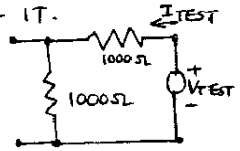
SINCE $\frac{V}{R}$ IS A CONSTANT (I_1), AS V INCREASES AND APPROACHES INFINITY, R ALSO APPROACHES INFINITY. THIS MEANS THAT R EVENTUALLY BECOMES AN OPEN CIRCUIT. i.e. THE NORTON EQUIVALENT IS JUST AN IDEAL CURRENT SOURCE. ■

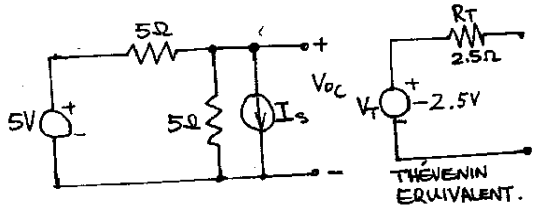
(3.11) SETTING THE CURRENT SOURCE TO ZERO MEANS OPEN-CIRCUITING IT.

$\therefore \; R_T = (1000+1000)\Omega = \underline{2\,K\Omega}$



■

(3.12)



TO DETERMINE R_T, REPLACE THE VOLTAGE SOURCE BY A SHORT CIRCUIT AND THE CURRENT SOURCE BY AN OPEN CIRCUIT. THEN $R_T = 5\Omega \,||\, 5\Omega = \underline{2.5\Omega}$

TO DETERMINE V_{OC}, WRITE A NODE EQUATION FOR THE OUTPUT NODE:

$$\frac{V_{OC}-5V}{5\Omega} + \frac{V_{OC}}{5\Omega} + I_S = 0 \quad \text{OR} \quad V_{OC} = \frac{5(1-I_S)}{2}$$

FOR $I_S = 2A$, $V_T = V_{OC} = \frac{5(1-2)}{2} = \underline{-2.5V}$

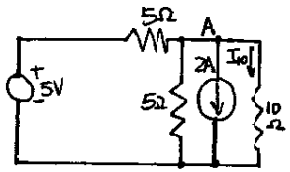
THEN THE THÉVENIN EQUIVALENT IS SHOWN ABOVE. ■

(3.13) SEE SOLUTION TO PROB. 3.12.

FOR $I_S = 1A$, $V_T = V_{OC} = 0$

THE THÉVENIN EQUIVALENT IS SIMPLY A 2.5 Ω RESISTOR. NOTE THAT THE FORMULA $R_T = -V_{OC}/I_{SC}$ CAN STILL BE USED. ■

(3.14) (1) AT NODE A

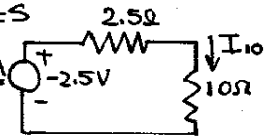


$$\frac{V_A-5V}{5\Omega} + \frac{V_A}{5\Omega} + 2A + \frac{V_A}{10\Omega} = 0$$

$\Rightarrow V_A = -2V$

THEN $I_{10} = \frac{V_A}{10\Omega} = \underline{-0.2A}$

(2) FROM THE SOLUTION TO PROBLEM 3.12, THE CIRCUIT BECOMES



$\therefore \; I_{10} = \frac{-2.5}{2.5+10} = \underline{-0.2A}$

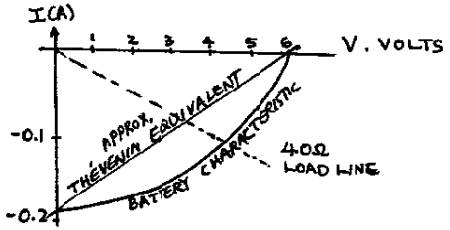
(3.15) AN IDEAL , VOLTMETER (AMMETER) IS AN OPEN (SHORT) CIRCUIT. THUS FROM FIG 3.38, $V_{oc} = 6V$ AND $I_{sc} = -0.19A$. IT FOLLOWS THAT THE CORRESPONDING THÉVENIN EQUIVALENT

