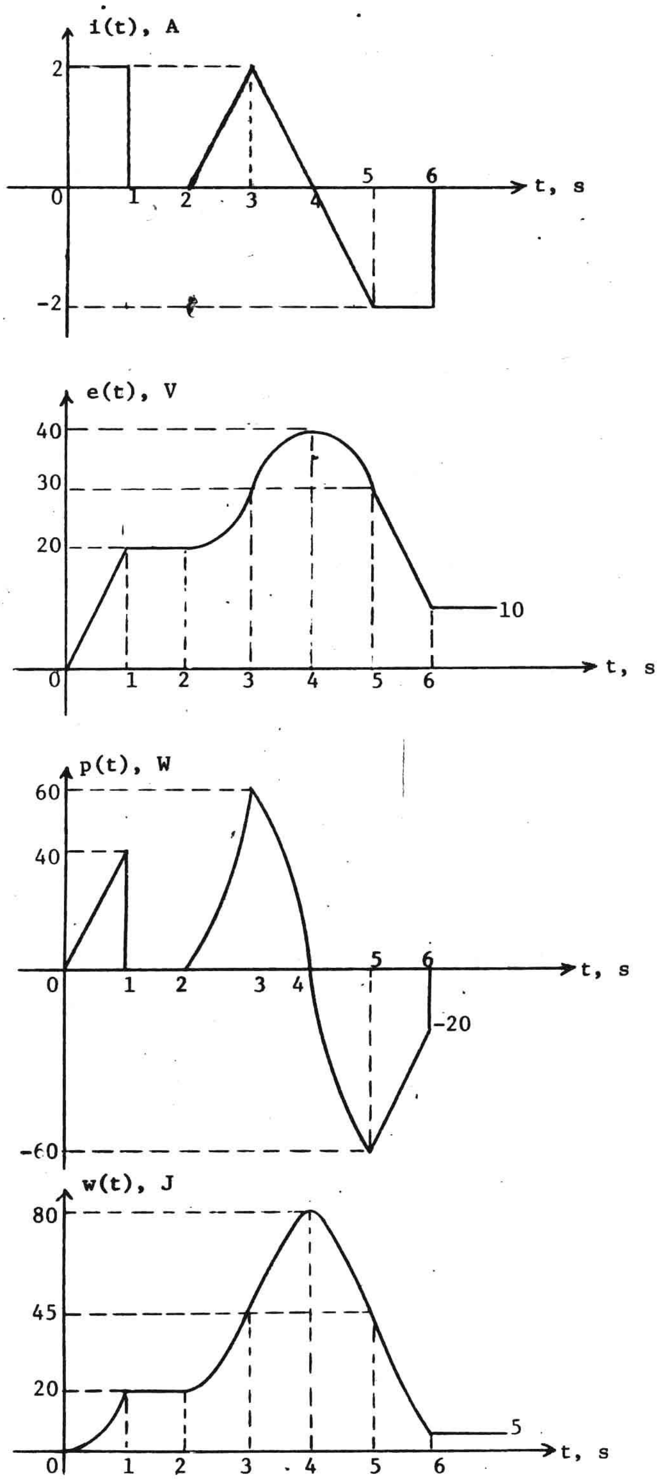
e(t), V
2
1
0
1
2
4
5
t, s
i(t), A
8
0
t, s
-4
p(t), W
16
0
t, s
-4
-8

(b)



