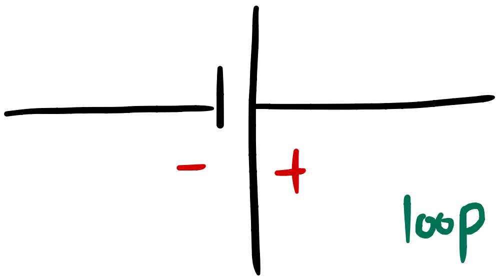
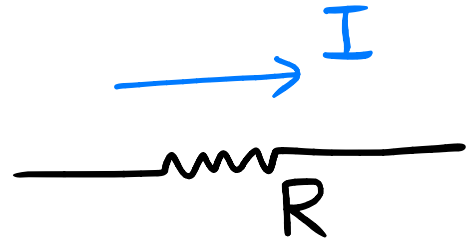
W 9.

- Kirchhoff's law
- Equivalent circuit.
- Magnetic field ?

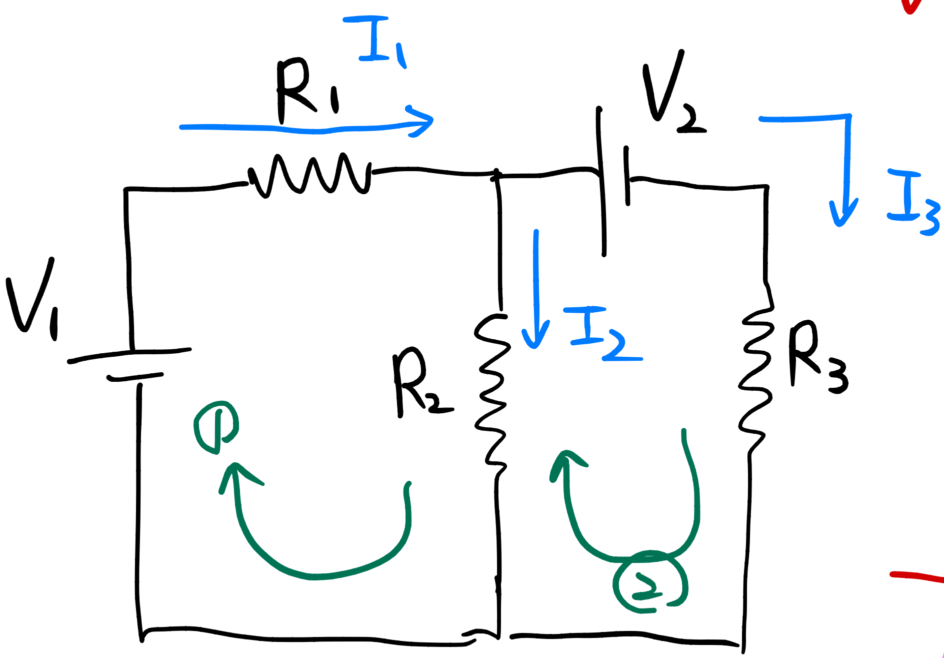
< Kirchhoff's law >





loop

loop →	→	$+V$
loop ←	→	$-V$
loop →	→	$-IR$
loop ←	→	$+IR$



- Junction rule

$$\sum I_{in} = \sum I_{out}$$

→

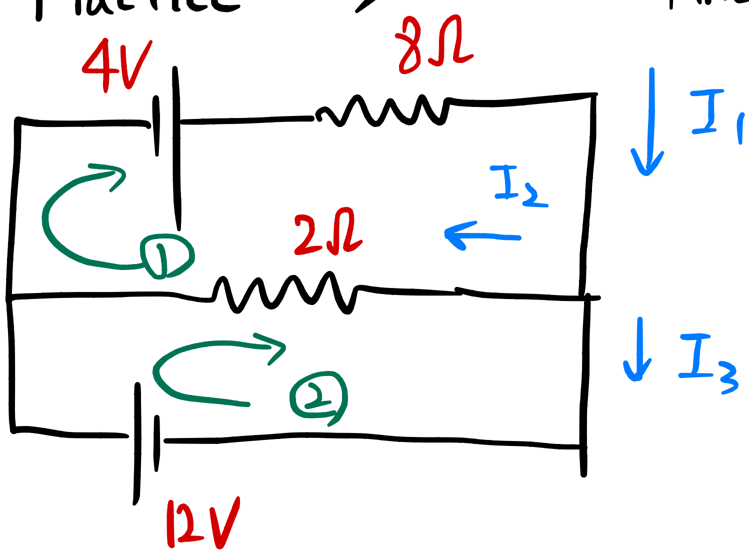
$$I_1 = I_2 + I_3$$

① $V_1 - I_1R_1 - I_2R_2 = 0$

② $+I_2R_2 - V_2 - I_3R_3 = 0$

⟨Practice 1⟩

Find the current in the 8Ω and 2Ω resistors.



