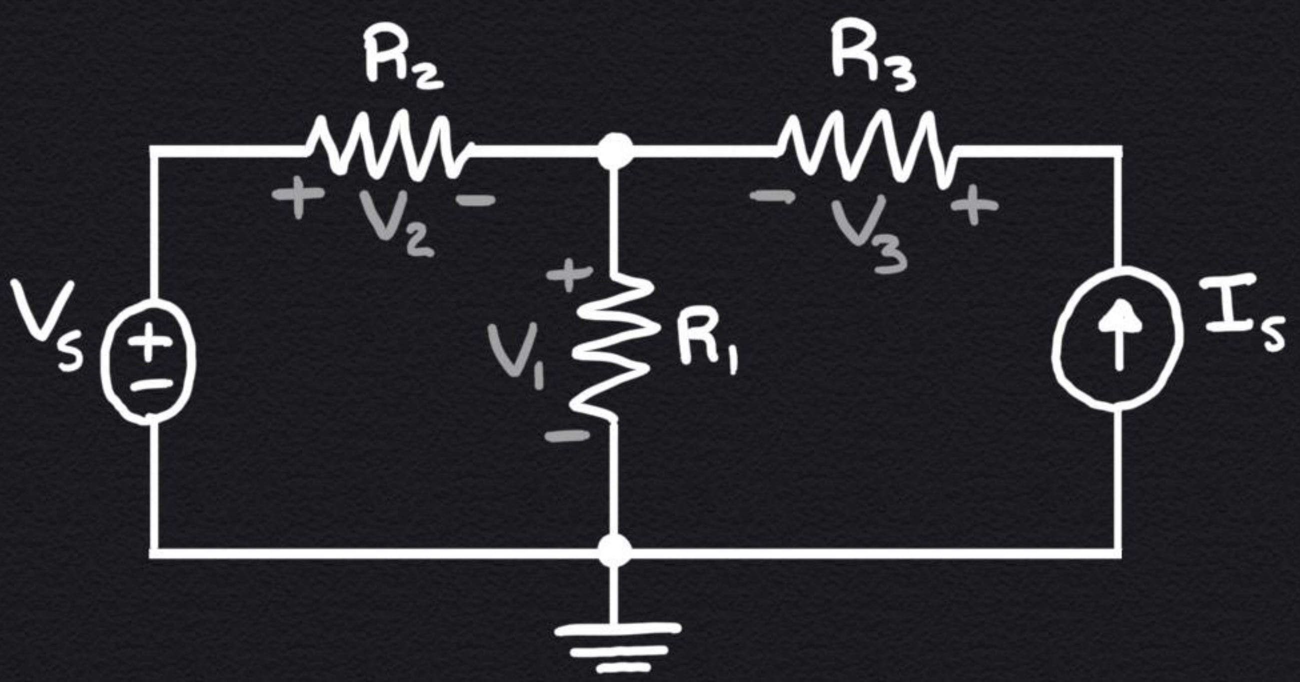
① Superposition

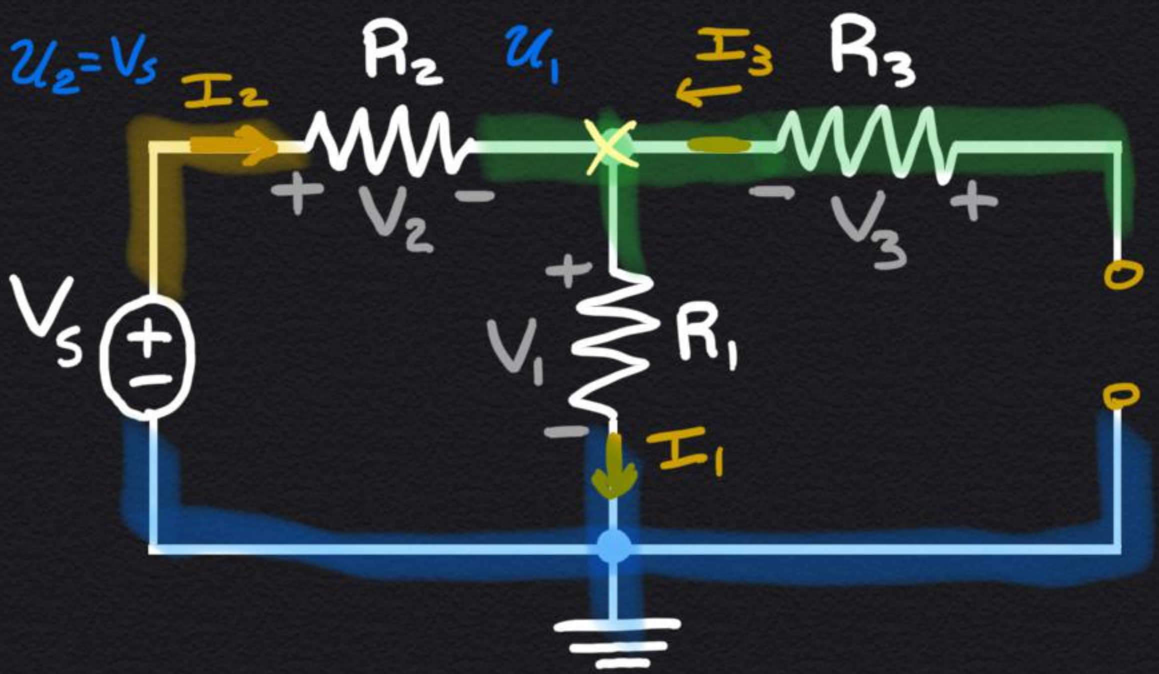
i. Use superposition to solve for resistor voltages

ii. For (b) and (c), identify power generated/dissapated. Is energy conserved?

a)



Case 1: $I_s = 0$



$I_3 = 0$

$$I_2 + I_3 - I_1 = 0 \quad (I_3 \to 0)$$

