e^- $\quad q = -1.6 \times 10^{-19}\ C$

$I = \dfrac{\text{charge}}{\text{time}}$ amps $\quad 1A = \dfrac{1C}{s}$

Energy?

$F_e = qE$

$W = \int F\,dx = \int qE\,dx$

$-\Delta U = \int qE\,dx$

$$\frac{\Delta U}{q} = -\int E\,dx$$

potential energy / charge

= Voltage (electric potential)

240 Reminder

$$E = -\nabla \phi_e$$

↑ electric potential

Ohm's Law

$V = IR$ → resistance Ω

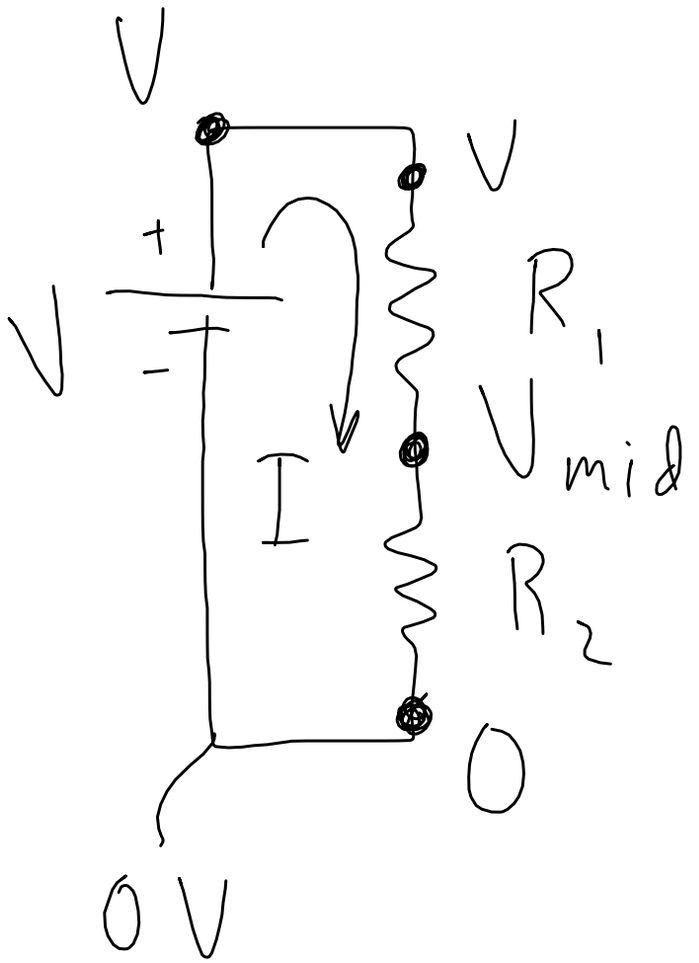
$V = \frac{I}{G}$ or $I = GV$

↑ conductance

B

↓

A ~~~ potentiometer



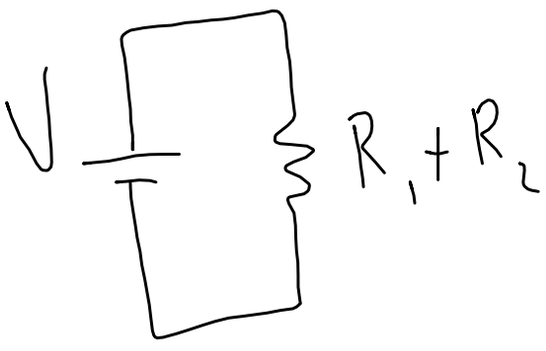
$$V - V_{mid} = I R_1$$

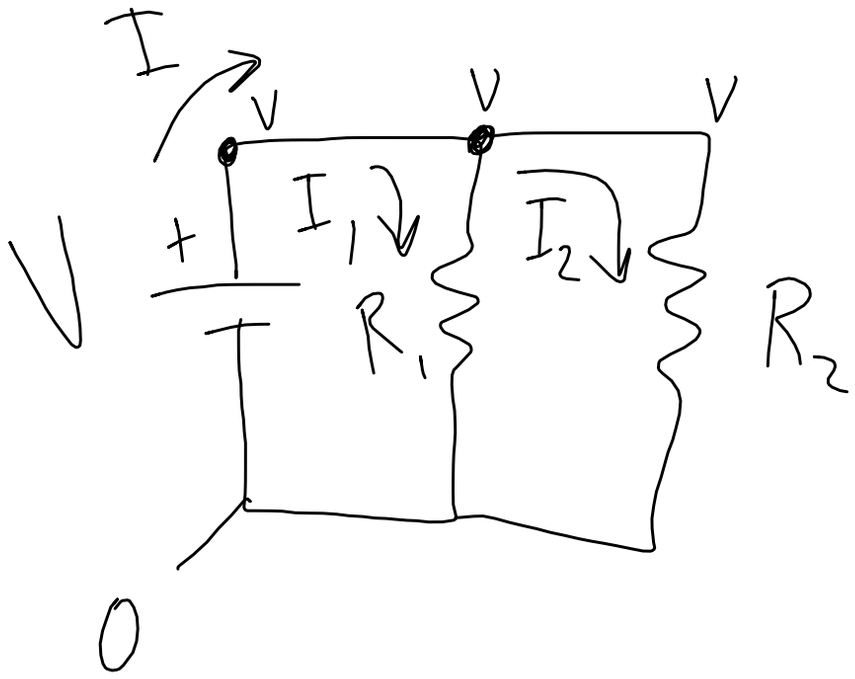
$$V_{mid} - 0 = I R_2$$

$$I = \frac{V - V_{mid}}{R_1}$$

