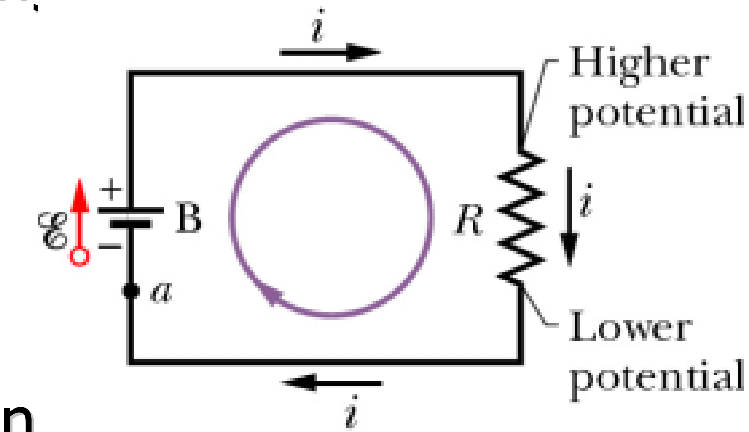
September 30th

Circuits - Chapter 28

Review (Fig. 28-3)

- Kirchhoff's loop rule – in traversing a circuit loop the sum of the changes in V is zero, $\Delta V = 0$



- Resistance rule – Move through resistor in direction of current $V = -iR$ (+ to -; higher to lower), in opposite direction $V = +iR$ (- to +; up the hill).

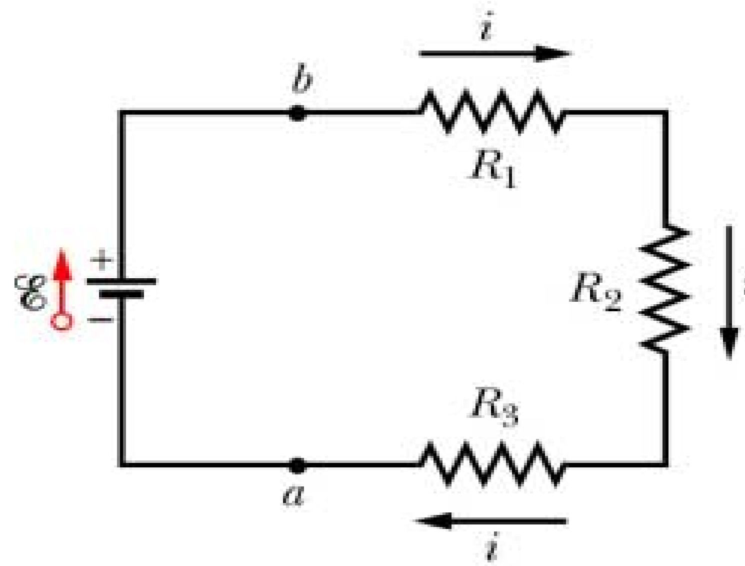
- Emf rule – Move through emf device $V = +E$ going – to +, in opposite direction $V = -E$.

Circuits (Fig. 28-5a)

- Resistors in series (one path from b to a)
- Have identical currents, *i*, through them
- Use Kirchhoff's loop rule

