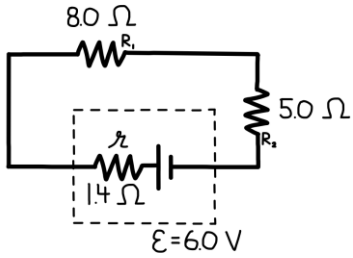
Terminal Voltage and Power

Notes for students

- The **terminal voltage** is the voltage across the **external circuit**.
- The internal resistance of the battery must be included when determining the current.
- You may use the relationship $V_{\text{terminal}} = \varepsilon - Ir$

1) A **real battery** with an **emf of** 6.0 Vand an **internal resistance of** 1.4 is connected to an external circuit, as shown in the diagram.



The external circuit consists of **two resistors connected in series**:

- $R_1 = 8.0$
- $R_2 = 5.0$

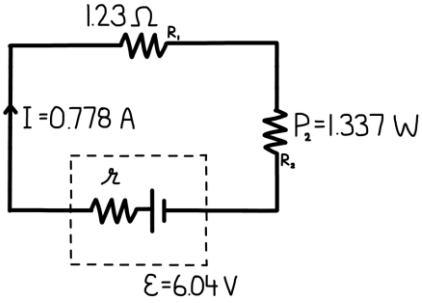
Assume all connecting wires have negligible resistance.

Determine the terminal voltage of the battery while the circuit is operating.

Notes for students

- The internal resistance is **in series** with the external resistors.
- Power dissipated in a resistor can be found using $P = I^2R$
- The emf of the battery is related to the current and total resistance by $V_{\text{terminal}} = \varepsilon - Ir$

2) A **real battery** with an **emf of** $\varepsilon = 6.04$ Vand an **unknown internal resistance** $r$is connected to an external circuit, as shown in the diagram.



The external circuit consists of **two resistors connected in series**:

- $R_1 = 1.23\ \Omega$
- R_2, which dissipates power at a rate of $P_2 = 1.337$ W

The **current in the circuit** is measured to be $I = 0.778$ A

Assume all connecting wires have negligible resistance.

Determine the internal resistance $r$of the battery.

Notes for students

- The internal resistance affects the **current supplied by the cell**, but not the measured voltage across R_1.

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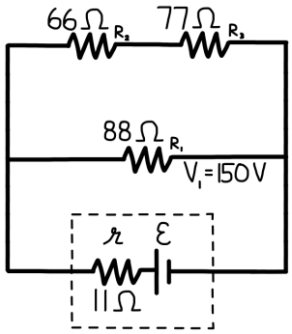
3) A **real cell** with an **internal resistance of** $r = 11\ \Omega$is connected to an external circuit, as shown in the diagram. The external circuit consists of **two parallel branches**:
   - **Upper branch**: two resistors connected in series
     - $R_2 = 66\ \Omega$
     - $R_3 = 77\ \Omega$
   - **Middle branch**: a single resistor $R_1 = 88\ \Omega$

   The **voltage across** $R_1$is measured to be $V_1 = 150$ V
   Assume all connecting wires have negligible resistance.
   Determine the electromotive force (emf), ε, of the cell.



Notes for students

- Power dissipated in the internal resistance can be found using $P = I^2 r$

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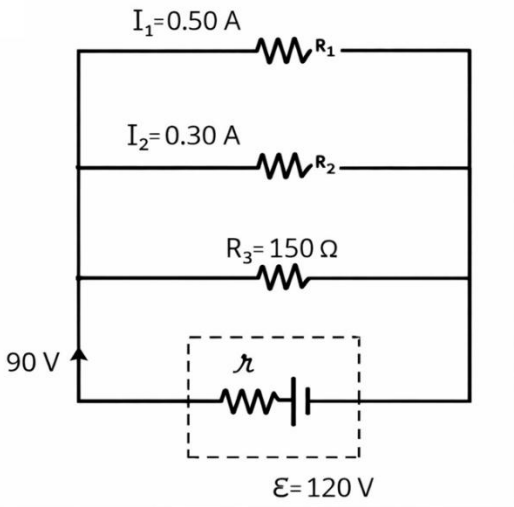
4) A real battery with an emf of $\boldsymbol{\varepsilon}$ **= 120 V** and an internal resistance **r** is connected to an external circuit, as shown in the diagram. The external circuit consists of **three resistors connected in parallel**:
   - Top resistor: current $\boldsymbol{I_1}$ **= 0.50 A**
   - Middle resistor: current $\boldsymbol{I_2}$ **= 0.30 A**
   - Bottom resistor: resistance $\boldsymbol{R_3}$ **= 150 Ω**

