

Solutions Manual

**FUNDAMENTALS OF CIRCUITS,
ELECTRONICS, AND SIGNAL ANALYSIS**

Kendall L. Su
Georgia Institute of Technology

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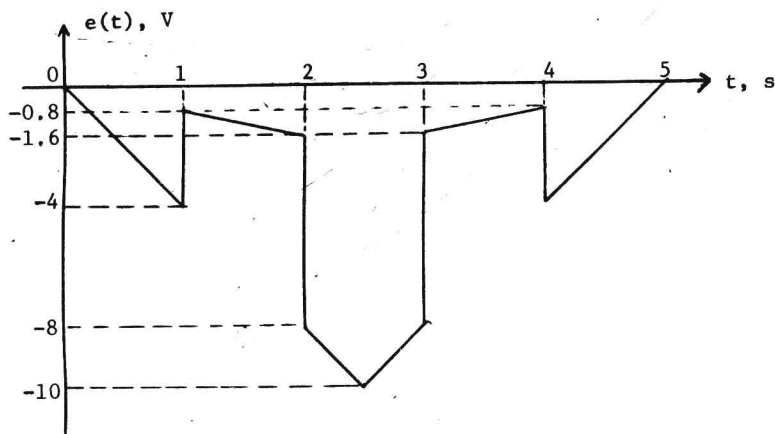
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CONTENTS

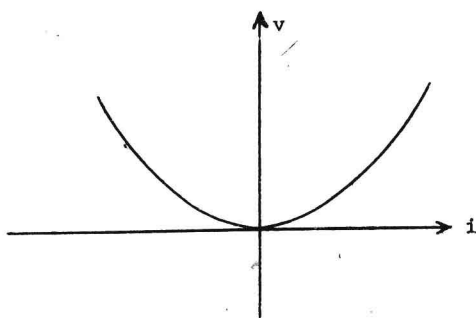
CHAPTER 1	PRELIMINARIES AND CIRCUIT ELEMENTS	1
CHAPTER 2	NETWORK EQUILIBRIUM EQUATIONS AND ANALYSIS OF LTI NETWORKS	8
CHAPTER 3	SOME NETWORK PROPERTIES AND THEOREMS	25
CHAPTER 4	ANALYSIS OF SIMPLE CIRCUITS WITH DYNAMIC EXCITATIONS	36
CHAPTER 5	STEADY-STATE CIRCUIT ANALYSIS	50
CHAPTER 6	TWO-TERMINAL ELECTRONIC DEVICES AND THEIR CIRCUIT MODELS	67
CHAPTER 7	TWO-PORT AND THREE-TERMINAL LINEAR NETWORKS	79
CHAPTER 8	FIELD-EFFECT-TRANSISTOR CIRCUITS	103
CHAPTER 9	BIPOLAR TRANSISTOR CIRCUITS	115
CHAPTER 10	OTHER ELECTRONIC DEVICES AND CIRCUITS	139
CHAPTER 11	NETWORK ANALYSIS IN THE FREQUENCY DOMAIN	146
CHAPTER 12	NETWORK ANALYSIS IN THE TIME DOMAIN AND THE SYSTEM CONCEPT	165
CHAPTER 13	SYSTEM RESPONSE TO PERIODIC EXCITATIONS: FOURIER ANALYSIS	173
CHAPTER 14	FOURIER TRANSFORM AND APPLICATIONS	186
CHAPTER 15	LAPLACE TRANSFORM AND APPLICATIONS	207
CHAPTER 16	STATE-VARIABLE METHOD OF SYSTEM ANALYSIS	222
CHAPTER 17	LOGIC CIRCUITS	244
APPENDIX B	MATRIX ALGEBRA	251