CIRCUIT IS CHARACTERIZED BY $V_T = V_{oc} = 6V$,

$$R_T = -\frac{V_{oc}}{I_{sc}} = -\frac{6V}{-0.19A} \approx 33\Omega$$ AN

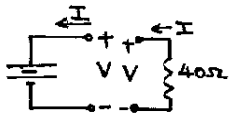
I-V CHARACTERISTIC GIVEN BY BY EQ. (3-1)

$$I = \frac{V}{R_T} - \frac{V_T}{R_T} = -\frac{1}{33\Omega}V \quad 0.19A.$$



THE TWO CHARACTERISTICS SHOWN DO NOT AGREE BECAUSE THE BATTERY IS NON-LINEAR AND HENCE HAS NO THÉVENIN EQUIVALENT, A THÉVENIN CIRCUIT IS ALWAYS REPRESENTED BY A LINEAR I-V CHARACTERISITIC. ■

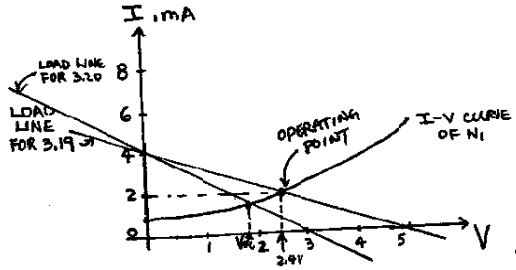
(3.16) FOR THE 40Ω RESISTOR, THE I-V CHARACTERISTIC IS



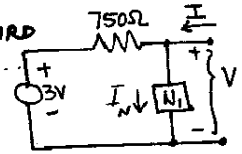
$$I = -\frac{V}{40\Omega}$$

BY THE GRAPHICAL METHOD PORTRAYED ABOVE WE CAN FIND THE VOLTAGE ACROSS THE RESISTOR AND THE CURRENT THROUGH IT FOR BOTH PARTS (a) & (b)

WE GET THE LOAD LINE. NOW THE INTESECTION OF THE I-V CURVE AND THE LOAD LINE GIVES THE CURRENT FLOWING THROUGH N_1 TO BE $\underline{2mA}$



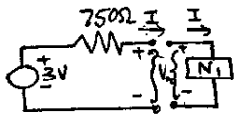
(3.20) NOTE: N_1 HAS THE WEIRD PROPERTY THAT $I_N(V=0) \neq 0$



$$\frac{3}{750} + I_{sc} - I_N(V=0) = 0$$

$$I_{sc} = -4\,mA + 1\,mA = -3\,mA$$

TO FIND V_{oc}, WE SPLIT THE CIRCUIT INTO A THÉVENIN SECTION AND THE NON-LINEAR ELEMENT. THE EQUATION OF THE LOAD LINE IS

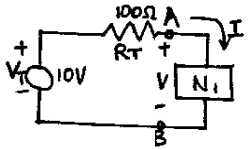


$$3 - 750I - V = 0$$

$$\Rightarrow I = -\frac{V}{750} + \frac{1}{250}$$

BY DRAWING THE LOAD LINE IN THE ABOVE GRAPH, WE GET $\underline{V_{oc} = 1.7\,VOLT}$

(3.21) THE I-V CHARACTERISTIC OF THE NONLINEAR ELEMENT IS



$$I = 0.002V^2 \quad \text{—— (a)}$$

(1) NODE A : $\dfrac{V_A - (V_B + V_T)}{R_T} + I = 0$

$$\Rightarrow V - V_T + IR_T = 0 \quad \text{—— (b)}$$

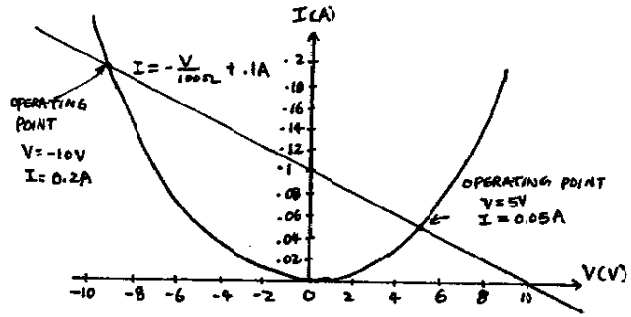
ELIMINATING I FROM THE TWO EQUATIONS RESULTS IN A QUADRATIC EQUATION FOR V:

$$V^2 + \frac{500}{R_T}V - \frac{500V_T}{R_T} = 0$$

FOR $R_T = 100\Omega$, $V_T = 10V$: $V = -10V$, $I = 0.2A$
$V = 5V$, $I = 0.05A$

THE CIRCUIT HAS TWO OPERATING POINTS.