$$\left(\frac{V_s - u_1}{R_2}\right) + 0 - \left(\frac{u_1 - 0}{R_1}\right) = 0$$

$$\left(\frac{V_s}{R_2}\right) = u_1\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

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

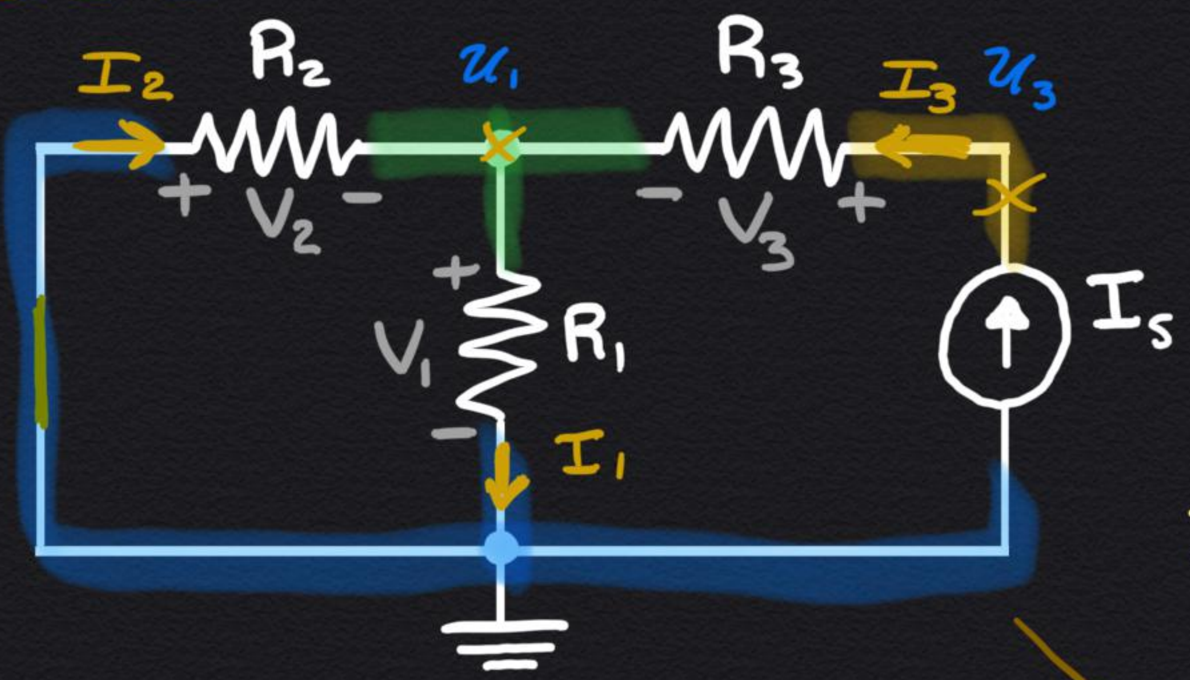
$$u_1 = V_s\left(\frac{R_1}{R_1 + R_2}\right)$$