1.1



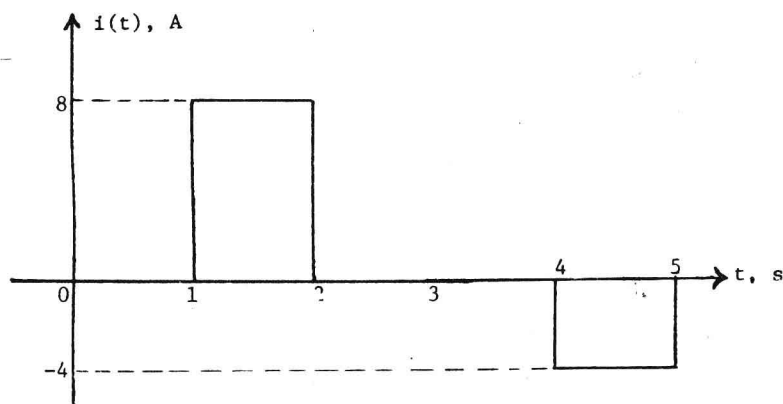
1.2

(a)

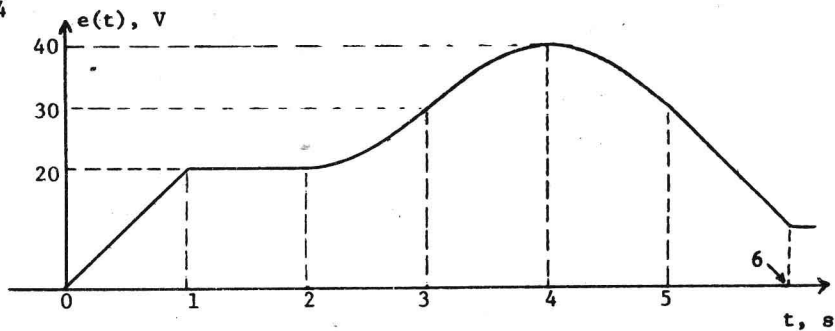


$$(b) v(t) = i^2(t) = 1 + \sin 3t + \frac{1}{2} \cos 10t + \sin 13t - \frac{1}{2} \cos 16t$$

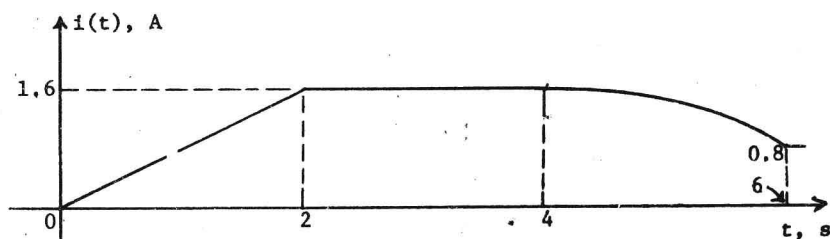
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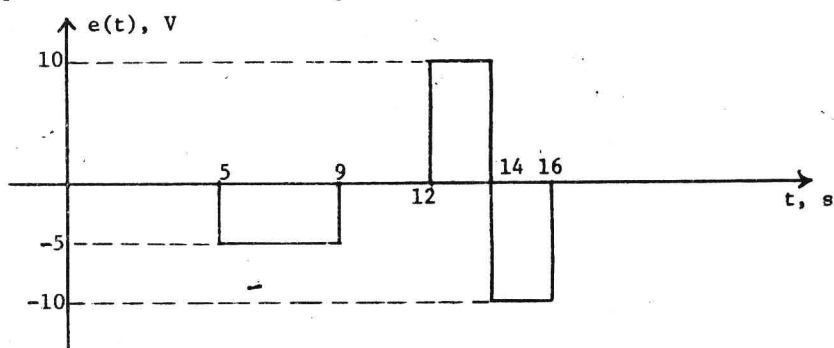
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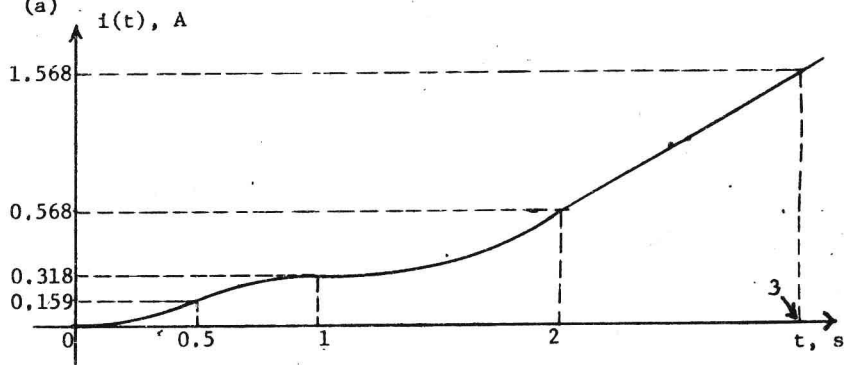


