

CHAPTER 1 - PROBLEMS

1.1 THE CURRENT FLOWING FROM B TO A IS  $(10^{17})(1.6 \times 10^{-19}) = -1.6 \cdot 10^{-2}$  AMPERE. THE CURRENT FLOWING FROM A TO B IS  $+1.6 \cdot 10^{-2}$ , OR 16 mA.

1.2  $I = 2q(4 \cdot 10^{15}) - 2q(6 \cdot 10^{15}) = -2q(2 \cdot 10^{15}) = -6.4 \cdot 10^{-4}$  A (FROM A TO B). FROM B TO A THE CURRENT IS 0.64 mA.

1.3 FROM KIRCHHOFF'S CURRENT LAW, THE SUM OF THE CURRENTS ENTERING NODE X MUST BE ZERO. HENCE  $I_1 - I_2 = 0$ . THUS  $I_2 = I_1 = 2$  mA.

1.4 (a) NO

(b) FROM KIRCHHOFF'S CURRENT LAW

$$I_A - I_1 - I_2 - I_3 = 0. \quad \text{IF}$$

$$I_A \text{ IS KNOWN, } (I_2 + I_3) =$$

$$I_A - 2 \text{ mA.}$$

1.5 (a)  $V_A - V_B = 6 - 9 = -3$  V

(b)  $V_{BA} \equiv V_B - V_A = 3$  V

1.6 GIVEN:  $V_A - V_B = -2$  V,  $V_A - V_C = 5$  V,  $V_D - V_B = -4$  V,  $V_C = 3.5$  V. THUS

$$V_D = V_B - 4 = (V_A + 2) - 4$$

$$= [(V_C + 5) + 2 - 4] = 6.5 \text{ V}$$

1.7 GIVEN:  $V_X - V_Y = -6$ ,  $V_2 - V_Y = 5$ ,  $V_X = -3$ . THUS  $V_2 = V_Y + 5 = (V_X + 6) + 5 = 8$  V

1.16 NOTE THAT ALL POINTS MARKED  $\perp$  ARE CONNECTED BY WIRES NOT SHOWN ON THE DIAGRAM.  
 THUS  $I_1 - I_2 - I_3 = 0$   
 $\therefore I_3 = 5 - (-3) = 8 \text{ mA}$

1.17  $i_3 = i_1 + i_2 = 10 [\sin 376t + \cos 376t]$

LET  $i_3 = A [\cos (376t + \phi)]$  WHERE  $A$  AND  $\phi$  ARE TO BE FOUND. THEN

$$i_3 = A [\cos 376t \cos \phi - \sin 376t \sin \phi]$$

$$\therefore A \cos \phi = 10, \quad A \sin \phi = -10$$

$$\frac{A \sin \phi}{A \cos \phi} = \tan \phi = -1 \Rightarrow \phi = -45^\circ$$

$$\therefore A \cos(-45^\circ) = A \cdot \frac{1}{\sqrt{2}} = 10 \Rightarrow A = 14.14$$

$$i_3 = 0 \text{ when } \cos \left[ 376t - \left( \frac{\pi}{4} \text{ RADIANS} \right) \right] = 0$$

$$376t - \frac{\pi}{4} = \frac{\pi}{2} \pm N\pi \quad (N = \text{INTEGER})$$

$$t = \left( \frac{3\pi}{4} \pm N\pi \right) / 376 \text{ SEC}$$

1.18 (a)  $V_{12} + V_{23} + V_{34} = V_1 - V_2 + V_2 - V_3 + V_3 - V_4$   
 $= V_1 - V_4$

$$V_{16} + V_{65} + V_{54} = V_1 - V_6 + V_6 - V_5 + V_5 - V_4$$

$$= V_1 - V_4$$

(b)  $V_{12} + V_{34} + V_{56} = V_1 - V_2 + V_3 - V_4 + V_5 - V_6$   
 $V_{23} + V_{45} + V_{61} = V_2 - V_3 + V_4 - V_5 + V_6 - V_1$

(c)  $V_{13} + V_{24} + V_{35} + V_{46} + V_{51} + V_{62}$   
 $= V_1 - V_3 + V_2 - V_4 + V_3 - V_5 + V_4 - V_6 + V_5 - V_1$   
 $+ V_6 - V_2 = 0$

1.19  $P_{\text{TOTAL}} = I (V_{12} + V_{23} + V_{34} + V_{45} + V_{56} + V_{61}) = 0$

THIS RESULT EXPRESSES ENERGY CONSERVATION. WHATEVER POWER IS DISSIPATED (IN BLOCKS WHERE  $VI$  IS POSITIVE) MUST BE BALANCED BY POWER BEING GENERATED (IN BLOCKS WHERE  $VI$  IS NEGATIVE).