$$= \frac{V - I R_2}{R_1}$$

$$V = I(R_1 + R_2) \Rightarrow$$





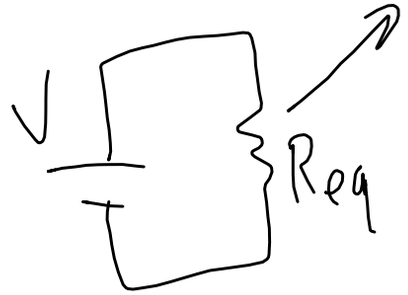
$$I = I_1 + I_2$$

$$V = I_1 R_1$$

$$V = I_2 R_2$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

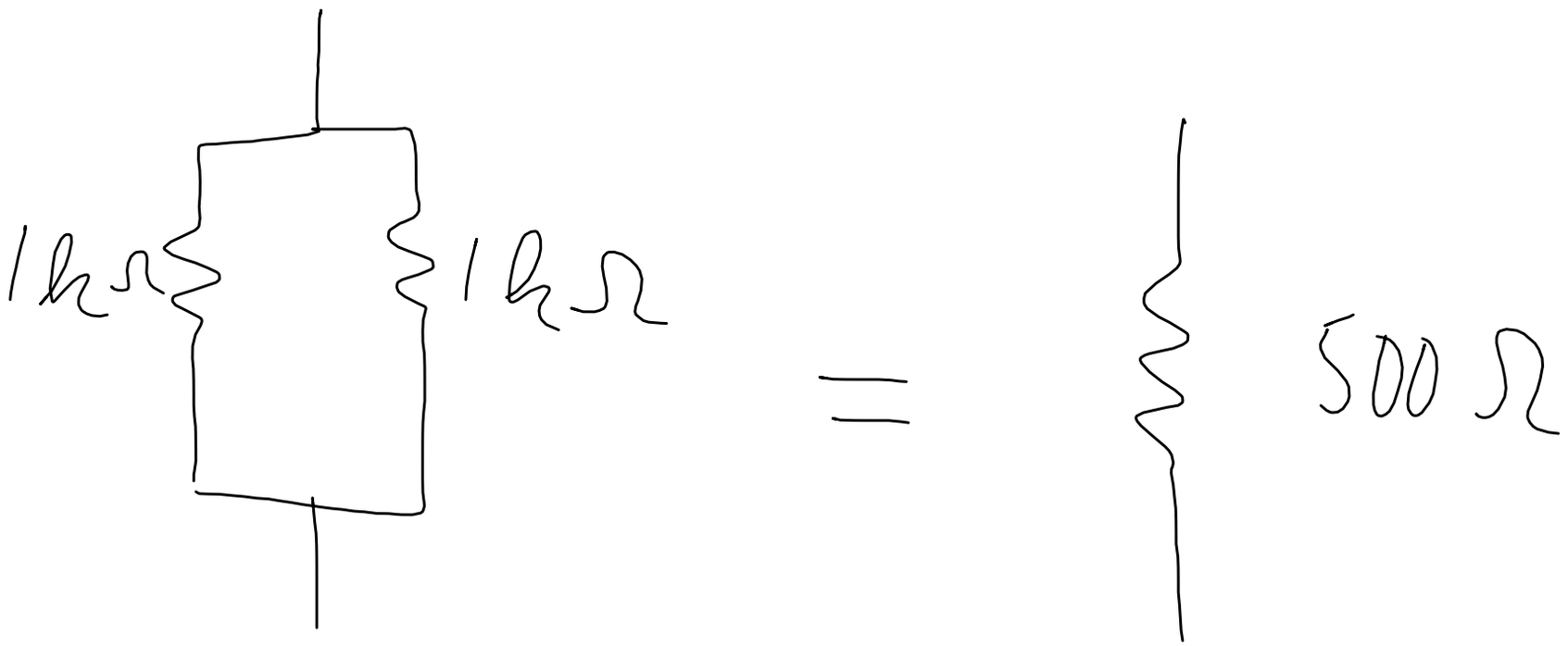
$$V = I\left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} \Rightarrow$$