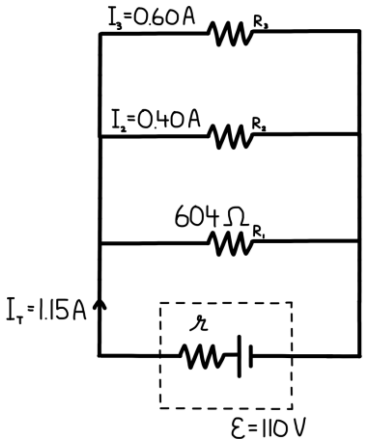
   The **terminal voltage of the battery is measured to be 90 V**.
   Assume all connecting wires have negligible resistance.
   (a) Determine the total current supplied by the battery.
   (b) Determine the internal resistance **r** of the battery.



Notes for students

- Power dissipated in the internal resistance can be found using $P = \mathrm{I}^2 r$

5) A **real battery** with an **emf of** $\varepsilon = 110$ Vand an **unknown internal resistance** $r$is connected to **three external resistors**, arranged as shown in the diagram. The three external resistors are connected **in parallel** and have the following information:



- The current through the **top resistor** is $I_1 = 0.60$ A
- The current through the **middle resistor** is $I_2 = 0.40$ A
- The resistance of the **bottom resistor** is $R_3 = 604$

The **total current supplied by the battery** is: $I_T = 1.15$ A

Assume all connecting wires have negligible resistance.

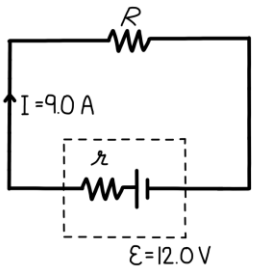
(a) Determine the **internal resistance** $r$of the battery.

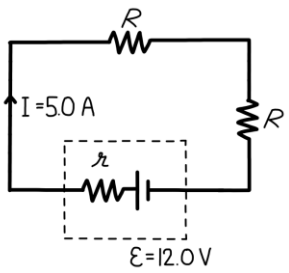
(b) Determine the **power dissipated in the battery's internal resistance**.

Notes for students

- The internal resistance is **in series** with the external circuit.
- You may use the relationship $V_{\text{terminal}} = \varepsilon - Ir$

6) A **power supply** has an **emf of** $\varepsilon = 12.0$ Vand an **internal resistance** r. Two experiments are performed using the **same power supply**, as shown in the diagrams.





Experiment 1

The power supply is connected to **one resistor of resistance** R.

- The current delivered by the supply is $I_1 = 9.0$ A

Experiment 2

The same power supply is connected to **two identical resistors**, each of resistance R, **connected in series**.

- The current delivered by the supply is $I_2 = 5.0$ A

Assume all connecting wires have negligible resistance.

Determine the internal resistance r**of the power supply.**

Notes for students

- Useful relationships: $Q = It, \quad P = IV, \quad P = I^2R, \quad E = Pt$

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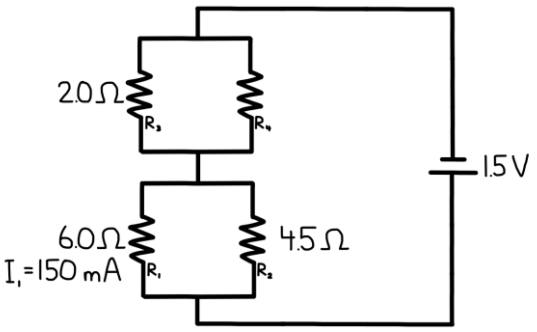
7) A resistor of resistance $\boldsymbol{R}$ **= 40 Ω** is connected to a power supply. The current through the resistor is measured to be $\boldsymbol{I}$ **= 0.50 A**. Assume the circuit operates continuously for **30 minutes**.

(a) Determine the power dissipated by the resistor.

(b) Determine the total energy dissipated by the resistor during this time.

8) The circuit consists of **two parallel sections connected in series**:



Upper parallel section

- $R_1 = 6.0\ \Omega$
- $R_2 = 45\ \Omega$

Lower parallel section

- $R_3 = 20\ \Omega$
- R_4(resistance not specified)

The **current through resistor** $R_3$is measured to be: $I_1 = 150$ mA

Assume all connecting wires have negligible resistance.

(a) Determine the **amount of electric charge** that flows through resistor R_4 in **1.0 hour**.

(b) Determine the **power dissipated** by resistor R_4.

(c) Determine the **total energy dissipated** by resistor R_4during **1.0 hour** of operation.