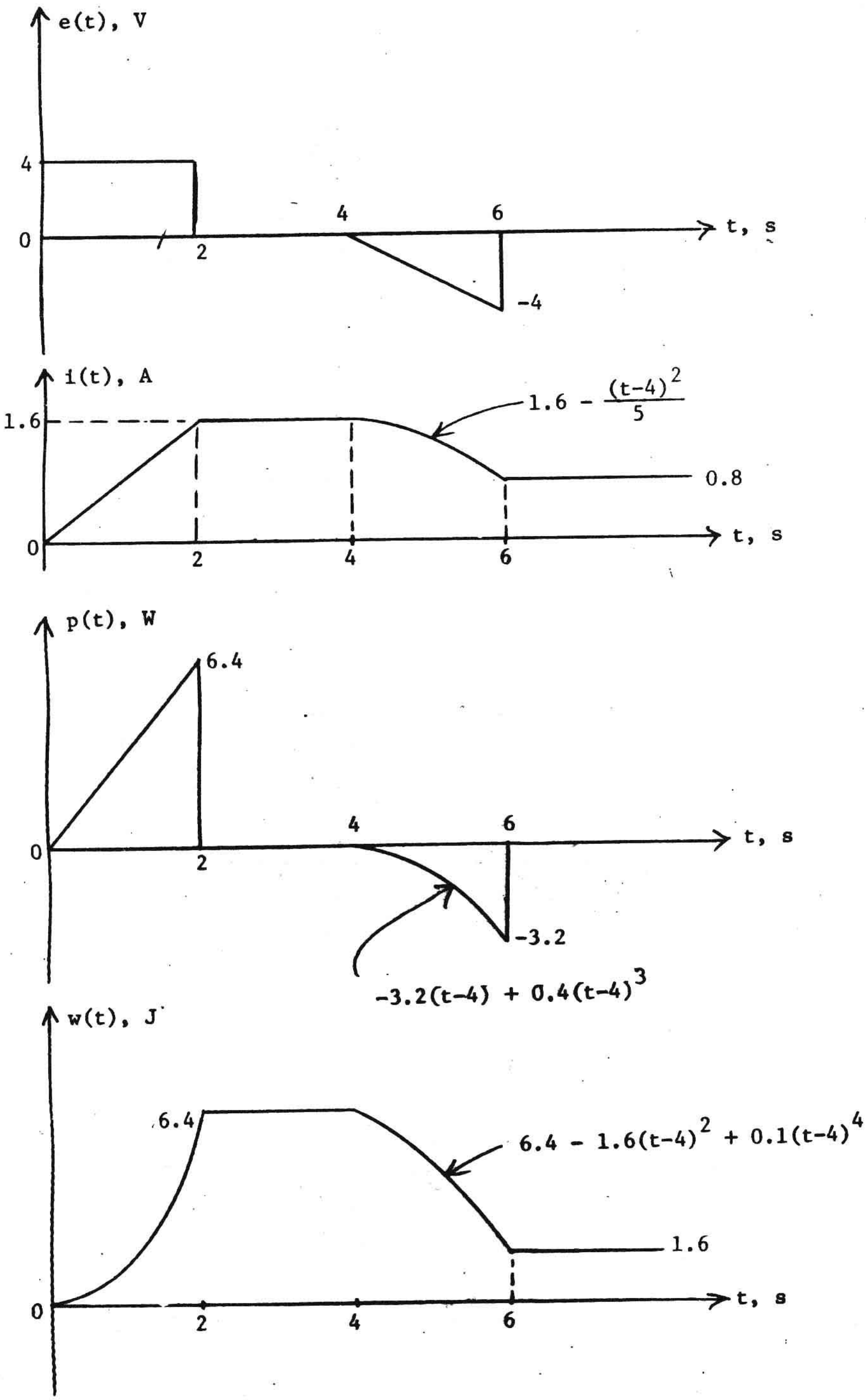
w(t), J
8
2
0
1
2
4
5
t, s

1.9

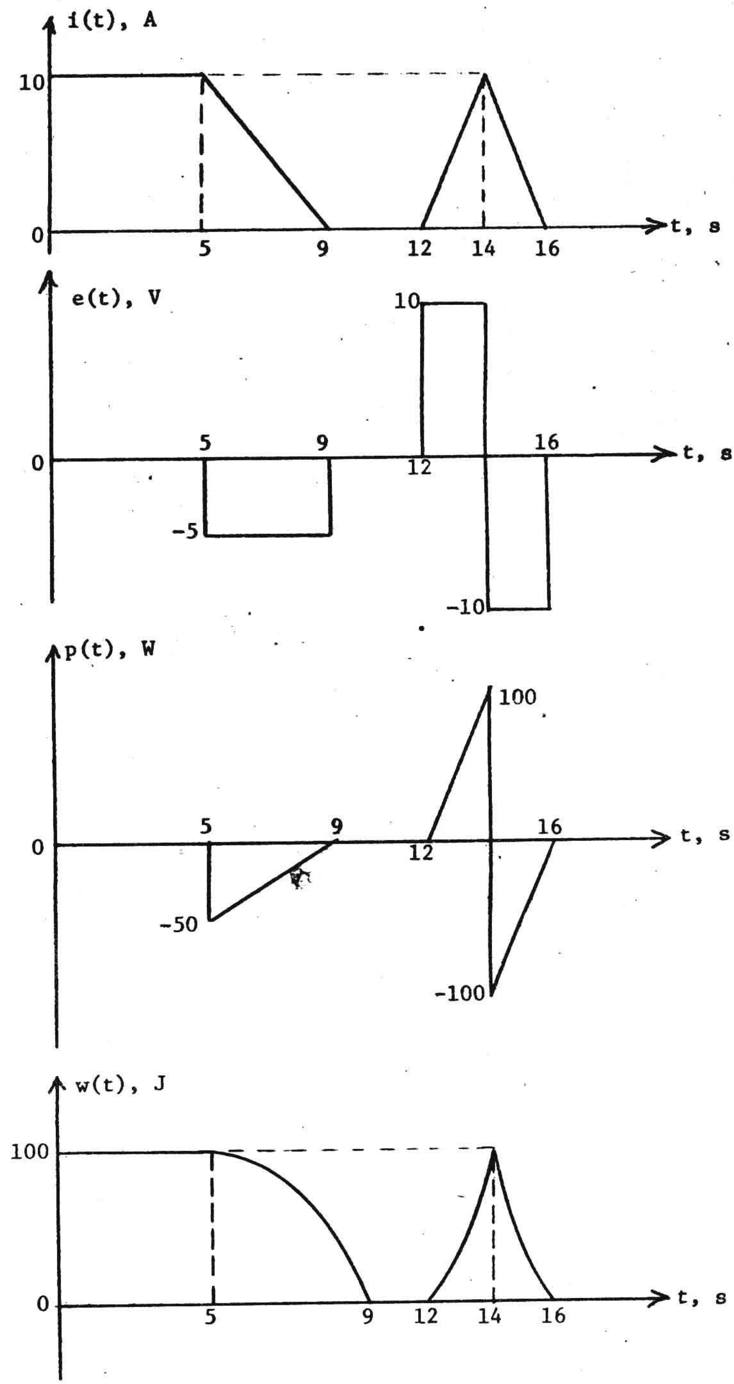


i(t), A
2
-2
0
1
2
3
4
5
6
t, s
e(t), V
40
30
20
10
0
1
2
3
4
5
6
t, s
p(t), W
60
40
-20
-60
0
1
2
3
4
5
6
t, s
w(t), J
80
45
20
5
0
1
2
3
4
5
6
t, s

1.10


e(t), V
4
0
2
4
6
-4
t, s
i(t), A
1.6
0
0.8
$1.6 - \frac{(t-4)^2}{5}$
2
4
6
t, s
p(t), W
6.4
0
2
4
6
-3.2
$-3.2(t-4) + 0.4(t-4)^3$
t, s
w(t), J
6.4
0
2
4
6
1.6
$6.4 - 1.6(t-4)^2 + 0.1(t-4)^4$
t, s

1.11



i(t), A
10
0
5
9
12
14
16
t, s
e(t), V
10
0
5
9
12
16
-5
-10
t, s
p(t), W
100
0
5
9
12
16
-50
-100
t, s
w(t), J
100
0
5
9
12
14
16
t, s

1.12 (a) A non-zero voltage source and a short circuit are contradictory.