$$V_1 = u_1 - 0 = V_s\left(\frac{R_1}{R_1 + R_2}\right)$$

$$V_2 = V_s - u_1 = V_s\left(\frac{R_2}{R_1 + R_2}\right)$$

$$V_3 = 0$$

Case 2: $V_s = 0$



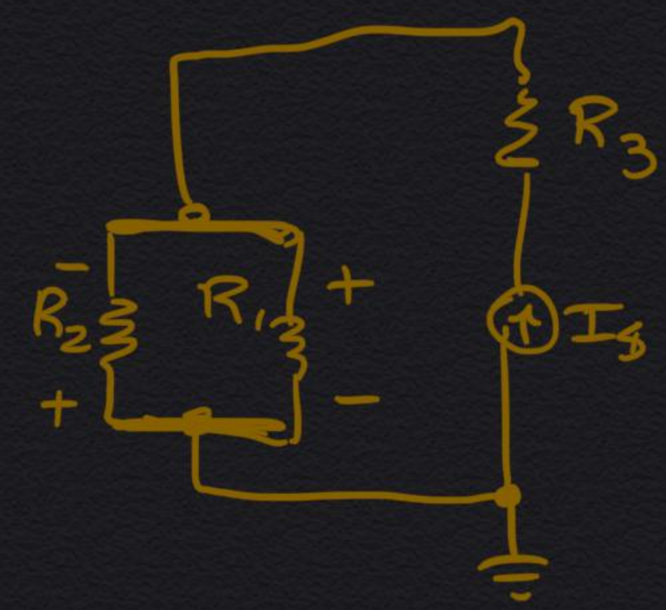
$$V_3 = \cancel{I_3}^{\,I_s} R_3$$

$$I_3 = I_s$$

$$I_2 + \cancel{I_3}^{\,I_s} - I_1 = 0$$

$$\left(\frac{0-u_1}{R_2}\right) + I_s - \left(\frac{u_1-0}{R_1}\right) = 0$$

$$I_s = u_1 \underbrace{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}_{\frac{R_2+R_1}{R_1 R_2}} \rightarrow u_1 = I_s\left(\frac{R_1 R_2}{R_1+R_2}\right)$$