- $I_1 = I_2 + I_3$
- ① $4V - 8I_1 - 2I_2 = 0$
- ② $2I_2 + 12V = 0$

$\Rightarrow \quad 2I_2 + 12V = 0$

$I_2 = -6A$

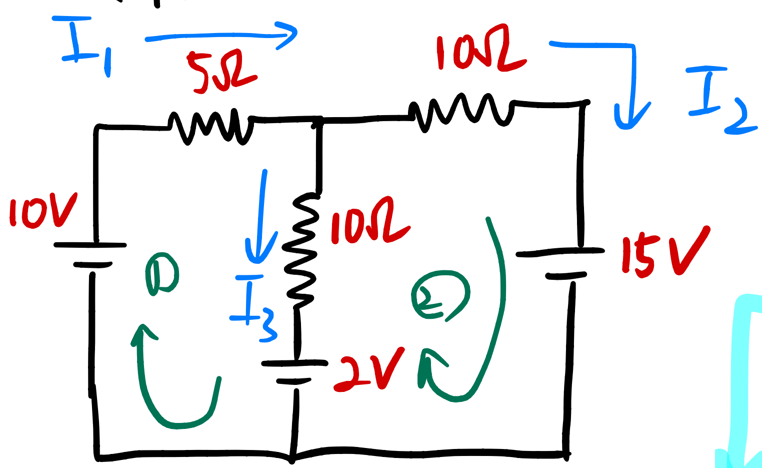
$4V - 8I_1 - 2I_2 = 0$

$4V - 8I_1 - 2(-6) = 0$

$I_1 = 2A$

< Practice 2 >

Determine the voltage across 5Ω resistor.



$I_1 = I_2 + I_3$

① $10V - 5I_1 - 10I_3 - 2 = 0$

② $2V + 10I_3 - 10I_2 - 15 = 0$

$I_1 = I_2 + I_3 \rightarrow I_2 = I_1 - I_3$

$10I_3 - 10I_2 - 13 = 0 \rightarrow 10I_3 - 10(I_1 - I_3) - 13 = 0$

$20I_3 = 10I_1 + 13$

$I_3 = 0.5I_1 + 0.65$

$10 - 5I_1 - 10(0.5I_1 + 0.65) = 0$

$10 - 10I_1 - 6.5 = 0$

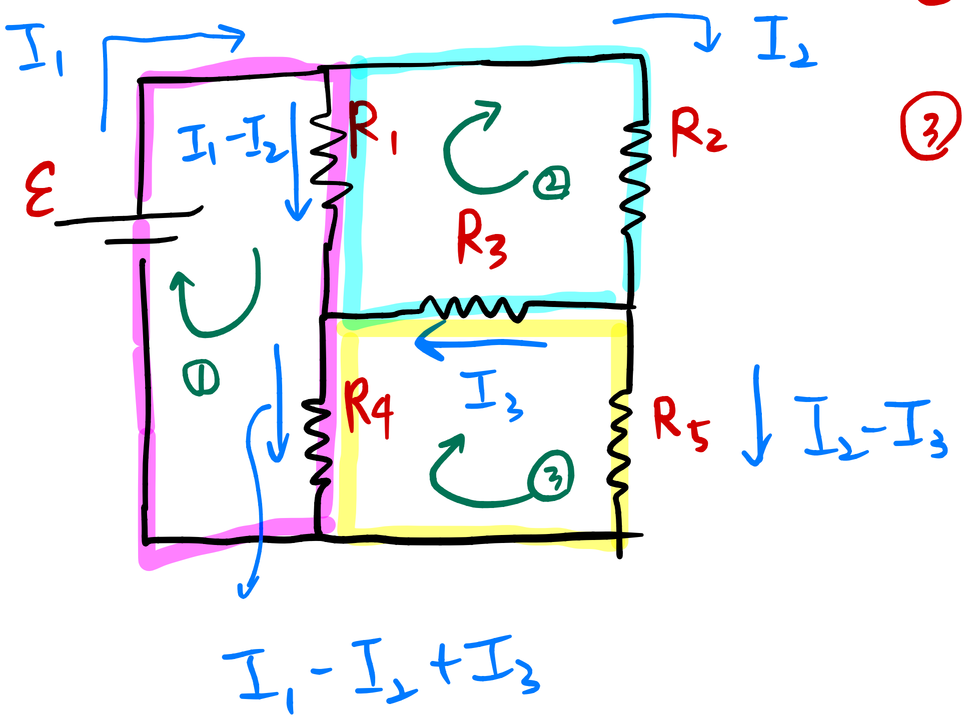
$I_1 = 0.15A.$

$\rightarrow \Delta V_{5\Omega} = 5\Omega \cdot (0.15A)$

$= 0.75V$

< Challenge HW >

Wheatstone bridge.