(b) There is no inconsistency in this circuit.

1.13 Current controlled.

1.14 $q = (1 + 0.1 \sin t)^2$

$$i = \frac{dq}{dt} = 2(1 + 0.1 \sin t)(0.1 \cos t)$$

$$= 0.2 \cos t + 0.02 \cos t \sin t$$

$$= 0.2 \cos t + 0.01 \sin 2t$$

1.15

$$v = \frac{d}{dt}(Li) = L\frac{di}{dt} + i\frac{dL}{dt} = (t + \tanh t) \times 100 \cos 10t + 10 \sin 10t \times (1 + \operatorname{sech}^2 t)$$

1.16

$$w\big|_{v=1} = \int_0^q v\,dq = \int_0^1 (1 + \operatorname{sech}^2 v) v\,dv = \left[\frac{v^2}{2} + v \tanh v - \ln(\cosh v)\right]_0^1$$

$$= \frac{1}{2} + \tanh 1 - \ln(\cosh 1) + \ln(1) = 0.5 + 0.7616 - 0.4338$$

$$= 0.8278 \text{ J}$$

$$w\big|_{v=3} = \left[v^2/2 + v \tanh v - \ln(\cosh v)\right]_0^3 = 4.5 + 3 \times \tanh 3$$

$$-\ln(\cosh 3) = 4.5 + 2.9852 - 2.3093 = 5.1758 \text{ J}$$

$$w\big|_{v=3} - w\big|_{v=1} = 4.3480 \text{ J}$$

1.17

From (1.28)

$$w(t_1, t_2) = \int_{\tau=t_1}^{\tau=t_2} v(\tau) i(\tau)\, d\tau$$

Since

$$i(\tau)\, d\tau = dq(\tau)$$

we have

$$w(t_1, t_2) = \int_{\tau=t_1}^{\tau=t_2} v(\tau)\, dq(\tau)$$

2.1 $V_a - V_b = -25$ V, $V_b - V_c = 33$ V, $V_d - V_e = 13$ V, $V_e - V_b = -35$ V, $V_e - V_c = -2$ V, $V_d - V_a = 3$ V, $I_3 = -2$ A.

2.2 $V_{12} = -1$ V, $V_{23} = -1$ V, $V_{34} = 7$ V, $V_{45} = -9$ V, $V_{51} = 4$ V, $V_{13} = -2$ V, $V_{35} = -2$ V.

