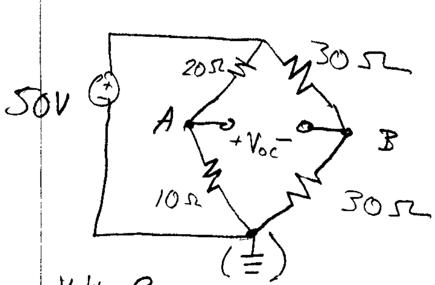
ENGR 210
FALL 2003
HW # 5
SOLUTIONS

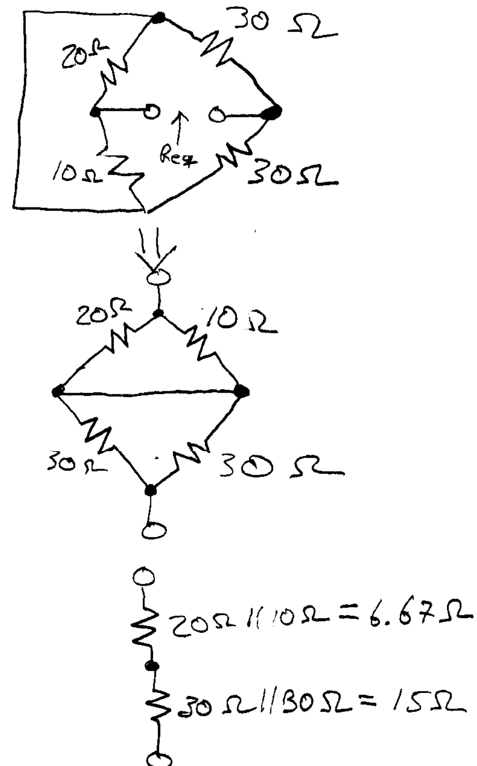
3-53) find V_{oc}:



Voltage Division: $V_A = 50\,V \cdot \frac{10\Omega}{10\Omega + 20\Omega}$
$= 16.7\,V$
$V_B = 50\,V \cdot \frac{30\Omega}{30\Omega + 30\Omega}$
$= 25\,V$

$V_{oc} = -8.3\,V = V_T$

R_{eq}:

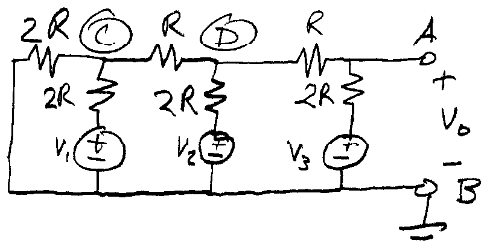


$$P_{MAX} = \frac{V_T^2}{4R_T}$$

$p_{max} = 0.801\,W$ for $R_L = R_{eq} = 21.67\Omega$

$R_{eq} = 21.67\Omega = R_T$

3-71) a)



central nodes can be ignored, have node-voltage of adjacent source

$$A: \left(\frac{1}{R} + \frac{1}{2R}\right)V_o - \frac{1}{R}V_D - \frac{1}{2R}V_3 = 0$$
$$C: \left(\frac{1}{2R} + \frac{1}{2R} + \frac{1}{R}\right)V_C - \frac{1}{R}V_D - \frac{1}{2R}V_1 = 0$$
$$D: -\frac{1}{R}V_o - \frac{1}{R}V_C + \left(\frac{1}{R} + \frac{1}{2R} + \frac{1}{R}\right)V_D - \frac{1}{2R}V_2 = 0$$

$$\begin{bmatrix} \frac{1}{R}+\frac{1}{2R} & 0 & -\frac{1}{R} \\ 0 & \frac{1}{2R}+\frac{1}{2R}+\frac{1}{R} & -\frac{1}{R} \\ -\frac{1}{R} & -\frac{1}{R} & \frac{1}{R}+\frac{1}{2R}+\frac{1}{R} \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{2R}V_3 \\ \frac{1}{2R}V_1 \\ \frac{1}{2R}V_2 \end{bmatrix}$$