EX.

2.4 CHOOSING THE TWO

MESH CURRENTS AS SHOWN, BY INSPECTION

$$I_1 = I_0 = 1 \text{ mA}$$

ADDING VOLTAGES AROUND LOOP CONTAINING  $I_2$

$$\text{WE HAVE } V_0 + I_2 R_2 + (I_1 + I_2) R_3 = 0$$

$$\Rightarrow I_2 = -\frac{I_1 R_3 + V_0}{R_2 + R_3}$$

$$= -\frac{1 \text{ m}(510) + 0.5}{330 + 510}$$

$$= \underline{\underline{-1.2 \text{ mA}}}$$

END

CHAPTER 2 - PROBLEMS

2.1

BECAUSE OF THE IDEAL VOLTAGE SOURCE, THE POTENTIAL AT "A" IS 5V HIGHER THAN AT GROUND (WHERE THE POTENTIAL IS ZERO). THUS

$$V_A - (0) = 5$$

$$V_A = 5 \text{ V}$$

BECAUSE OF THE OTHER IDEAL VOLTAGE SOURCE,

$$V_A - V_B = 7$$

$$V_B = V_A - 7 = -2 \text{ V}$$

2.2

$$I_1 = -6 \text{ mA}$$

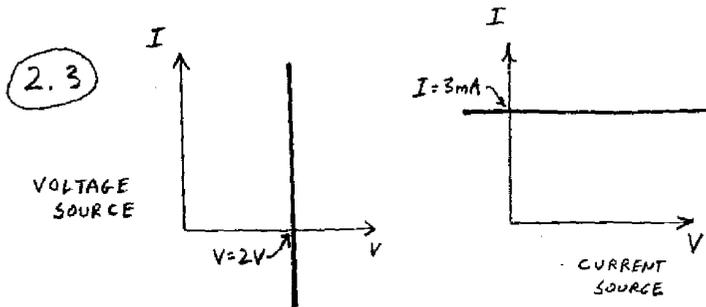
SUMMING CURRENTS INTO THE NODE BETWEEN  $I_1$  AND  $I_2$ ,

$$I_1 + 3 - I_2 = 0 \Rightarrow I_2 = -3 \text{ mA}$$

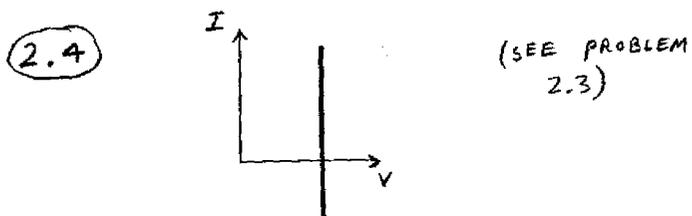
SIMILARLY

$$I_2 - (-5) + I_3 = 0$$

$$I_3 = -I_2 - 5 = -2 \text{ mA}$$



NOTE THAT, FOR EXAMPLE, THE VOLTAGE ACROSS THE IDEAL VOLTAGE SOURCE SIMPLY DOESN'T CARE WHAT THE CURRENT IS; THE VOLTAGE ACROSS IT IS ALWAYS 2V. THAT IS THE DISTINCTIVE PROPERTY OF THIS CIRCUIT ELEMENT.



- 2.5 (a) NO (b) NO (c) YES (d) NO  
(e) NO

2.6 (a)  $I = -\frac{5}{2.7 \cdot 10^3} = 1.85 \text{ mA}$

(b) SAME AS (a)

(c)  $I = \frac{3-7}{3300} = 1.21 \text{ mA}$

2.7 A IS HIGHER by  $(.003)(6800) = 20.4 \text{ V}$

2.8  $I_1 = (V_A - V_B) / R = \frac{6 - (-4)}{470} = 21 \text{ mA}$

2.9  $8 \cdot 10^{-4} = \frac{8-3}{R} \Rightarrow R = 6250 \Omega$

2.10 (a)  $-I, R_1$   
(b)  $I_1 = V_{AB} / R_1 \Rightarrow V_{AB} = -80 \text{ V}$

2.11  $R = \frac{R_1 R_3}{R_1 + R_3} + \frac{R_2 R_4}{R_2 + R_4} = 5.064 \text{ k}\Omega$

2.12  $R = \frac{R_1 \left( \frac{R_2 R_3}{R_2 + R_3} \right)}{R_1 + \left( \frac{R_2 R_3}{R_2 + R_3} \right)} = \frac{R_1 R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$

2.13  $\text{Power} = \frac{(2.1+6.3)^2}{75} = 0.941 \text{ W}$   
 CHOOSE THE 1-WATT RESISTOR.