① $\mathcal{E} - R_1(I_1 - I_2) - R_4(I_1 - I_2 + I_3) = 0$

② $R_1(I_1 - I_2) - R_2 I_2 - R_3 I_3 = 0$

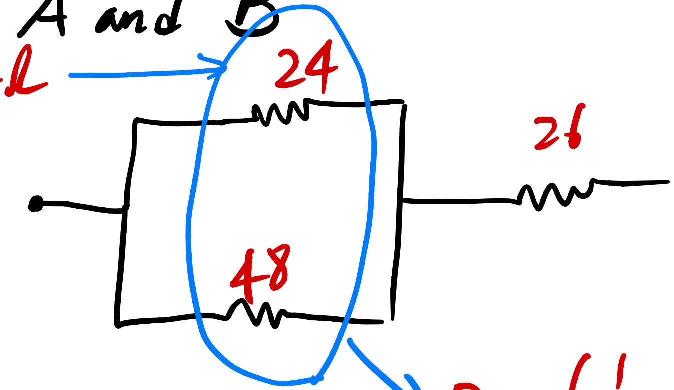
③ $R_3 I_3 - R_5(I_2 - I_3) + R_4(I_1 - I_2 + I_3) = 0$

⋮

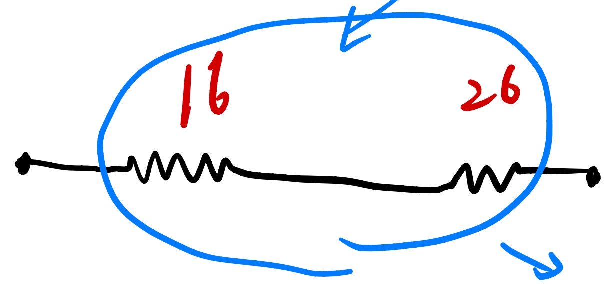
<Practice 3>

Find the equivalent resistance between A and B

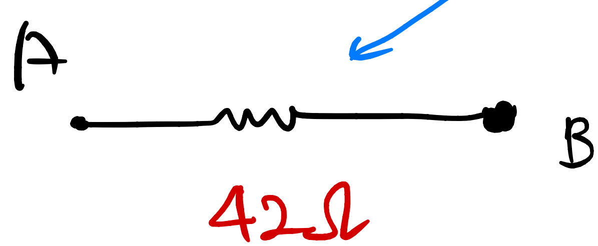
$R = 16 + 8 = 24\Omega$

