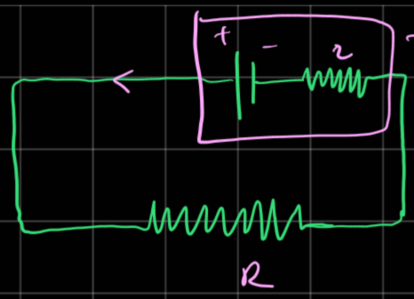
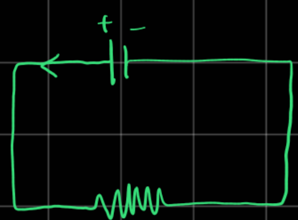




$I = \dfrac{\Delta V}{R}$

ε: Electromagnetic Force (EMF)
Voltage written on batteries

$$I = \frac{\varepsilon}{R+r}$$

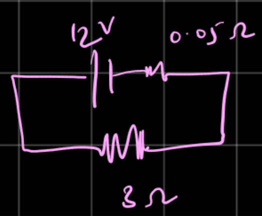
$$P_{batt} = I\varepsilon = I^2 r + I^2 R$$

$$R = \frac{\Delta V^2}{P} = \frac{(11.6)^2}{20}$$

$$= 6.728$$

$$I = \frac{\Delta V}{R} = \frac{11.6}{6.7} = 1.72 \text{ A}$$

$$r = \frac{\Delta V}{I} = 1.972\ \Omega$$



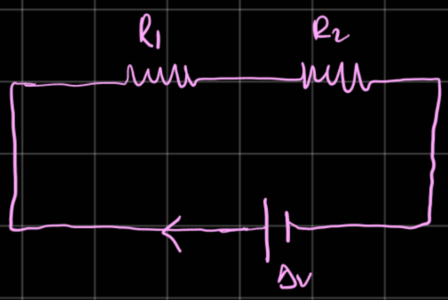
a) $I = \dfrac{\varepsilon}{R+r} = \dfrac{12}{3+0.05} = 3.93 \text{ A}$

$\Delta V_R = \varepsilon - Ir = 11.8035 \text{ V}$
$\Delta V_r = 0.1965 \text{ V}$

b) $P_r = I^2 r = 0.77 \text{ W}$
$P_R = I^2 R = 46.33 \text{ W}$
$P = I\varepsilon = 47.16 \text{ W}$

$I_b = I_C = \ldots$

Resistors in series



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

$$I = I_1 = I_2$$

$$\Delta V = \Delta V_1 + \Delta V_2$$

$$\Delta V_1 = I_1 R_1 \qquad \Delta V_2 = I_2 R_2$$

Resistors in parallel

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

$$I = I_1 + I_2$$

$$\Delta V = \Delta V_1 = \Delta V_2$$

$$I_1 = \frac{\Delta V_1}{R_1} \qquad I_2 = \frac{\Delta V_2}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{6} + \frac{1}{9}$$

$$= \frac{6}{18} + \frac{3}{18} + \frac{2}{18}$$

$$= \frac{11}{18}$$

$$R_{eq} = \frac{18}{11}$$

$$I_1 = \frac{\Delta V}{R_1} = \frac{18}{3} = \underline{6\text{ A}}$$

$$I_2 = \frac{\Delta V}{R_2} = \frac{18}{6} = \underline{3\text{ A}}$$

$$I_3 = \frac{\Delta V}{R_3} = \frac{18}{9} = \underline{2\text{ A}}$$

$$I = I_1 + I_2 + I_3 = 11\text{ A}$$

$$\frac{1}{R_{eq}} = \frac{3}{R}$$

$$R_{eq} = \frac{R}{3}$$

$$R_{eq} = \frac{R}{3} + 2R = \frac{7R}{3} \ \Omega$$

Kirchoff's Law

Exam Question

KVL	KCL
Kirchoff's Voltage Law	Kirchoff's Current Law
↓ Define direction of the loop	↓ Sum of currents entering a junction = Sum of currents leaving a junction