$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

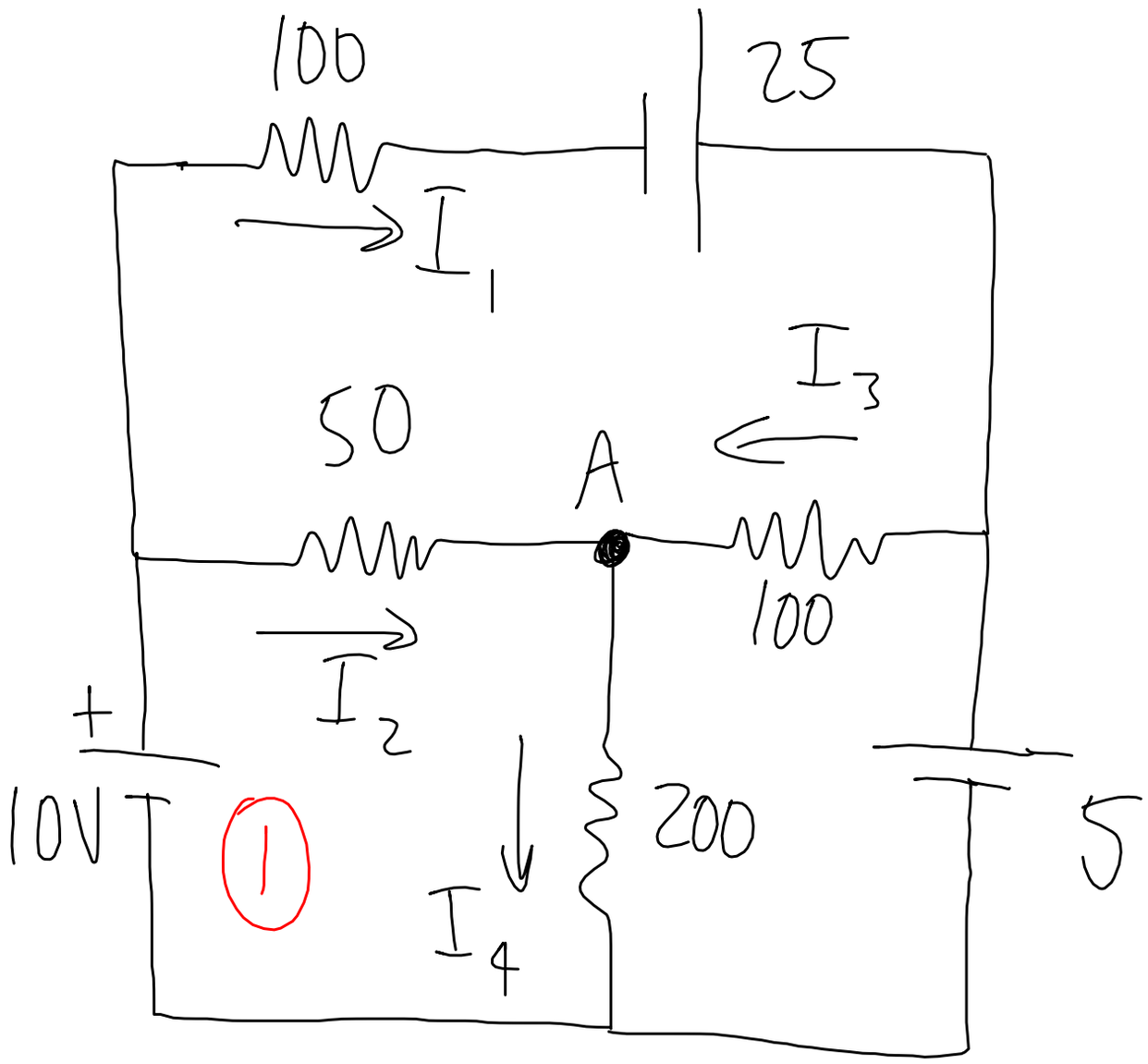


Power $P = \frac{\text{Work or energy}}{\text{time}} = \frac{V \cdot \boxed{Q}}{\boxed{t}}$