2.14  $I_1 = \frac{10\text{V}}{100\Omega} = 0.1 \text{ A}$   
 FROM KIRCHHOFF'S CURRENT LAW  
 $I_2 + 0.5 - I_1 = 0$   
 $\therefore I_2 = -0.5 + 0.1 = -0.4 \text{ A}$

2.15 (a) THE VOLTAGE ACROSS EACH RESISTOR IS THE SAME; CALL IT  $V$ . THEN  
 $P = \frac{V^2}{R_1} + \frac{V^2}{R_2} \Rightarrow V = \left( \frac{PR_1R_2}{R_1+R_2} \right)^{1/2}$

THE POWER DISSIPATED IN  $R_1$  IS THEN

$$P_1 = \frac{V^2}{R_1} = P \cdot \frac{R_2}{R_1+R_2}$$

(b) LET THE CURRENT THROUGH BOTH BE  $I$ .

$$P = I^2 R_1 + I^2 R_2 \Rightarrow I = \left( \frac{P}{R_1+R_2} \right)^{1/2}$$

$$P_1 = I^2 R_1 = P \frac{R_1}{R_1+R_2}$$

2.16 LET VOLTAGE AT TOP OF CIRCUIT BE  $V_x$ .

$$I_0 - \frac{V_x}{R_1} - \frac{V_x}{R_2+R_3} = 0$$

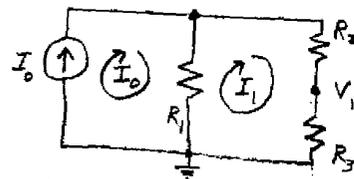
$$\Rightarrow V_x = \frac{I_0 R_1 (R_2+R_3)}{R_1+R_2+R_3}$$

TO FIND  $V_1$  WE WRITE ANOTHER NODE EQUATION:

$$\frac{V_1 - V_x}{R_2} + \frac{V_1}{R_3} = 0 \Rightarrow V_1 = \frac{R_3}{R_2+R_3} V_x$$

$$\therefore V_1 = \frac{I_0 R_1 R_3}{(R_1+R_2+R_3)} = 1.43 \text{ V}$$

2.17

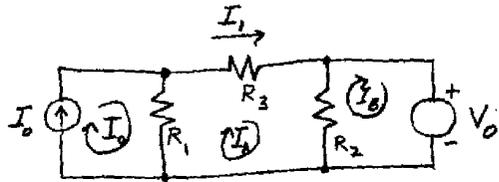


$$R_1(I_1 - I_0) + I_1 R_2 + I_1 R_3 = 0$$

$$I_1 = I_0 \frac{R_1}{R_1+R_2+R_3}$$

$$V_1 = I_1 R_3 = I_0 \frac{R_1 R_3}{R_1+R_2+R_3} = 1.43 \text{ V}$$

2 (2.18)



$$(I_A - I_0)R_1 + I_A R_3 + V_0 = 0$$

$$I_1 = I_A = \frac{I_0 R_1 - V_0}{R_1 + R_3} = 0$$

THIS RATHER SURPRISING RESULT OCCURS BECAUSE THE CONTRIBUTIONS OF THE TWO SOURCES TO  $I_1$  JUST HAPPEN TO CANCEL EXACTLY.

2 (2.19) CALL THE VOLTAGE AT THE TOP OF  $R_1 = V_1$ , LET BOTTOM OF CIRCUIT BE GROUND. THEN

$$I_0 - \frac{V_1}{R_1} - \frac{V_1 - V_0}{R_3} = 0$$

$$\therefore V_1 = \frac{R_1 (I_0 R_3 + V_0)}{R_1 + R_3}$$

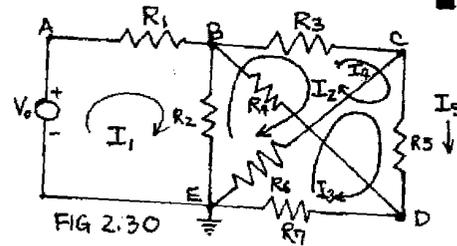
$$I_1 = \frac{V_1 - V_0}{R_3} = \frac{I_0 R_1 - V_0}{R_1 + R_3} = 0$$

2.20 (1) THERE ARE FIVE NODES INCLUDING THE GROUND NODE.