2.3 $I_6 = I_1 - I_2 = 1 - 2 = -1$ A

$I_7 = I_2 - I_3 = 2 - 3 = -1$ A

$I_8 = I_3 - I_4 = 3 - (-4) = 7$ A

$I_9 = I_4 - I_5 = -4 - 5 = -9$ A

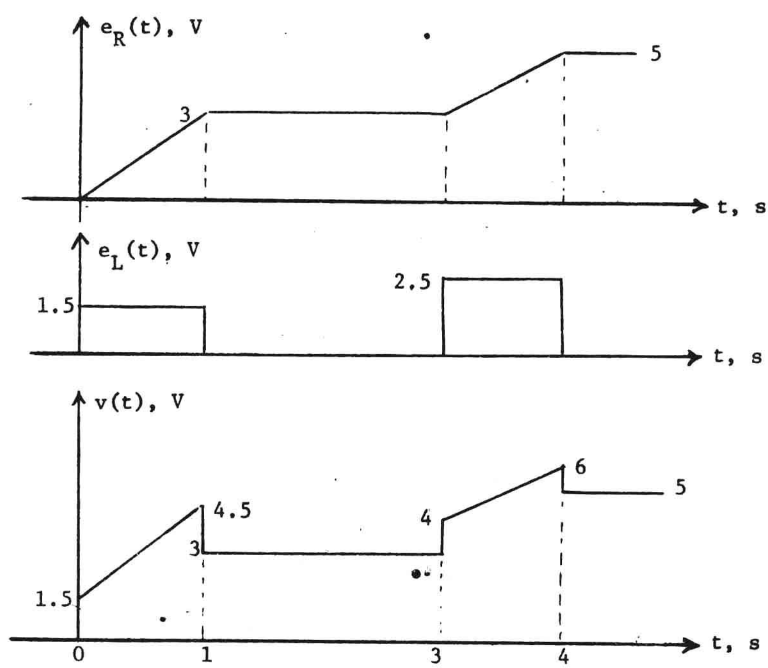
$I_{10} = I_5 - I_1 = 5 - 1 = 4$ A

$I_{11} = I_6 + I_7 = -1 + (-1) = -2$ A

$I_{12} = -(I_8 + I_9) = -(7 - 9) = 2$ A

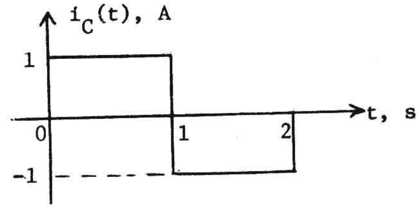
2.4 $I = -2 + 5 + 3 - 4 + 7 = 9$ A

2.5

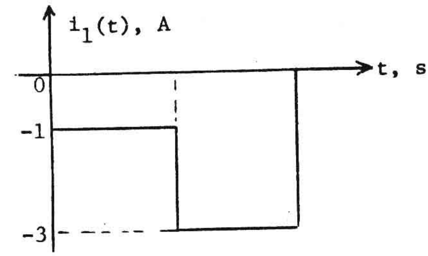


2.6

$$i_C(t) = \frac{1}{2}\frac{de}{dt}$$



$$i_1(t) = i_C(t) - i(t)$$



2.7

$I_3 = 6 + 12 = 18$ A

$I_1 = 10 - 6 = 4$ A

$I_2 = 10 + 12 = 22$ A

$e_4 = -(e_1 + e_2) = -(2 + 22) = -24$ V

$e_5 = -e_1 + e_3 = -2 + 3 = 1$ V

$e_6 = e_2 + e_3 = 22 + 3 = 25$ V

$e_3 = I_3/6 = 3$ V

$e_1 = 4/2 = 2$ V

$e_2 = I_2/1 = 22$ V

2.8 Around the left mesh, we have

$$V_{ab} = 2 - 6 + 10 = 6 \text{ V}$$

Around the right mesh, we have

$$V_{bc} = -4 + 9 - 2 = 3 \text{ V}$$
$$V_{ca} = V_{cb} + V_{ba} = -V_{bc} - V_{ab} = -3 - 6 = -9 \text{ V}$$