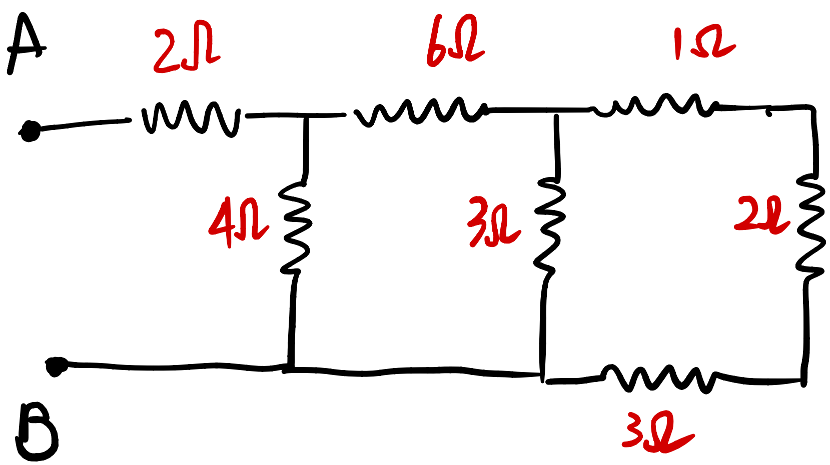


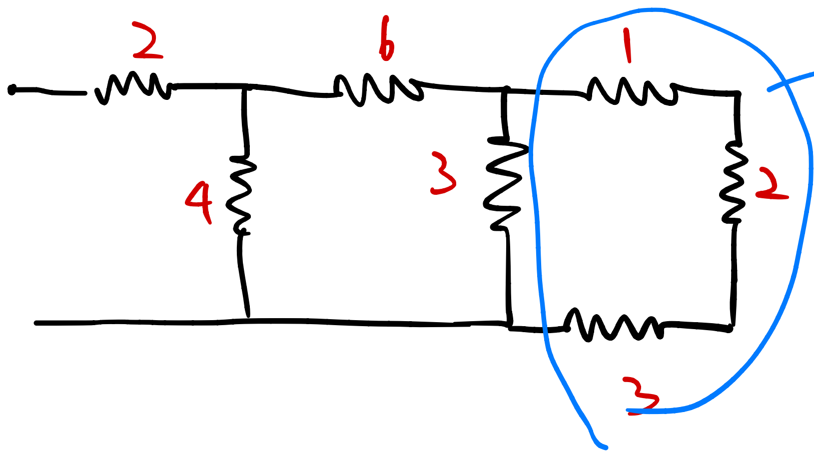
$R = \left(\frac{1}{24} + \frac{1}{48}\right)^{-1} = 16$



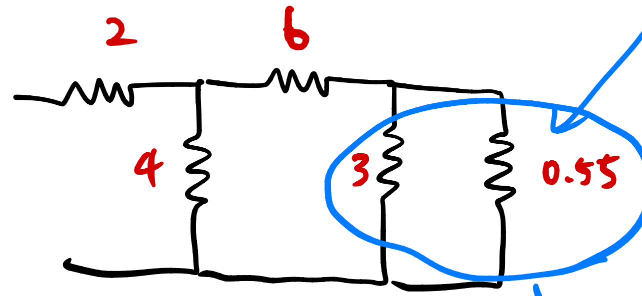
$R = 16 + 26 = 42$



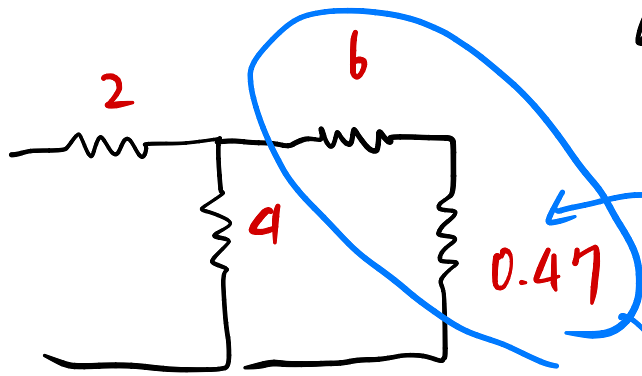




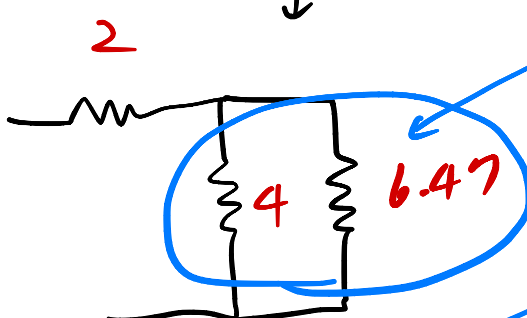
$$R = \left(1 + \frac{1}{2} + \frac{1}{3}\right)^{-1} = 0.55\,\Omega$$