$$V_1 = u_1 - 0 = I_s\left(\frac{R_1 R_2}{R_1 + R_2}\right)$$

$$V_2 = 0 - u_1 = -I_s\left(\frac{R_1 R_2}{R_1 + R_2}\right)$$

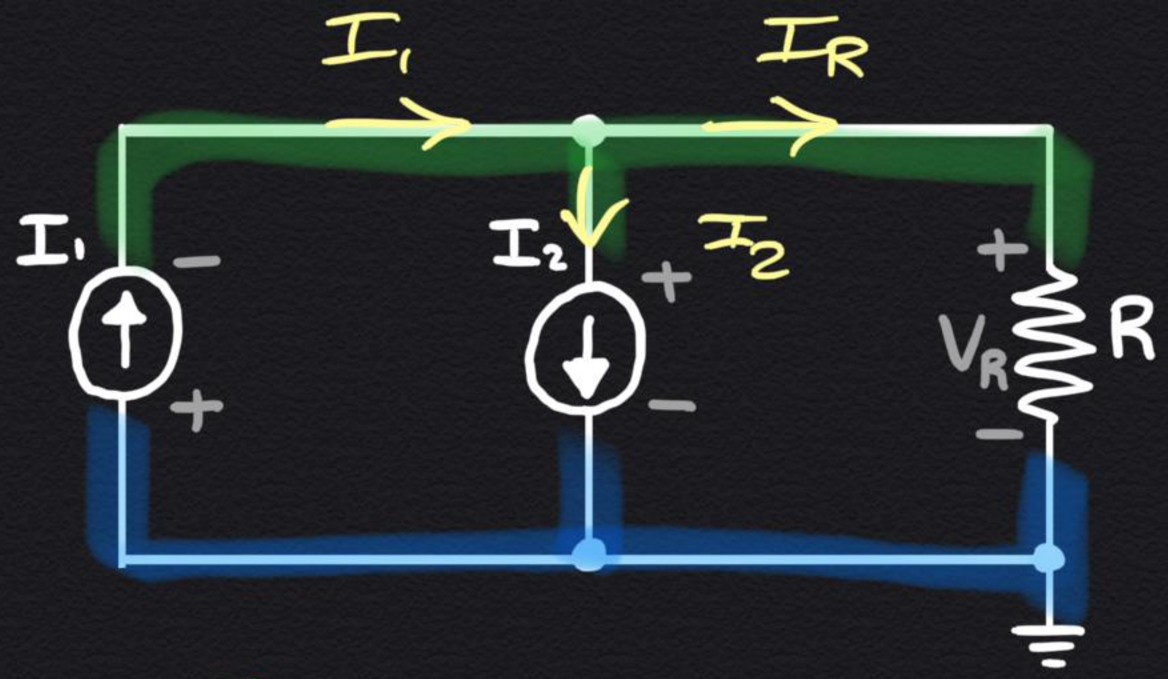
$$V_3 = u_3 - u_1 = I_s R_3$$

$$V_2 = V_s\left(\frac{R_2}{R_1+R_2}\right) - I_s\left(\frac{R_1 R_2}{R_1 + R_2}\right)$$

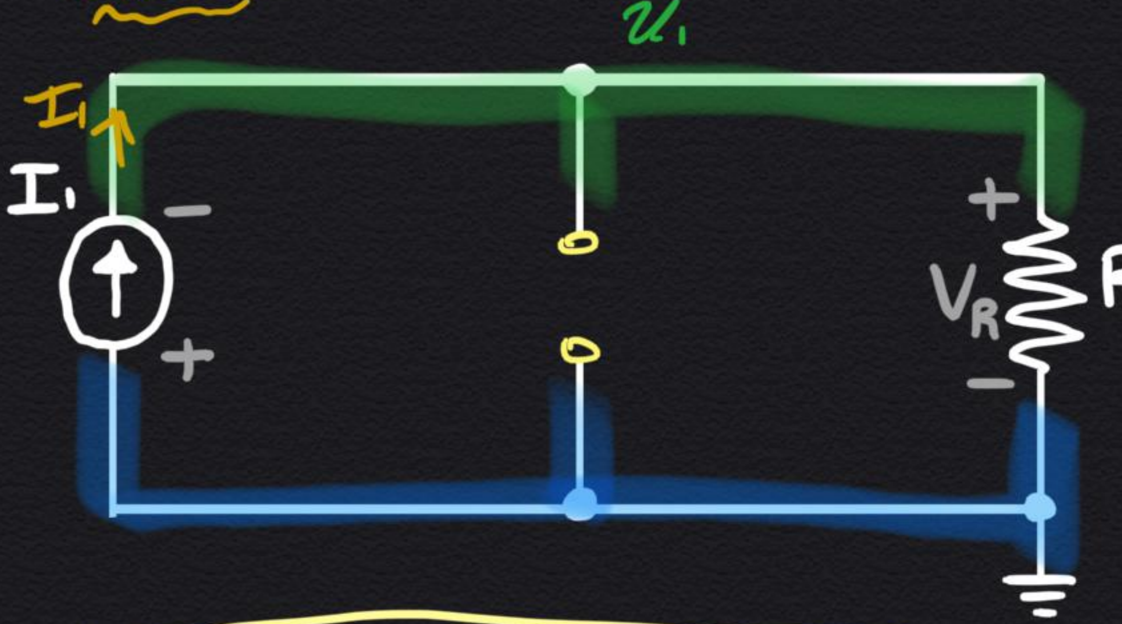
$$V_1 = V_s\left(\frac{R_1}{R_1+R_2}\right) + I_s\left(\frac{R_1 R_2}{R_1 + R_2}\right)$$