(2) GRAPHICAL SOLUTION.



(3.31) WHEN $V_T = 5V$, $V \cong 2.6V$, $I \cong 2.2mA$ ACROSS N_1 i.e. $P = 2.6 \times 2.2 mW \cong 5.72 mW$

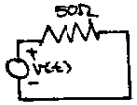
THEREFORE FROM (3) OF PROBLEM 3.29

P_{AV} ENTERING N_1 = INSTANTANEOUS POWER × DUTY CYCLE

$= 5.72 \times 25\% \ mW$

$= \underline{1.43 \ mW}$ ■

(3.32) $P_{AV} = \frac{1}{T}\int_0^T \frac{v^2(t)}{R}\,dt$



$= \frac{1}{0.002}\int_0^{0.002} \frac{\left(\frac{0.3}{0.002}t\right)^2}{50}\,dt$

$= \frac{1}{0.002}\left[\frac{0.3^2}{0.002^2}\frac{t^3}{3}(50)\right]_0^{0.002}$

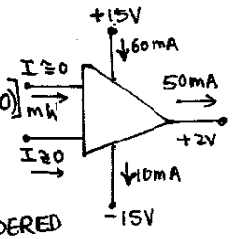
$= \frac{1}{0.002}\left[\frac{0.3^2(0.002)}{150}\right]$

$= \underline{0.6 mW}$ ■

(3.33) $P = P_1V_1 + P_2V_2 + P_3V_3$

$= [15(60) + (-15)(-10) + (2)(-50)]\ mW$

$= \underline{950 \ mW}$

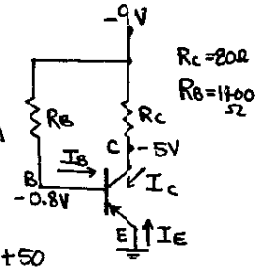


NOTE THAT CURRENT FLOWING INTO THE OP-AMP IS CONSIDERED POSITIVE. ■

(3.34) $I_B = \frac{-9-(-0.8)}{R_B}$

$= \frac{-8.2V}{1400\Omega} = -5.86 \ mA$

$I_C = \frac{-9(-5)}{80} = -50 mA$



$I_E = -(I_B + I_C) = 5.86 + 50$

$= 55.86 \ mA$

POWER DISSIPATED IN THE TRANSISTOR

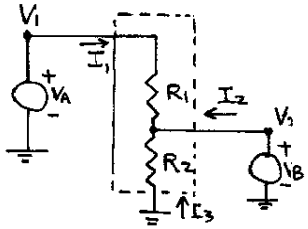
$= V_B I_B + V_C I_C + (0) I_E$

$= (-5.86m)(-0.8) + (-5)(-50m)$

$= \underline{254.7 \ mW}$ ■

(3.35) $I_1 = \frac{V_A - V_B}{R_1}$

$I_2 = \frac{V_B - 0}{R_2} - I_1$



(1) FROM EQT. 3.16

POWER DISSIPATED IN THE NETWORK

$= V_1 I_1 + V_2 I_2 + (0) I_3$

$= V_A\left(\frac{V_A - V_B}{R_1}\right) + V_B\left(\frac{V_B}{R_2}\right) - \left(\frac{V_A - V_B}{R_1}\right)V_B$

$= \underline{\underline{\frac{(V_A - V_B)^2}{R_1} + \frac{V_B^2}{R_2}}}$

(2) $P_{R1} = \frac{(V_A - V_B)^2}{R_1}$; $P_{R2} = \frac{(V_B - 0)^2}{R_2}$