$$R = \left(\frac{1}{3} + \frac{1}{0.55}\right)^{-1} = 0.47\,\Omega$$

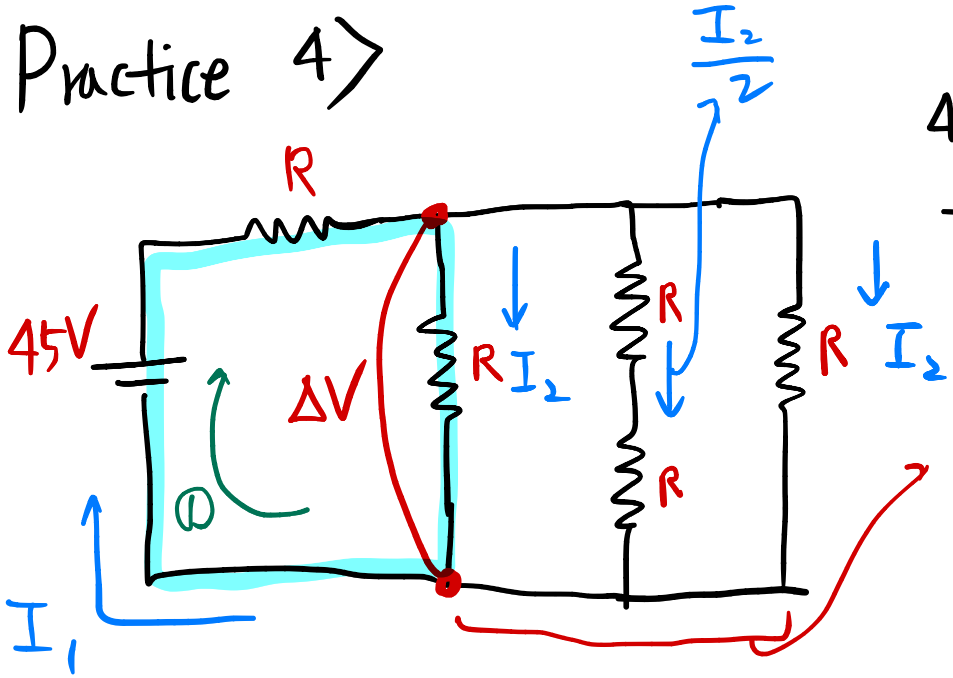


$$R = 6 + 0.47 = 6.47\,\Omega$$



$$R = \left(\frac{1}{4} + \frac{1}{6.47}\right)^{-1} = 2.47\,\Omega$$

⟨Practice 4⟩



45V battery delivers 58W of power to the circuit. What is the resistance R?

Parallel → have the same voltage (ΔV)

$\Delta V = 45 - RI_1$

Let current on single R be I_2.

Then, current on 2R is $\frac{I_2}{2}$.

Junction rule

$$I_1 = I_2 + \frac{I_2}{2} + I_2 = \frac{5}{2} I_2$$

① $45 - RI_1 - RI_2 = 0$

$$45 - R\left(\frac{5}{2} I_2\right) - RI_2 = 0 \rightarrow \frac{7}{2} RI_2 = 45$$

$$I_2 = \frac{90}{7R}$$

$$I_1 = \frac{5}{2}\left(\frac{90}{7R}\right) = \frac{225}{7R}$$

Total power

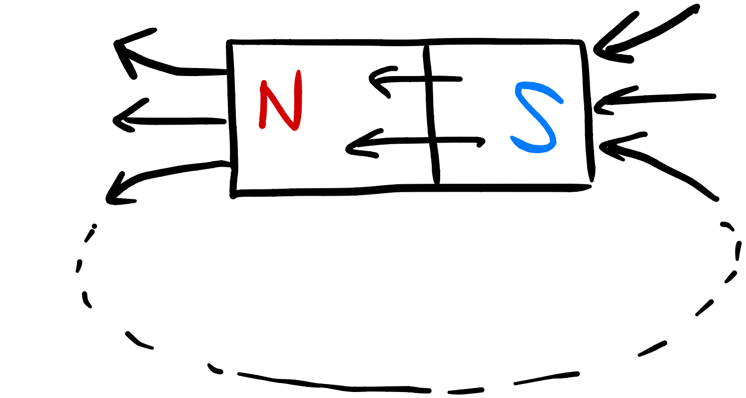
$$P = I_1^2 R + I_2^2 R + 2R\left(\frac{I_2}{2}\right)^2 + I_2^2 R$$

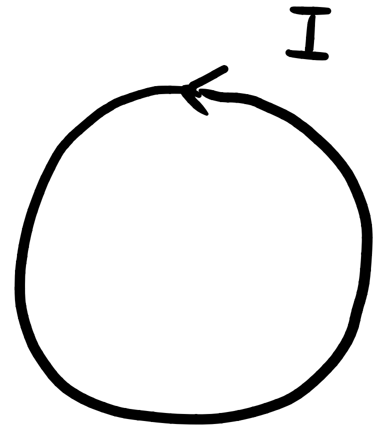
$$= I_1^2 R + \frac{5}{2} I_2^2 R$$

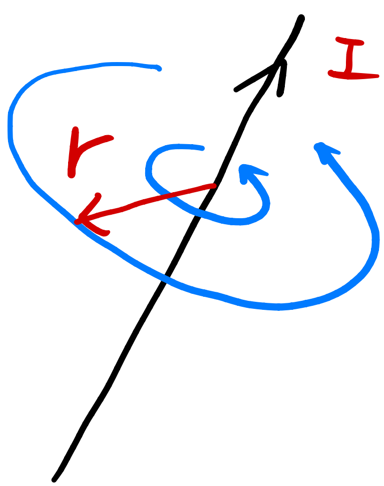
$$= \left(\frac{225}{7R}\right)^2 R + \frac{5}{2}\left(\frac{90}{7R}\right)^2 R = \frac{1446.4}{R} = 58\ W$$

$$\Rightarrow R = 25\,\Omega$$

<Magnetic field>







$$B = \frac{\mu_0 I}{2\pi r}$$