$$\mathrm{E} - iR_1 - iR_2 - iR_3 = 0$$

$$i = \frac{\mathrm{E}}{R_1 + R_2 + R_3}$$

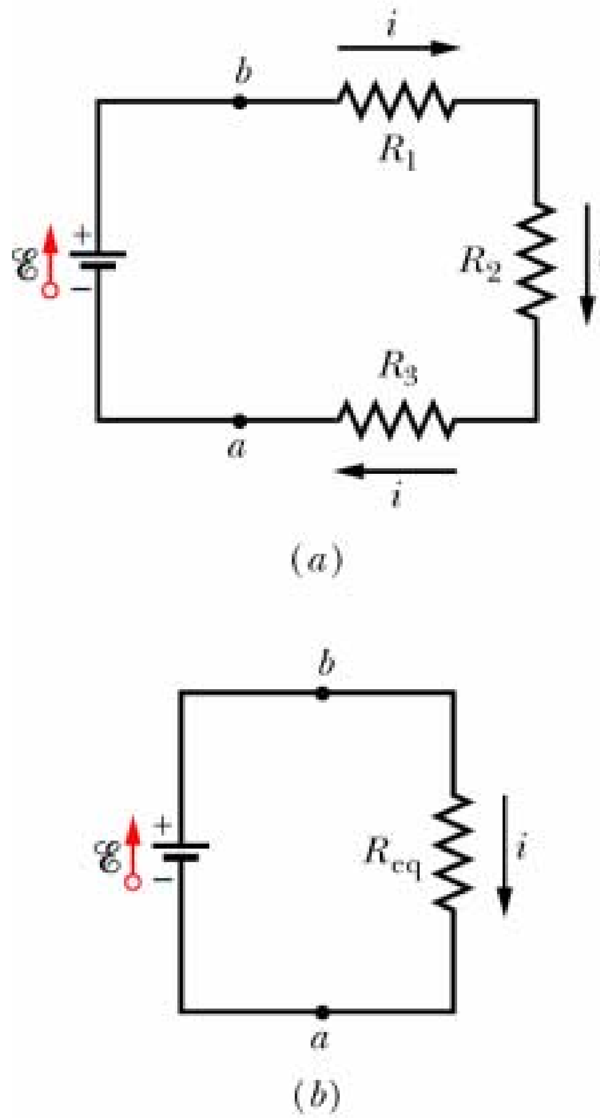


Circuits (Figs. 28-5a, 28-5b)

- Resistors in series
- The 3 resistors act the same as an equivalent resistor R_{eq}.

$$i = \frac{\text{☜}}{R_1 + R_2 + R_3} = \frac{\text{☜}}{R_{eq}}$$

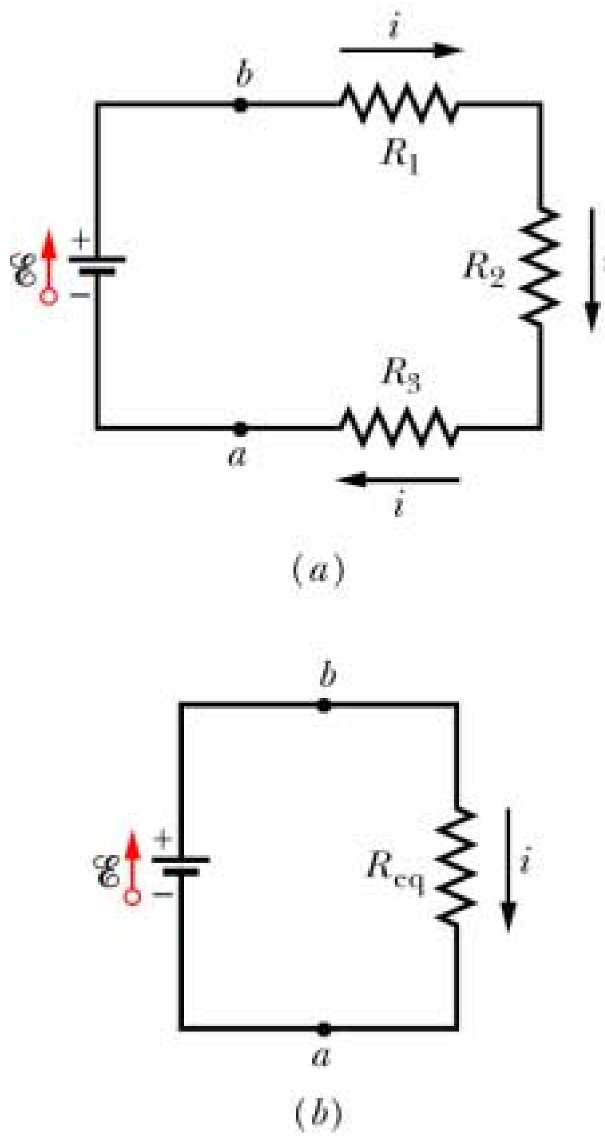
$$R_{eq} = R_1 + R_2 + R_3$$



Circuits (Figs. 28-5a, 28-5b)

- Resistors in series
- Resistors have identical currents, *i*
- Sum of *V*s across resistors = applied *V*
- R_{eq} is sum of all resistors

$$R_{eq} = \sum_{j=1}^{n} R_j$$



Circuits - Checkpoint #2 (Fig. 28-5a)