$$V_3 = I_s R_3$$

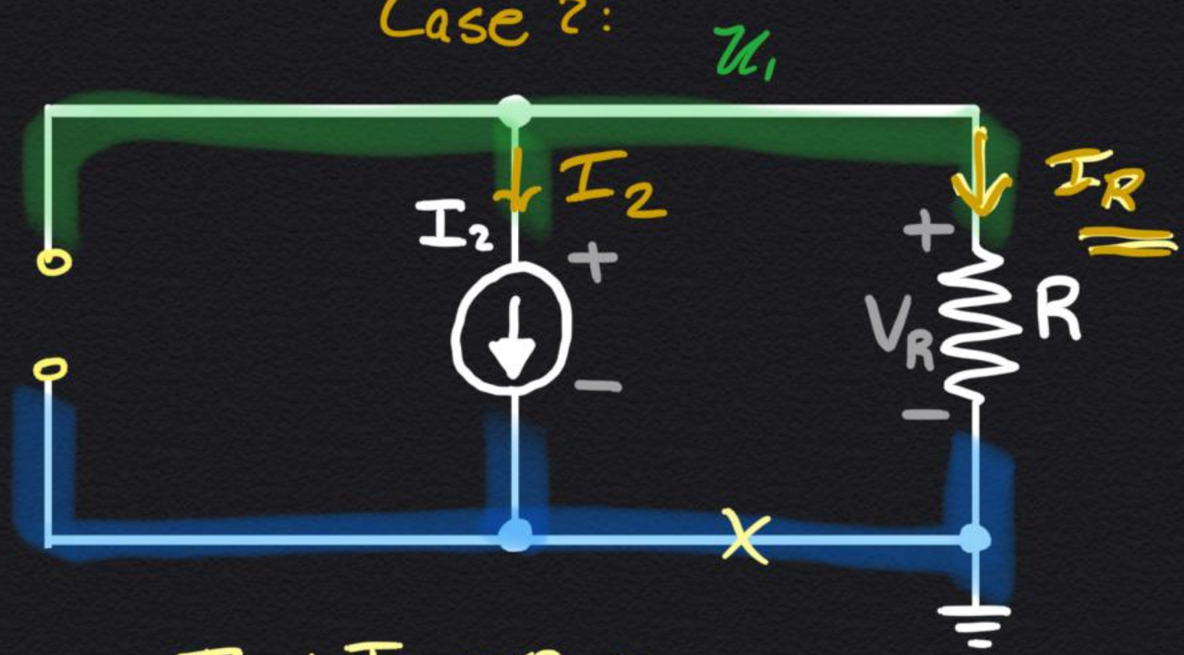
b)



Case 1:



Case 2:



$$V_R = u_1 - 0 = I_1 R$$

$$I_2 + I_R = 0 \rightarrow I_R = -I_2$$

$$V_R = u_1 - 0 = -I_2 R$$

$$V_R = (I_1 - I_2) R$$

Power (dissapated): $P = IV$ ~ $P = \frac{1}{R} V^2 = R I^2$

$$P_1 = I_1 (0 - u_1) \rightarrow \quad = -I_1 (I_1 - I_2) R$$

$$P_2 = I_2 (u_1 - 0) \quad = I_2 (I_1 - I_2) R$$

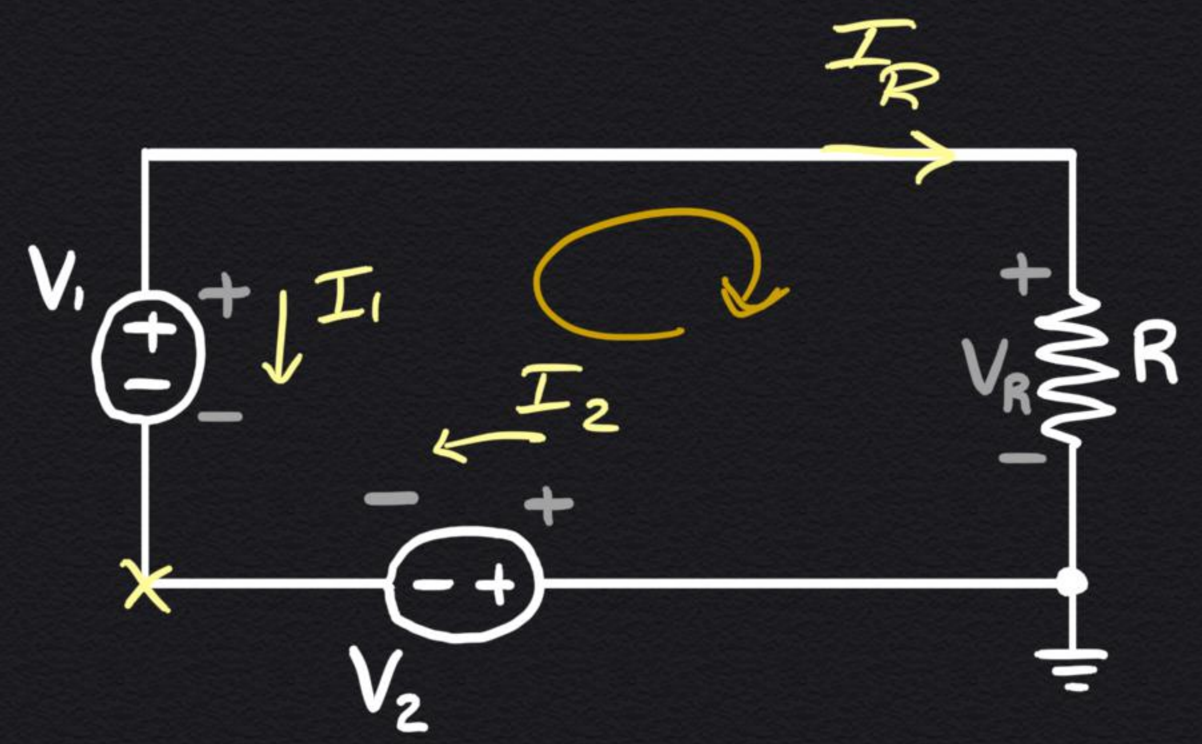
$$P_R = (I_1 - I_2)(I_1 - I_2) R = (I_1 - I_2)^2 R$$

$$P_1 + P_2 = R \left(I_1 I_2 - I_1^2 + I_1 I_2 - I_2^2 \right)$$

$$= -R \left(I_1^2 - 2 I_1 I_2 + I_2^2 \right) = -R (I_1 - I_2)^2$$

$$P_1 + P_2 + P_R = -R (I_1 - I_2)^2 + R (I_1 - I_2)^2 = 0$$ ✓

c]



$I_1 + I_2 = 0$

$I_R - I_2 = 0$

$I_R = I_2 = -I_1$

KVL: $V_R + V_2 - V_1 = 0$

$\boxed{V_R = (V_1 - V_2)} = I_R R$

$I_R = \frac{(V_1 - V_2)}{R}$

$P_1 = I_1 V_1 = -I_R V_1$

$P_2 = I_2 V_2 = +I_R V_2$

$P_R = I_R V_R = I_R^2 R$

$(I_R \cdot R)$

$$P_1 + P_2 + P_R = I_R R \left(\underbrace{-\frac{V_1}{R} + \frac{V_2}{R}}_{-\left(\frac{V_1 - V_2}{R}\right)} + I_R \right) = I_R R(-I_R + I_R) = 0$$

✓