Cramer's Rule: $V_0 = \frac{\Delta_{V_0}}{\Delta}$

$$\Delta_{V_0} = \begin{vmatrix} \frac{V_3}{2R} & 0 & -\frac{1}{R} \\ \frac{V_1}{2R} & \frac{2}{R} & -\frac{1}{R} \\ \frac{V_2}{2R} & -\frac{1}{R} & \frac{5}{2R} \end{vmatrix} = \frac{10V_3}{4R^3} + 0 + \frac{V_1}{2R^3} + \frac{2V_2}{2R^3} - \frac{V_3}{2R^3} - 0$$

$$= \frac{2v_1 + 4v_2 + 8V_3}{4R^3} = \frac{V_1 + 2v_2 + 4v_3}{2R^3}$$

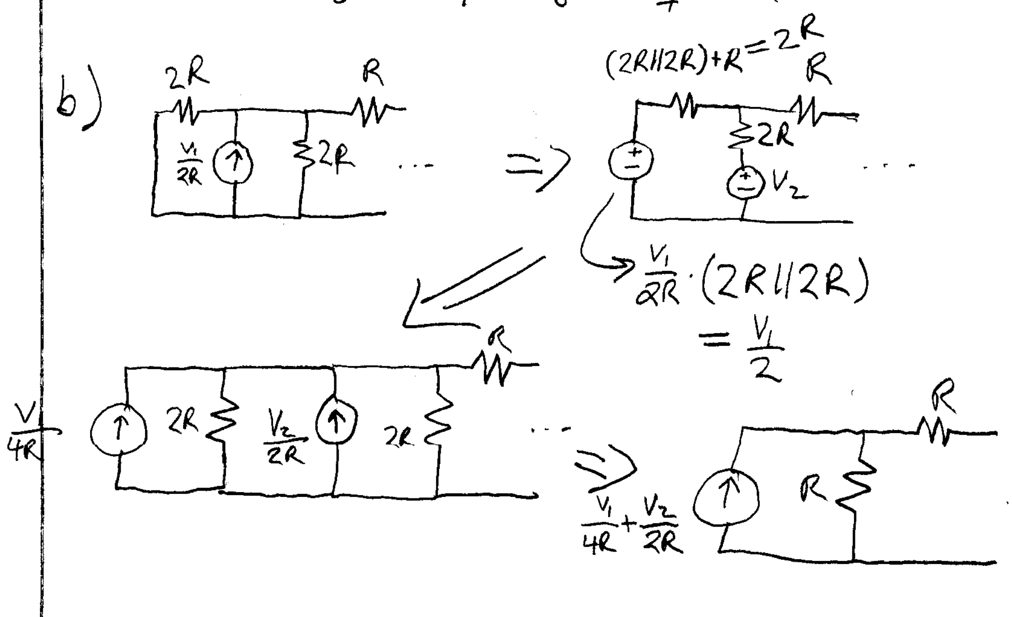
$$\Delta = \begin{vmatrix} \frac{3}{2R} & 0 & -\frac{1}{R} \\ 0 & \frac{2}{R} & -\frac{1}{R} \\ -\frac{1}{R} & -\frac{1}{R} & \frac{5}{2R} \end{vmatrix} = \frac{30}{4R^3} + 0 + 0 - \frac{2}{R^3} - \frac{3}{2R^3} - 0$$