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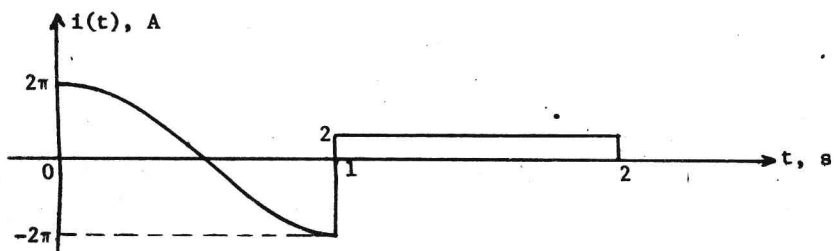


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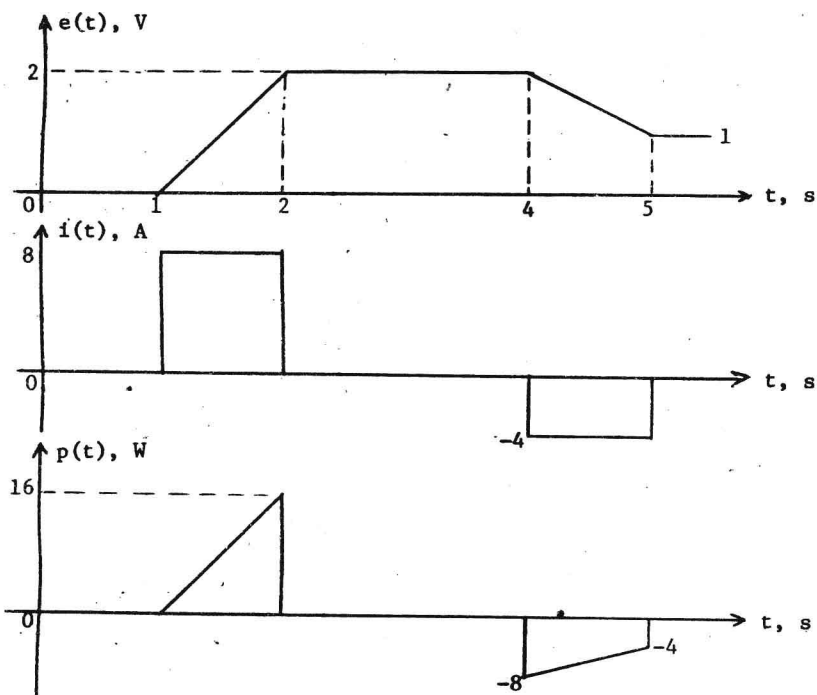
(a)



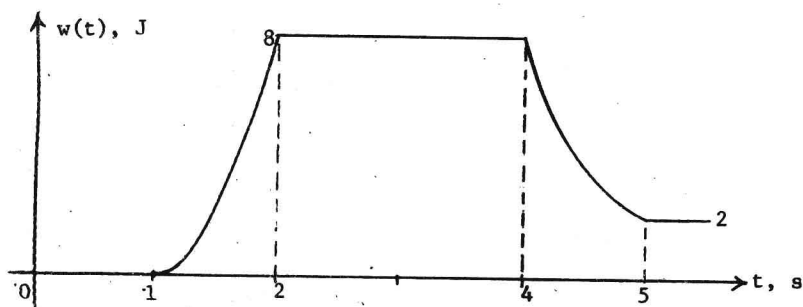
1.7 (b)