If $P_{max} = \frac{1}{4} W$ $= VI$

$+ V_{max} = 10\,V$ $= I^2 R$

$R_{min} = \frac{10^2}{.25} = 400\,\Omega$ $= \frac{V^2}{R}$



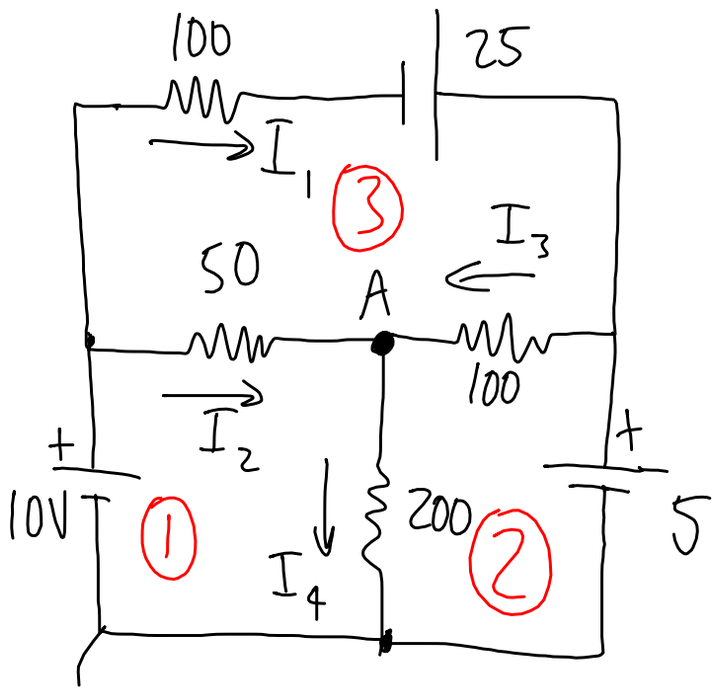
$V_A = ?$

Kirchhoff's Laws

KVL ⇒ cons of Energy

KCL ⇒ cons of charge

(1) $10 - I_2 50 - I_4 200 = 0$



(2) $200 I_4 + 100 I_3 - 5 = 0$

(3) $-100 I_1 + 25 - 100 I_3 + 50 I_2 = 0$

