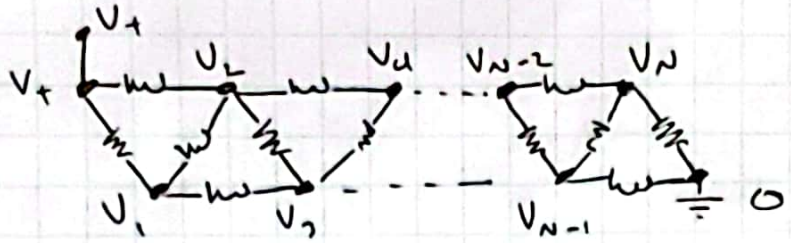
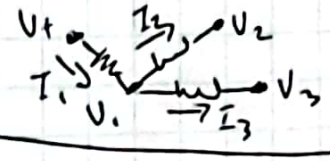


& all resistors have resistance = R Ω

using junction rule: $\sum I_i = 0$

@ V_1 junction:



$I_1 - I_2 - I_3 = 0$

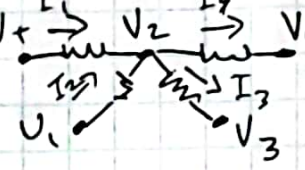
$\Delta V_1/R - \Delta V_2/R - \Delta V_3/R = 0$

$(V_+ - V_1) - (V_1 - V_2) - (V_1 - V_3) = 0$

$V_+ - 3V_1 + V_2 + V_3 = 0$

$3V_1 - V_2 - V_3 = V_+$

@ V_2 junction:



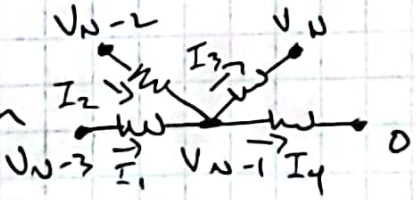
$I_1 + I_2 - I_3 - I_4 = 0$

$0 = (V_+ - V_2) + (V_1 - V_2) - (V_2 - V_3) - (V_2 - V_4)$

$0 = V_+ - 4V_2 + V_1 + V_3 + V_4$

$-V_1 + 4V_2 - V_3 - V_4 = 0$

@ V_{N-1} junction



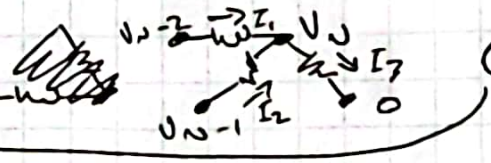
$0 = I_1 + I_2 + (-I_3) - I_4$

$0 = (V_{N-3} - V_{N-1}) + (V_{N-2} - V_{N-1}) - (V_{N-1} - V_N) - (V_{N-1} - 0)$

$0 = V_{N-3} + V_{N-2} - 4V_{N-1} + V_N$

$= -V_{N-3} - V_{N-2} + 4V_{N-1} - V_N$

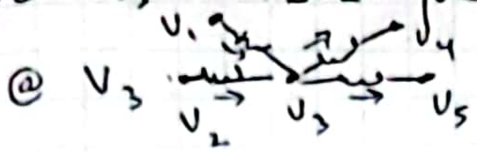
@ V_N junction



$0 = (V_{N-2} - V_N) + (V_{N-1} - V_N) - (V_N - 0)$

$0 = -V_{N-2} - V_{N-1} + 3V_N$

For V_3 – V_{U-2} junctions



: 2 currents in
2 currents out
so all will have $0 = I_{in1} + I_{in2} - I_{out1} - I_{out2}$

all currents are equal to

$$I_i = \Delta V_i / R = \begin{cases} \frac{V_{i-2} - V_i}{R} \\ \frac{V_{i-1} - V_i}{R} \\ \frac{V_i - V_{i+1}}{R} \\ \frac{V_i - V_{i+2}}{R} \end{cases}$$

$i \neq 1, 2, U-1, N$

At i^{th} junction $0 = \sum I_i = \frac{1}{R}[(V_{i-2} - V_i) + (V_{i-1} - V_i) - \ldots - (V_i - V_{i+1}) - (V_i - V_{i+2})]$

$$0 = V_{i-2} + V_{i-1} + V_{i+1} + V_{i+2} - 4V_i$$
$$= -V_{i-2} - V_{i-1} + 4V_i - V_{i+1} - V_{i+2}$$

Putting this into matrix form: $\vec{A}\vec{v} = \vec{w}$

$$\vec{A} = \begin{bmatrix} 3 & -1 & -1 & & & & \\ -1 & 4 & -1 & -1 & & & \\ -1 & -1 & 4 & -1 & -1 & & \\ & -1 & -1 & 4 & -1 & -1 & \\ & & \ddots & \ddots & \ddots & \ddots & \ddots \\ & & & -1 & 4 & -1 & -1 \\ & & & & -1 & -1 & 3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ \vdots \\ V_{U-1} \\ V_N \end{bmatrix} \quad \vec{w} = \begin{bmatrix} V_+ \\ V_+ \\ 0 \\ 0 \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

- all blank elements are 0

$$\vec{A} = \begin{pmatrix} 3 & -1 & -1 & & & & & \\ -1 & 4 & -1 & -1 & & & & \\ & -1 & -1 & 4 & -1 & -1 & & \\ & & -1 & -1 & 4 & -1 & -1 & \\ & & \vdots & \vdots & & & & \\ & & -1 & -1 & 4 & -1 & -1 & \\ & & & & -1 & -1 & 34 & -1 \\ & & & & & -1 & -1 & 3 \end{pmatrix}$$

all blank space are zero

$$\vec{v} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ \vdots \\ v_{N-1} \\ v_N \end{pmatrix} \qquad \vec{w} = \begin{pmatrix} v_+ \\ v_+ \\ 0 \\ 0 \\ \vdots \\ 0 \end{pmatrix}$$