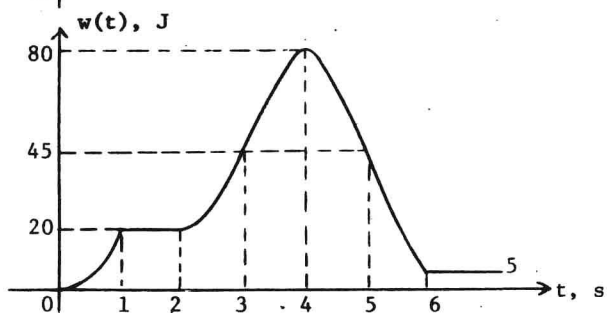
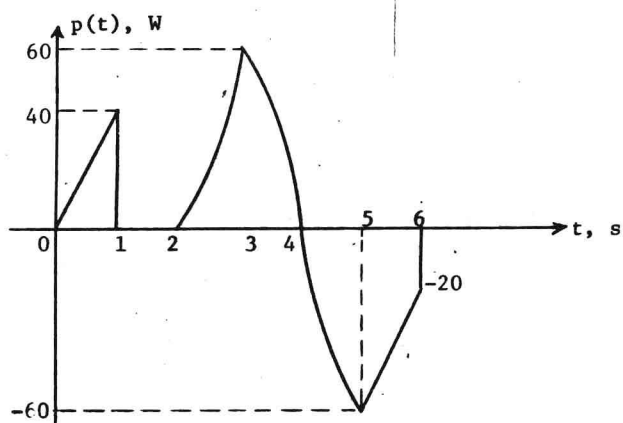
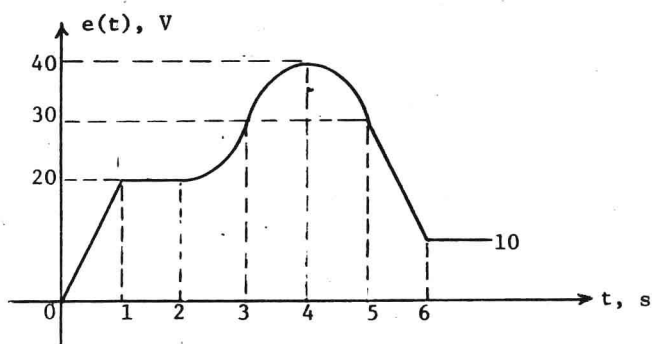
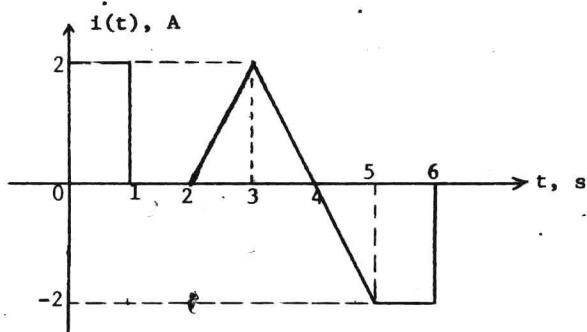
1.8 (a)