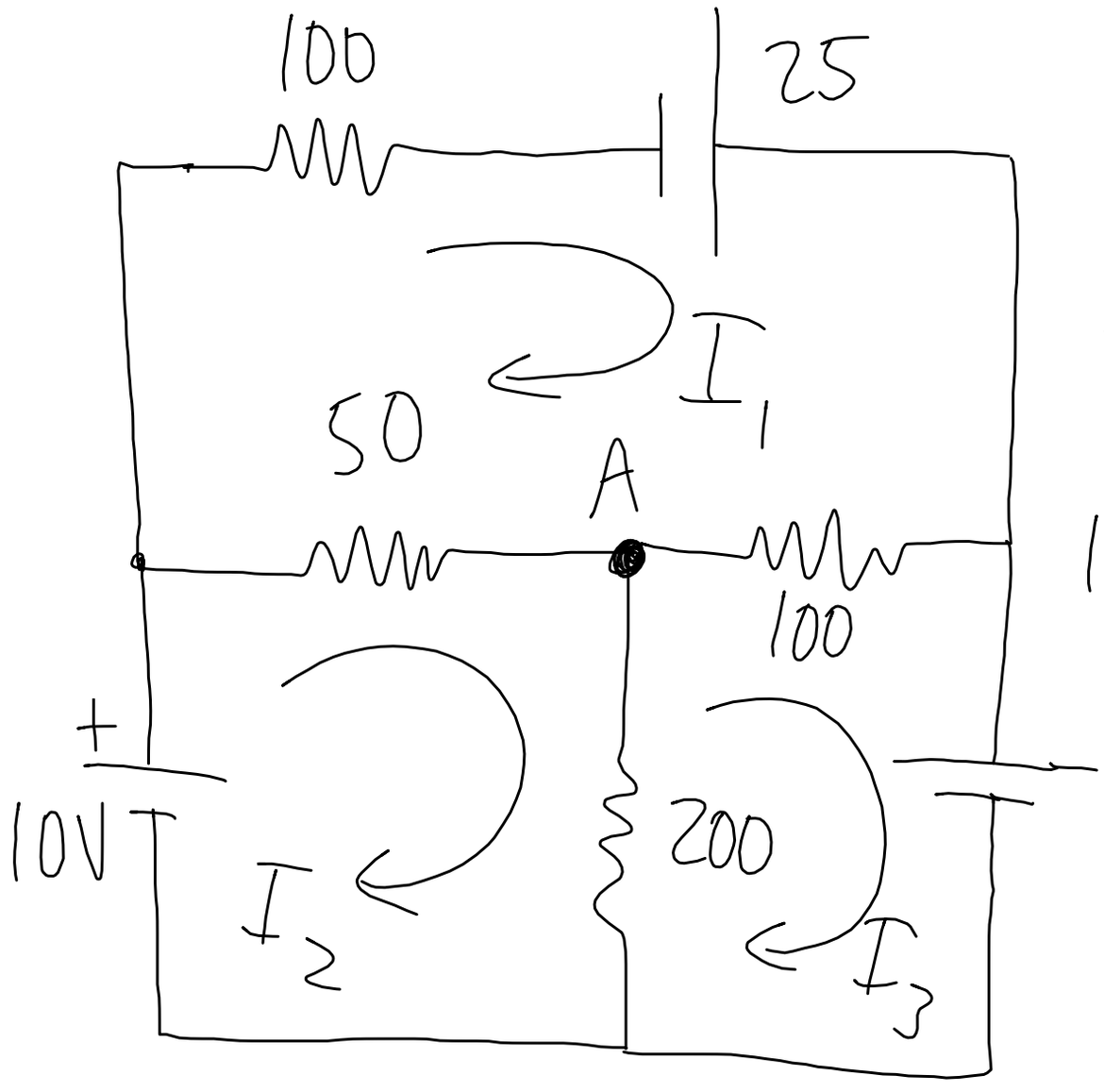
KCL: $I_2 + I_3 = I_4$

With Mathematica

$I_1 = 0.3\,A \quad I_2 = 0.05714\,A$

$I_3 = -0.02143\,A \quad I_4 = .035714$

$$\therefore V_A = 10 - 50(.05714) = 7.143\ V$$

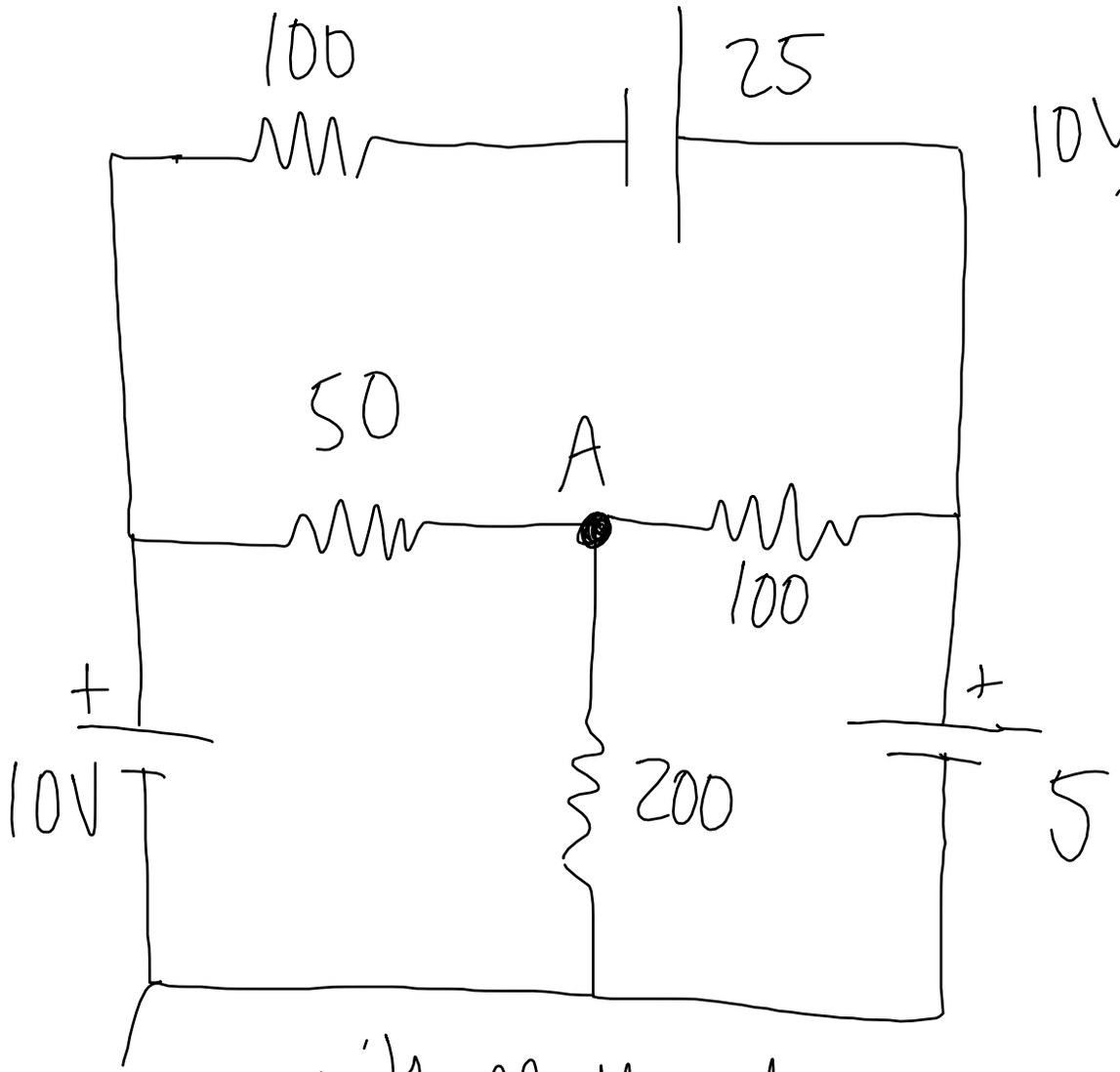


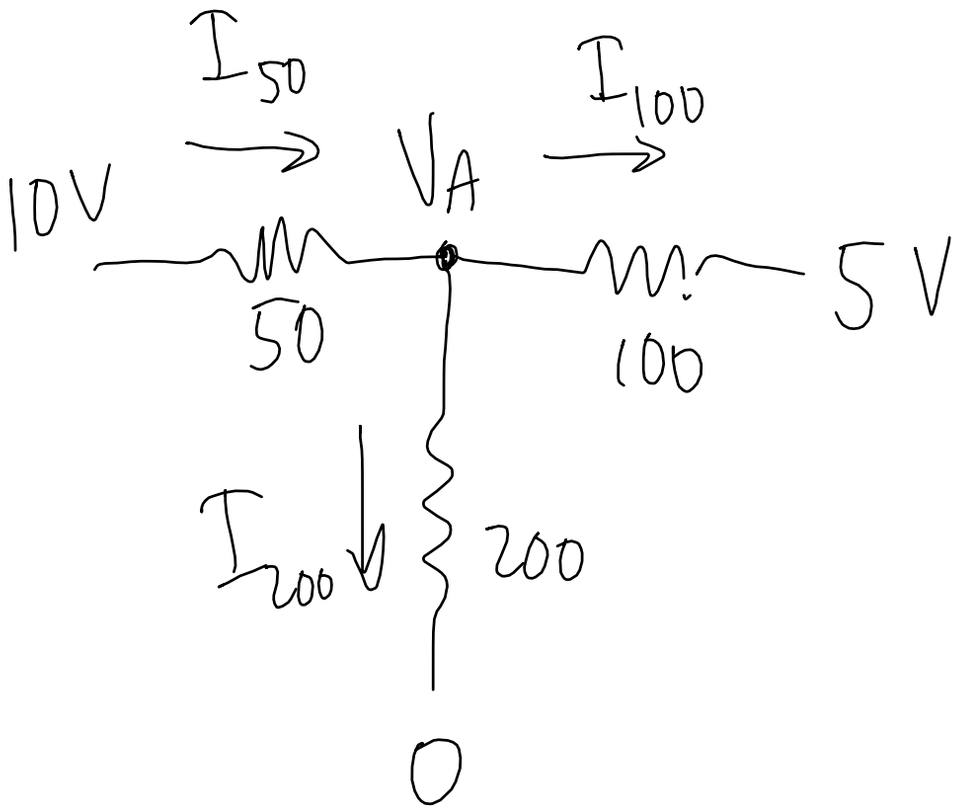
$$-100I_1 + 25 - 100I_1 + 100I_3$$

$$-50I_1 + 50I_2 = 0$$

$$10 - 50I_2 + 50I_1 - 200I_2 + 200I_3 = 0$$

$$-200I_3 + 200I_2 - 100I_3 + 100I_1 - 5 = 0$$





with Mathematica:

$$10 - V_A = 50\, I_{50}$$

$$V_A - 5 = 100\, I_{100}$$

$$V_A = 200\, I_{200}$$

$$I_{50} = I_{100} + I_{200}$$

$V_A = 7.14286$ $I_{50} = 0.05714$

$I_{100} = 0.02143$ $I_{200} = 0.035714$