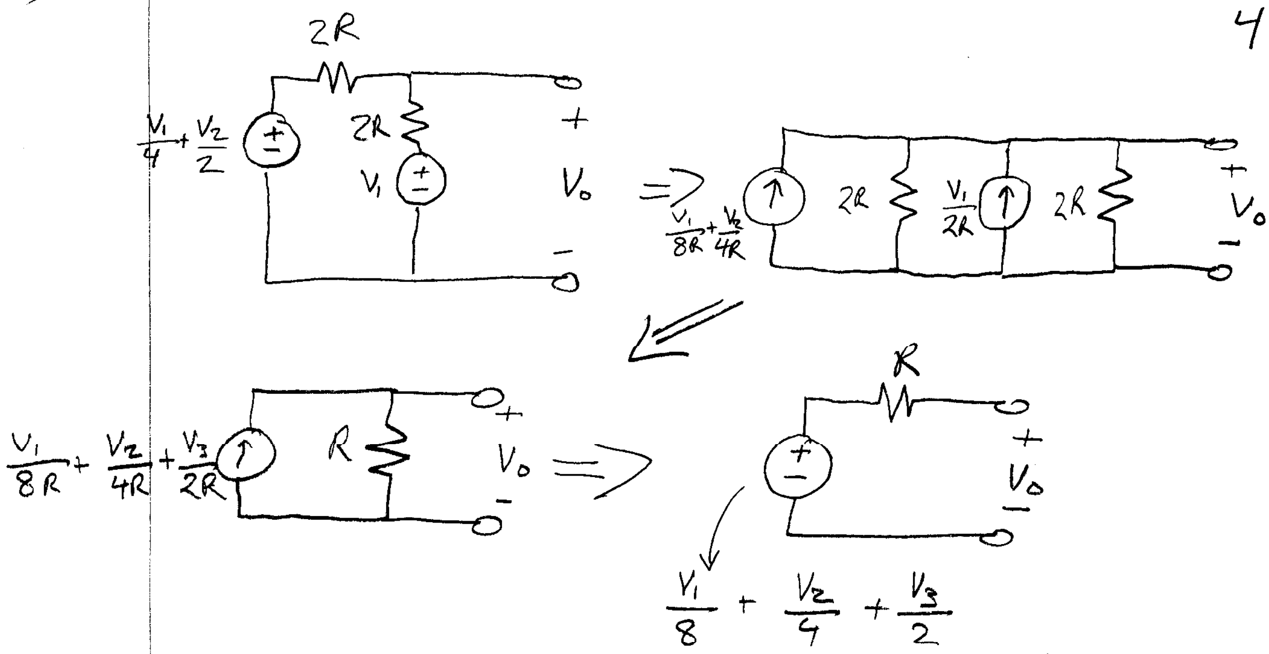
$$= \frac{8}{2R^3}$$

$$V_0 = \frac{V_1 + 2V_2 + 4V_3}{8}$$

$$= \frac{V_1}{8} + \frac{V_2}{4} + \frac{V_3}{8} \quad \text{q.e.d.}$$

b)





since no load (open circuit)

$$\boxed{V_o = \frac{V_1}{8} + \frac{V_2}{4} + \frac{V_3}{2}} \quad q.e.d.$$

c) either is acceptable, with explanation

3
4-2) $V_1 = i_1 \cdot 100\,\Omega$ current division: $i_1 = i_s \frac{100\,\Omega}{100\,\Omega + 100\,\Omega} = \frac{i_s}{2}$

$= i_s \cdot 50\,\Omega$

$V_o = i_o \cdot 2\,k\Omega$ Current division: $i_o = -10 i_1 \cdot \frac{1\,k\Omega}{1k\Omega + 2k\Omega}$

$= -3.33 i_1$

$= -1.67 i_s$

$= -i_s \cdot 3.33\,k\Omega$

$\boxed{\frac{i_o}{i_s} = -1.67}$

$\frac{V_o}{V_s} = \frac{-3.33\,k\Omega}{50\,\Omega}$

$\boxed{\frac{V_o}{V_s} = -66.7}$

$p = iV$

$= i_s^2 \cdot 50\,\Omega$

$\boxed{p = 200\,\mu W \text{ supplied}}$

$= i_s^2 \cdot 5.56\,k\Omega$

$\boxed{p = 22.2\,mW \text{ delivered}}$

4) 4-5) a) by KVL: $V_1 = V_{R_E}$

by Ohm's Law: $(i_s - i_x)5k\Omega = (i_x + 199 i_x)450\Omega$

$$5000 i_s - 5000 i_x = 90000\, i_x$$

$$5000 i_s = 95000\, i_x$$

$$i_x = \frac{i_s}{19}$$

$i_2 = -199 i_x$

$\boxed{i_2 = -262\mu A}$

$V_2 = i_2 \cdot 1k\Omega = -262mV$

$v_1 = (i_s - i_x)\,5k\Omega = 118mV$

$\boxed{\frac{V_2}{V_1} = -2.21}$

b) $i_1 = i_x = 1.32\mu A$

$R_{in} = 90k\Omega$

5) 4-12) by KVL: $V_s = V_x - \mu V_x$

$$V_x(1-\mu) = V_s$$

$$V_x = \frac{V_s}{1-\mu}$$

$V_{oc} = -\mu V_x = \frac{-\mu V_s}{1-\mu}$

$i_{sc} = -\frac{\mu V_x}{R_o}$

$$R_T = \frac{V_{oc}}{i_{sc}} = \frac{-\mu V_x}{-\mu V_x / R_o} = R_o$$