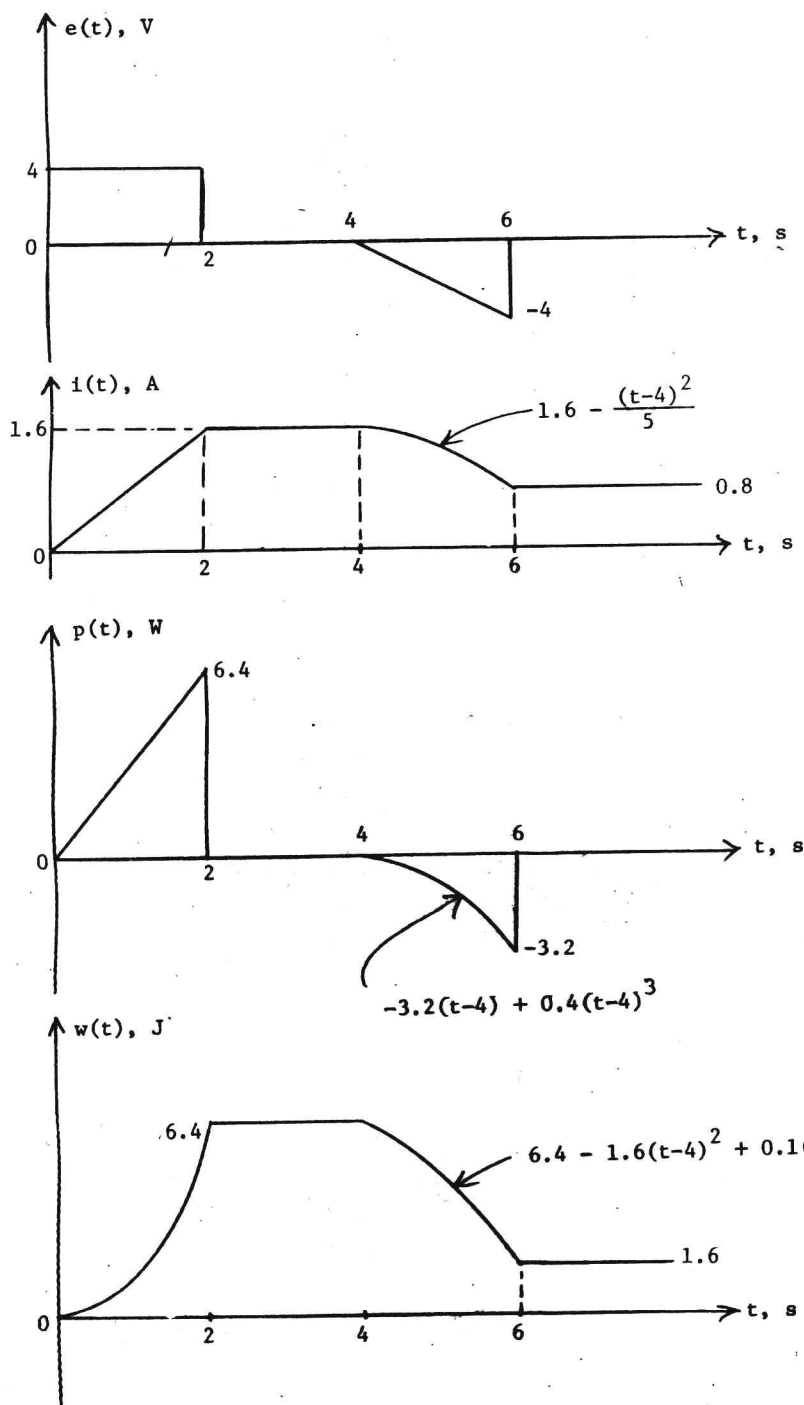
(b)