$I_1 = 6/2 = 3$ A

$I_2 = -3/3 = -1$ A

$I_3 = -(I_1 + I_2) = -2$ A

2.9 $I_7 = I_1 + I_2 + I_3 = 5 - 3 - 6 = -4$ A

$I_8 = I_3 + I_4 = -6 + 2 = -4$ A

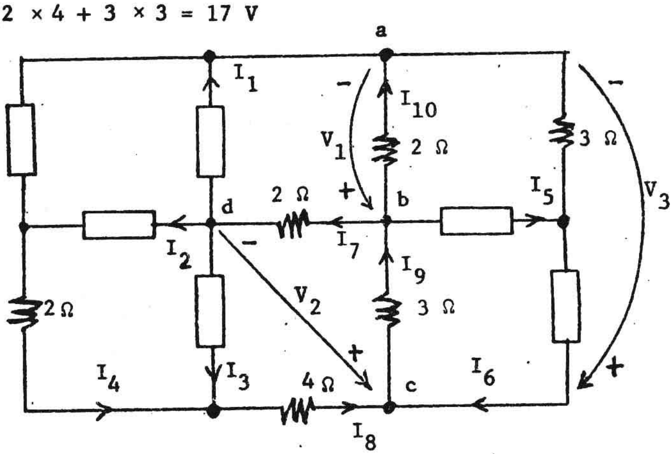
$I_9 = I_6 + I_8 = 7 - 4 = 3$A

$I_{10} = -I_5 - I_7 + I_9 = -3 + 4 + 3 = 4$ A

$V_1 = 2 \times 4 = 8$ V

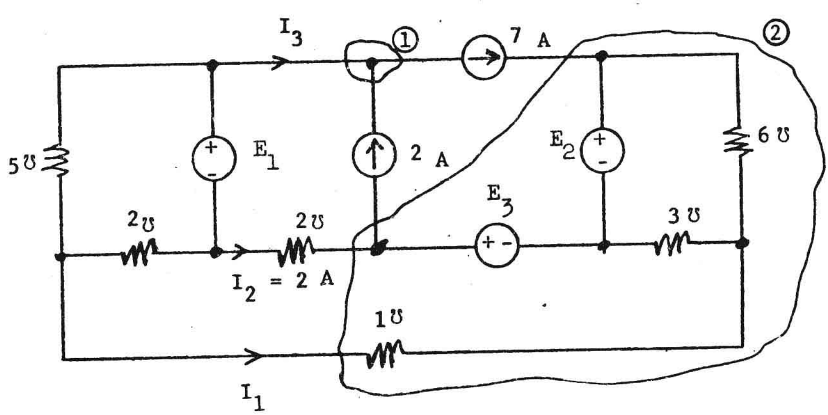
$V_2 = 2 \times (-4) + 3 \times 3 = 1$ V

$V_3 = 2 \times 4 + 3 \times 3 = 17$ V



2.10 $I_3 = 7 - 2 = 5$ A

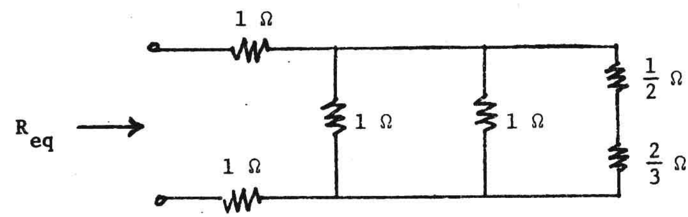
$I_1 = -2 + 2 - 7 = -7$ A



2.11 $I_1 = \frac{10}{8} = 1.25 \text{ A}$

$V_1 = 2I_1 = 2.5 \text{ V}$

2.12 (a)



$$R_{eq} = 2 + \frac{1}{1 + 1 + \frac{6}{5}} = 2\frac{5}{16} \ \Omega$$

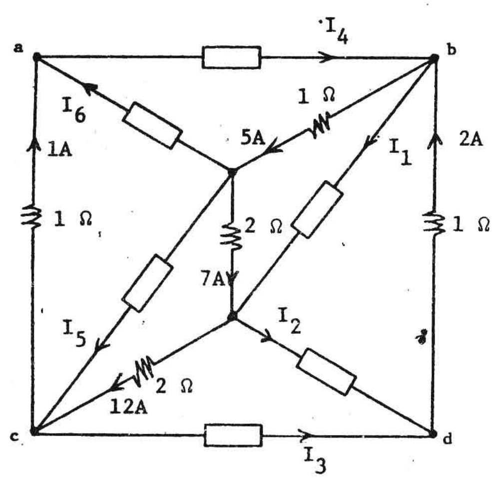
(b) The three resistors are in parallel. Hence

$$R_{eq} = \frac{1}{3} \ \Omega$$

2.13 $$I = \frac{28}{2 + \frac{10 \times 10}{10 + 10}} = \frac{28}{7} = 4 \text{ A}$$

$$V = \frac{10}{10 + 10} I \times 8 = 16 \text{ V}$$

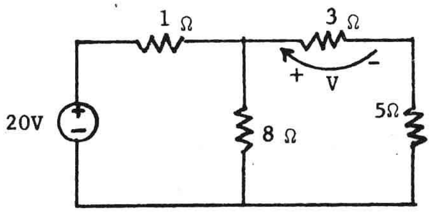
2.14 By KCL, all currents can be determined as shown. Then by KVL, we have

