SHOW ALL WORK!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

Given the circuit shown.

(a) Calculate the magnitude of the current in $R_1$.
(b) Calculate the magnitude of the current in $R_2$.
(c) Calculate the power being dissipated in $R_3$.
(d) Determine the direction of the conventional current in $R_2$ (to the right or to the left). Clearly state your reasoning.

\[ \varepsilon_1 = 12.00 \text{ V} \quad R_2 = 25 \Omega \\
\varepsilon_2 = 3.50 \text{ V} \quad R_3 = 100 \Omega \\
R_1 = 200 \Omega \quad R_4 = 150 \Omega \]

9 points are available for setting up a system of equations that allows you to solve for the currents in the circuit.

4 points for solving for the current in $R_1$ with correct units and significant figures.

4 points for solving for the current in $R_2$ with correct units and significant figures.

4 points for finding either the current in $R_3$ or the potential difference across $R_3$ and using it to find power.

4 points for correctly justifying the direction of the current.

Draw the simplified circuit:

\[ R_P = \frac{R_3 R_4}{R_3 + R_4} = \frac{100 \cdot 150}{100 + 150} = 60 \Omega \]

$R_P$ is the equivalent resistance of the two resistors $R_3$ and $R_4$.

\[ R_P = \frac{1}{\frac{1}{R_3} + \frac{1}{R_4}} \]

\[ \frac{R_1}{R_P} = 1 \]

\[ I_1 = I_P \]

\[ \frac{R_1}{R_2} = \frac{1}{2} \]

\[ \varepsilon_1 = \varepsilon_2 \]

\[ I_2 = I_P = \frac{\varepsilon_1}{R_1} = \frac{\varepsilon_2}{R_2} \]

\[ I_P = \frac{\varepsilon_1}{R_1} = \frac{\varepsilon_2}{R_2} \]

\[ \frac{R_1}{R_2} = \frac{1}{2} \]

\[ \varepsilon_1 = \varepsilon_2 \]

\[ I_1 = I_P \]

\[ I_2 = I_P = \frac{\varepsilon_1}{R_1} = \frac{\varepsilon_2}{R_2} \]
There are 3 unknown currents, I_1, I_2, I_p. I arbitrarily drew each direction.

**Junction:** \( I_1 + I_2 = I_p \) \hspace{1cm} (1)

**CW left loop:** \( \varepsilon_1 - R_1 I_1 - R_p I_p = 0 \) \hspace{1cm} (2)

**CCW right loop:** \( \varepsilon_2 - R_2 I_2 - R_p I_p = 0 \) \hspace{1cm} (3)

Solve (1) for \( I_1 = I_p - I_2 \) and substitute into (2)

\[ \varepsilon_1 - R_1 (I_p - I_2) - R_p I_p = 0 \]

Solve this equation for \( I_2 \)

\[ I_2 = \frac{(R_1 + R_p)I_p - \varepsilon_1}{R_1} \]

Substitute into (3)

\[ \varepsilon_2 - R_2 \left[ \frac{(R_1 + R_p)I_p - \varepsilon_1}{R_1} \right] - R_p I_p = 0 \]

Solve for \( I_p \)

\[ \left[ \frac{R_2 (R_1 + R_p) + R_p}{R_1} \right] I_p = \varepsilon_2 + \frac{R_2}{R_1} \varepsilon_1 \]

\[ I_p = \frac{\varepsilon_2 + \frac{R_2}{R_1} \varepsilon_1}{\frac{R_2 (R_1 + R_p)}{R_1} + R_p} = \frac{3.5 + \left( \frac{25}{200} \right) 12}{25(200 + 60) + 60} = 0.054054 \, A \]
From above

\[ I_2 = \frac{(R_1 + R_p)I_p - E_1}{R_1} = \frac{(200 + 60)(0.054054) - 12}{200} = 0.01027 \text{ A} \]

and

\[ I_1 = I_p - I_2 = 0.054054 - 0.01027 = 0.04378 \text{ A} \]

a) \[ I_1 = 0.0438 \text{ A} \]

b) \[ I_2 = 0.0103 \text{ A} \]

c) Since the potential difference across the equivalent resistor \( R_p \) is the same as the potential difference across \( R_3 \)

\[ P_3 = \frac{AV_3^2}{R_3} = \frac{AV_p^2}{R_3} = \frac{(I_p R_p)^2}{R_3} \]

\[ = \frac{[(0.054054)(60)]^2}{100} = 0.105 \text{ W} \]

d) Since \( I_2 \) was positive, the direction that I arbitrarily chose is correct: \[ \text{to the left} \]

The fact that \( E_2 \) has its positive side up does NOT mean that the current will go to the left. Had \( E_2 \) been smaller (but still positive), the current would have gone to the right.