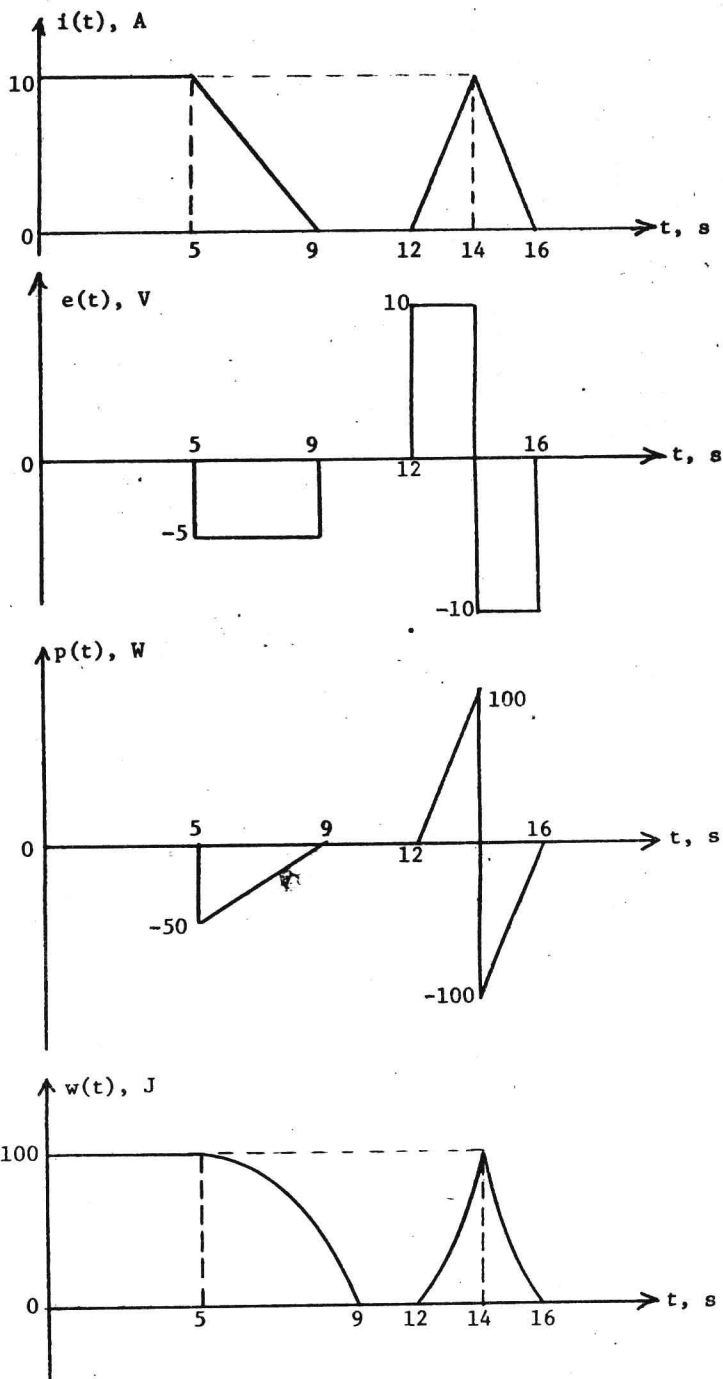
1.9



1,10



1.11



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.

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

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

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

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

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

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

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

$$= 0.8278 \text{ J}$$

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

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

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

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

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

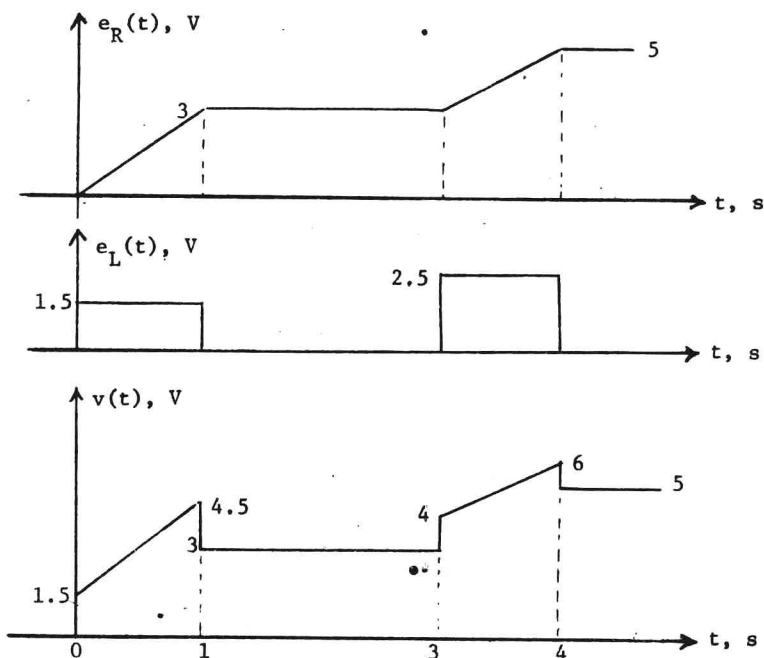
$$2.1 \quad v_a - v_b = -25 \text{ V}, \quad v_b - v_c = 33 \text{ V}, \quad v_d - v_e = 13 \text{ V}, \quad v_e - v_b = -35 \text{ V}, \\ v_e - v_c = -2 \text{ V}, \quad v_d - v_a = 3 \text{ V}, \quad I_3 = -2 \text{ A}.$$

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

$$2.3 \quad I_6 = I_1 - I_2 = 1 - 2 = -1 \text{ A} \\ I_7 = I_2 - I_3 = 2 - 3 = -1 \text{ A} \\ I_8 = I_3 - I_4 = 3 - (-4) = 7 \text{ A} \\ I_9 = I_4 - I_5 = -4 - 5 = -9 \text{ A} \\ I_{10} = I_5 - I_1 = 5 - 1 = 4 \text{ A} \\ I_{11} = I_6 + I_7 = -1 + (-1) = -2 \text{ A} \\ I_{12} = -(I_8 + I_9) = -(7 - 9) = 2 \text{ A}$$