(2) THERE ARE EIGHT BRANCHES.

$$\begin{aligned} (3) \text{ NUMBER OF MESH CURRENTS} \\ &= \# \text{ OF BRANCHES} - \# \text{ OF NODES} + 1 \\ &= 8 - 5 + 1 \\ &= \underline{4} \end{aligned}$$

2 (2.21)



WE CHOOSE THE FOUR MESH CURRENTS AS SHOWN. THE TRICK IS TO INCLUDE AS FEW ELEMENTS IN EACH LOOP AS POSSIBLE. KVL AROUND LOOP 1 TO 4 RESPECTIVELY GIVES

$$-V_0 + I_1 R_1 + (I_1 - I_4) R_2 = 0$$

$$(I_4 - I_1) R_2 + (I_2 + I_4) R_3 + (I_2 - I_3) R_6 = 0$$

$$(I_3 - I_2) R_6 + (I_4 + I_3) R_5 + I_3 R_7 = 0$$

$$(I_2 + I_4) R_3 + (I_4 + I_3) R_5 + I_4 R_4 = 0$$

$$\therefore I_5 = I_3 + I_4$$

2.22

USING THE DIAGRAM IN THE PREVIOUS SOLUTION,  $V_A = V_0$

KCL AT NODE B

$$\frac{V_A - V_B}{R_1} - \frac{V_B}{R_2} + \frac{V_C - V_B}{R_3} + \frac{V_D - V_B}{R_4} = 0$$

KCL AT NODE C

$$\frac{V_B - V_C}{R_3} + \frac{V_D - V_C}{R_3} - \frac{V_C}{R_6} = 0$$

KCL AT NODE D

$$\frac{V_C - V_D}{R_5} + \frac{V_B - V_D}{R_4} - \frac{V_D}{R_7} = 0$$

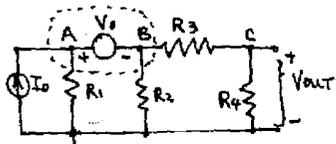
$$\therefore I_5 = \frac{V_C - V_D}{R_5}$$

2.23 (1)

SINCE WE HAVE A VOLTAGE SOURCE AS A BRANCH, WE MERGE NODE A & B FOR THE PURPOSE OF WRITING KCL EQUATIONS.

$$V_A = V_B + V_0 \quad \text{--- (a)}$$

$$\text{KCL AT A \& B } I_0 - \frac{V_A}{R_1} - \frac{V_B}{R_2} + \frac{V_C - V_B}{R_3} = 0 \quad \text{--- (b)}$$



$$\text{KCL AT C } \frac{V_B - V_C}{R_3} - \frac{V_C}{R_4} = 0 \quad \text{--- (c)}$$

ONLY THREE EQUATIONS ARE NECESSARY.

(2) SOLVING THE EQUATIONS GIVES

$$V_B = \frac{R_2(R_3 + R_4)(I_0 R_1 - V_0)}{(R_1 + R_2)(R_3 + R_4) + R_1 R_2}$$

$$V_C = \frac{R_4}{R_3 + R_4} \cdot V_B$$

$$= \frac{R_2 R_4 (I_0 R_1 - V_0)}{(R_1 + R_2)(R_3 + R_4) + R_1 R_2}$$

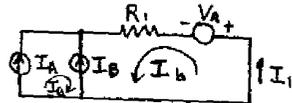
$$V_A = V_B + V_0$$

$$= \frac{R_1(R_3 + R_4)(V_0 + I_0 R_2) + R_1 R_2 V_0}{(R_1 + R_2)(R_3 + R_4) + R_1 R_2}$$

$$V_{OUT} = V_C$$

2.24

NORMALLY! WE WOULD ASSIGN TWO MESH CURRENTS AND WRITE TWO KVL EQUATIONS. HOWEVER, WE HAVE TWO LOOPS WITH CURRENT SOURCES HERE; SO WE CAN ONLY WRITE TWO EQUATIONS FROM KCL.



$$I_a = I_A \quad \text{--- (a)}$$

$$I_b = I_1 = -I_a - I_B \quad \text{--- (b)}$$