KCL

Assume any direction of current

Write KCL $\quad I_1 + I_2 = I_3$

KVL

Define loops

If battery terminal +ve, then write −ve

$$I_1 + I_2 = I_3$$

$$-14 + 6I_1 - 10 - 4I_2 = 0$$

$-2I_3 + 10 - 6I_1 = 0$

$6I_1 - 4I_2 = 24$

$-2I_1 - 2I_2 + 10 - 6I_1 = 0$

$-8I_1 - 2I_2 = -10$

$8I_1 + 2I_2 = 10$

$6I_1 - 4I_2 = 24$ — ①

$8I_1 + 2I_2 = 10$ — ⑪

① + 2⑪

$(6+16)I_1 = 44$

$22I_1 = 44$

$\underline{I_1 = 2\text{ A}}$

$6(2) - 4I_2 = 24$

$-4I_2 = 24 - 12$

$I_2 = -\frac{12}{4}$

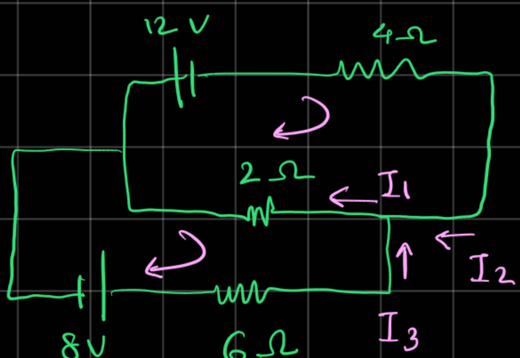
$= \underline{-3\text{ A}}$

$I_3 = I_1 + I_2$

$= 2 + 3$

$= \underline{-1\text{ A}}$

$I_1 = I_2 + I_3$



$6I_3 - 8 + 2I_1 = 0$

$\rightarrow -2I_1 - 12 - 4I_2 = 0$

$6I_3 - 8 + 2I_2 + 2I_3 = 0$

$2I_2 + 8I_3 = 8$

$3I_2 + I_3 = 6$

$2I_1 + 4I_2 = 12$

$6I_2 + 2I_3 = 12$

$3I_2 + I_3 = 6$

$$\begin{array}{l} \cancel{6I_2} + 24I_3 = 24 \\ \cancel{6I_2} + 2I_3 = 12 \\ \hline 22I_3 = 12 \end{array}$$

$I_3 = \frac{12}{22} = \frac{6}{11}$

$6I_2 = 12 - \frac{12}{11}$

$I_2 = \frac{11 \times 12 - 12}{66}$

$= \frac{12(11-1)}{66}$

$= \frac{\cancel{120}^{\cancel{6} \times 20}}{\cancel{6} \times 11}$

$= \frac{20}{11}$

$I_1 = \frac{20}{11} + \frac{6}{11} = \frac{26}{11}$

RC Circuits

$C = \frac{Q}{\Delta V} \implies Q_{max} = C\mathcal{E}$

when capacitor reaches voltage of battery, charge drops to zero

fully charged

Charging

$$q(t) = \underset{\downarrow\ C\mathcal{E}}{Q_{max}}\left(1 - e^{-t/RC}\right)$$

→ Time constant

↳ time taken to reach 63% of Q_{max}

$$\tau = RC$$

$$i(t) = \frac{\mathcal{E}}{R} e^{-t/RC}$$

↳ I_{max}

Discharging

$$q(t) = Q_i e^{-t/RC} \qquad i(t) = \frac{Q_i}{RC} e^{-t/RC}$$

Time taken to reach 36% of initial charge

$$\tau = 20 \times 100 = 2000\ \mu s$$
$$= 2\ ms$$

$$Q_{max} = C\mathcal{E}$$
$$= 20\ \mu F \times 9\ V$$
$$= 180\ \mu C$$

$$q(\tau) = 0.63 \times 180\ \mu C$$
$$= 113.4\ \mu C$$