$$2.4 \quad I = -2 + 5 + 3 - 4 + 7 = 9 \text{ A}$$

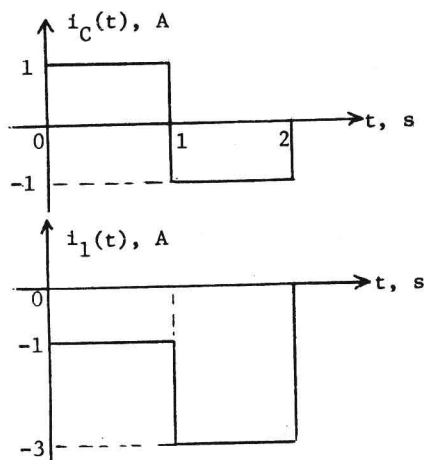
2.5



2.6

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

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



2.7

$$I_3 = 6 + 12 = 18 \text{ A}$$

$$I_1 = 10 - 6 = 4 \text{ A}$$

$$I_2 = 10 + 12 = 22 \text{ A}$$

$$e_4 = -(e_1 + e_2) = -(2 + 22) = -24 \text{ V}$$

$$e_5 = -e_1 + e_3 = -2 + 3 = 1 \text{ V}$$

$$e_6 = e_2 + e_3 = 22 + 3 = 25 \text{ V}$$

$$e_3 = I_3/6 = 3 \text{ V}$$

$$e_1 = 4/2 = 2 \text{ V}$$

$$e_2 = I_2/1 = 22 \text{ V}$$

2.8 Around the left mesh, we have

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

Around the right mesh, we have

$$V_{bc} = -4 + 9 - 2 = 3 \text{ V}$$

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

$$I_1 = 6/2 = 3 \text{ A}$$

$$I_2 = -3/3 = -1 \text{ A}$$

$$I_3 = -(I_1 + I_2) = -2 \text{ A}$$

$$2.9 \quad I_7 = I_1 + I_2 + I_3 = 5 - 3 - 6 = -4 \text{ A}$$

$$I_8 = I_3 + I_4 = -6 + 2 = -4 \text{ A}$$

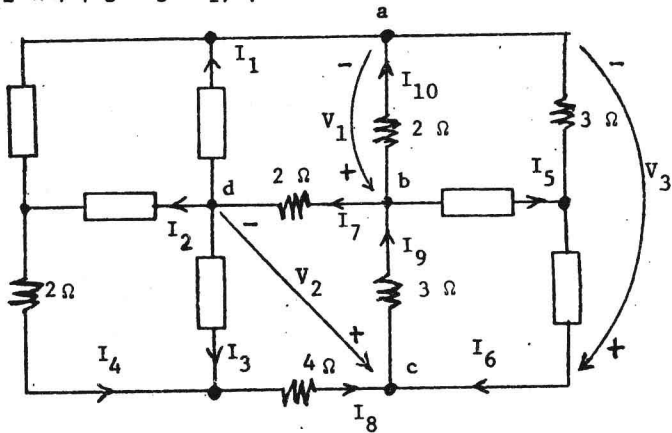
$$I_9 = I_6 + I_8 = 7 - 4 = 3 \text{ A}$$

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

$$V_1 = 2 \times 4 = 8 \text{ V}$$

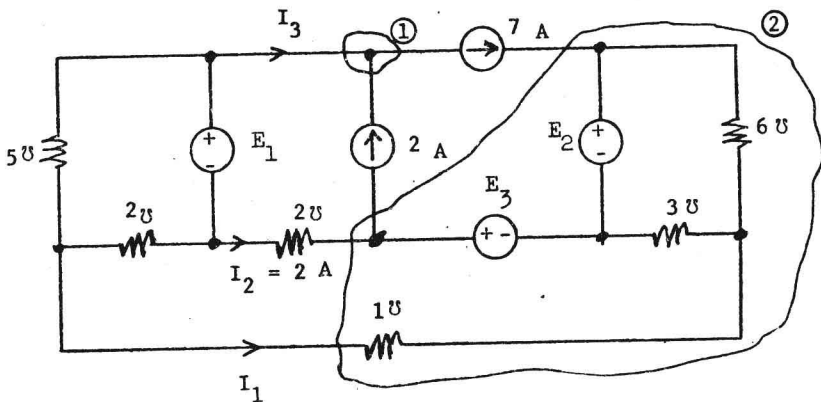
$$V_2 = 2 \times (-4) + 3 \times 3 = 1 \text{ V}$$