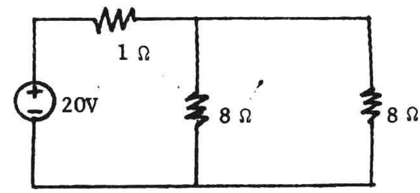


$V_{ba} = 1 + 24 + 14 + 5 = 44 \text{ V}$

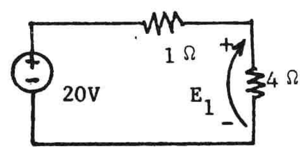
$V_{dc} = 24 + 14 + 5 + 2 = 45 \text{ V}$

2.15 The circuit can be simplified in the sequence below





By voltage division rule



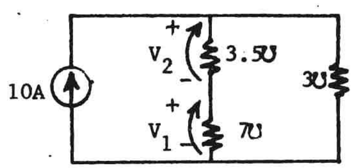
$$E_1 = \frac{4}{1+4} \times 20 = 16 \text{ V}$$

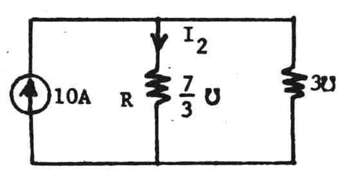
$$V = \frac{3}{3+5} \times E_1 = \frac{3}{8} \times 16 = 6 \text{ V}$$

2.16 Voltage ross G_1 and $G_2 = \dfrac{G_3 V_o}{G_1 + G_2 + G_3}$

$$I_1 = \frac{G_1 G_3 V_o}{G_1 + G_2 + G_3}$$

2.17





$$R = \frac{1}{3.5} + \frac{1}{7} = \frac{3}{7} \ \Omega$$

$$I_2 = \frac{\frac{7}{3}}{\frac{7}{3} + 3} \times 10 = \frac{70}{16} = \frac{35}{8} = 4.375 \text{ A}$$

$V_1 = 4.375/7 = 0.625$ V

$V_2 = 4.375/3.5 = 1.25$ V

$V_3 = -(V_1 + V_2) = -1.875$ V

2.18 $V_1 = \frac{2}{2+6} \times 5 = 1.25$ V

$I_1 = -\frac{5}{8} = -0.625$ A

2.19 $i_1 = C_1 \frac{de}{dt}$, $i_2 = C_2 \frac{de}{dt}$

$i = i_1 + i_2 = (C_1 + C_2)\frac{de}{dt}$

$$\frac{i_1}{i} = \frac{C_1 \frac{de}{dt}}{(C_1 + C_2)\frac{de}{dt}}$$

$$i_1 = \frac{C_1}{C_1 + C_2} i$$

Similarly $i_2 = \frac{C_2}{C_1 + C_2} i$

2.20 $e_1(t) = S_1 \int_{-\infty}^{t} i(\tau)d\tau$

$e_2(t) = S_2 \int_{-\infty}^{t} i(\tau)d\tau$

$e(t) = e_1(t) + e_2(t) = (S_1 + S_2) \int_{-\infty}^{t} i(\tau)d\tau$

$$\frac{e_1(t)}{e(t)} = \frac{S_1 \int_{-\infty}^{t} i(\tau)d\tau}{(S_1 + S_2)\int_{-\infty}^{t} i(\tau)d\tau}$$

$$e_1(t) = \frac{S_1}{S_1 + S_2} e(t)$$

Similarly $e_2(t) = \frac{S_2}{S_1 + S_2} e(t)$