$$V_3 = 2 \times 4 + 3 \times 3 = 17 \text{ V}$$



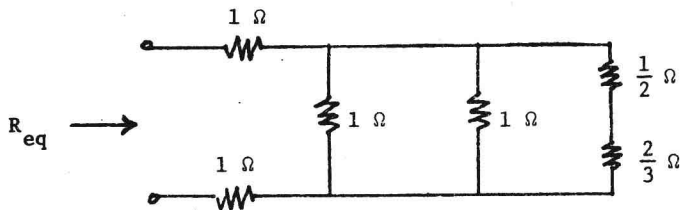
$$2.10 \quad I_3 = 7 - 2 = 5 \text{ A}$$

$$I_1 = -2 + 2 - 7 = -7 \text{ A}$$



2.11 $I_1 = \frac{10}{8} = 1.25 \text{ A}$
 $V_1 = 2I_1 = 2.5 \text{ V}$

2.12 (a)



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

(b) The three resistors are in parallel. Hence

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

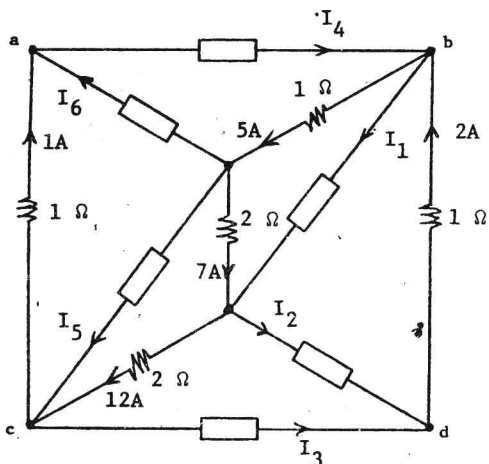
2.13 $I = \frac{28}{2 + \frac{10 \times 10}{10 + 10}} = \frac{28}{7} = 4 \text{ A}$

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

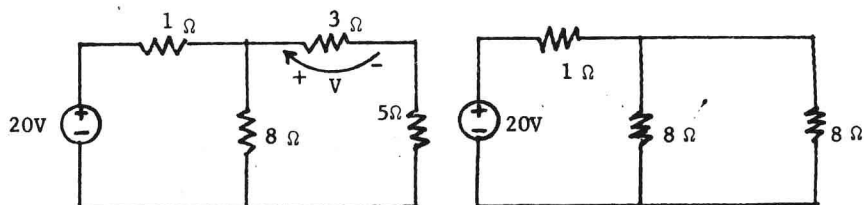
2.14 By KCL, all currents can be determined as shown. Then by KVL, we have

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

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



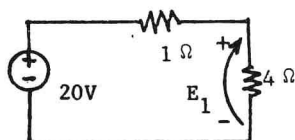
2.15 The circuit can be simplified in the sequence below



By voltage division rule

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

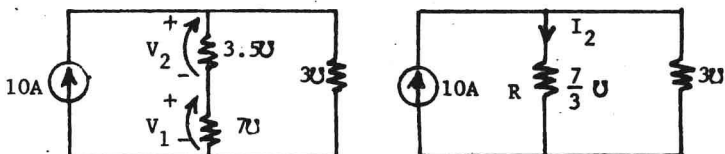
$$V = \frac{3}{3 + 5} \times E_1 = \frac{3}{8} \times 16 = 6 \text{ V}$$



2.16 Voltage across G_1 and $G_2 = \frac{G_3 V_o}{G_1 + G_2 + G_3}$

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

2.17



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

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

$$V_1 = 4.375/7 = 0.625 \text{ V}$$

$$V_2 = 4.375/3.5 = 1.25 \text{ V}$$

$$V_3 = -(V_1 + V_2) = -1.875 \text{ V}$$

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

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

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

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

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

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

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

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

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

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

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

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

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