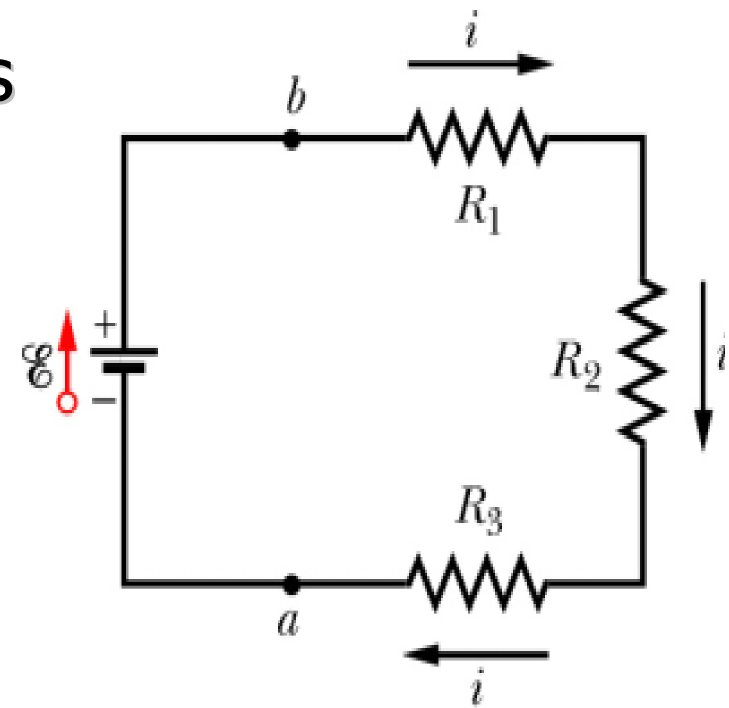
- If R1>R2>R3, rank greatest first
- A) current through resistors

  i is same for all, tie

$$V = iR$$

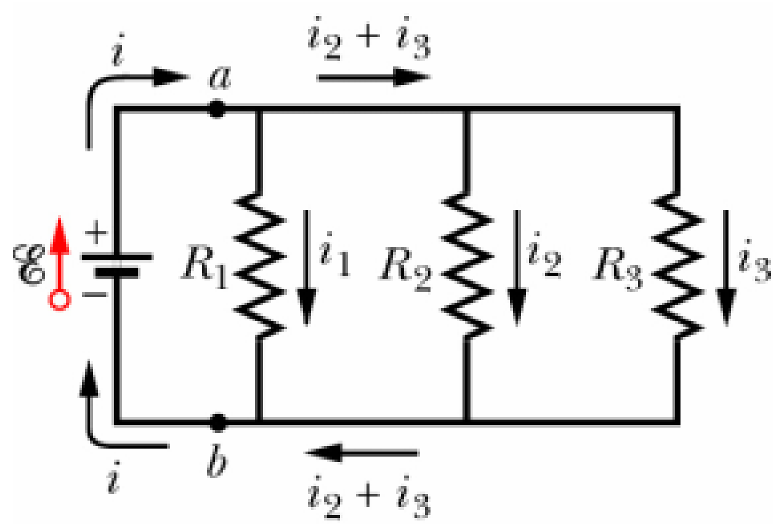
- B) V across them

  R1, R2, R3



Circuits (Fig. 28-8a)

- Resistors in parallel
- Have same V across them
- Arbitrarily choose direction for currents in each branch
- Write down current relation for each resistor



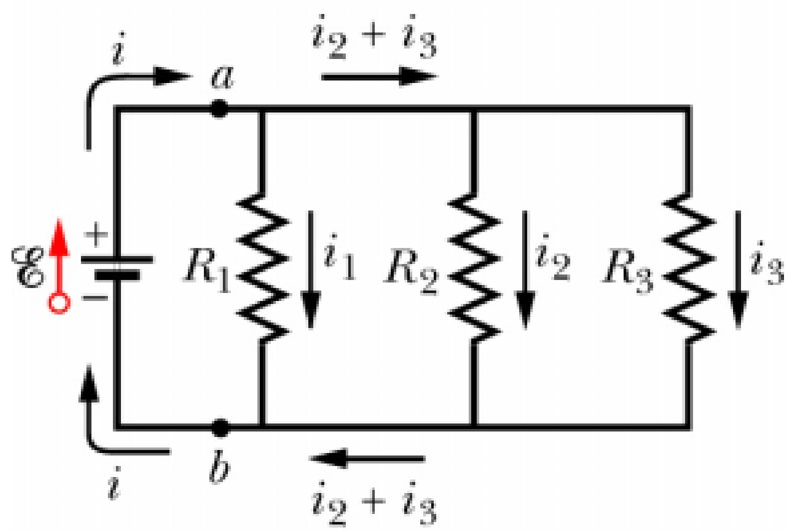
$$i_1 = \frac{V}{R_1}$$

$$i_2 = \frac{V}{R_2}$$

$$i_3 = \frac{V}{R_3}$$

Circuits (Fig. 28-8a)

- Resistors in parallel (more than one path from a to b)
- Apply Kirchhoff's junction rule at point a
- Substitute current values

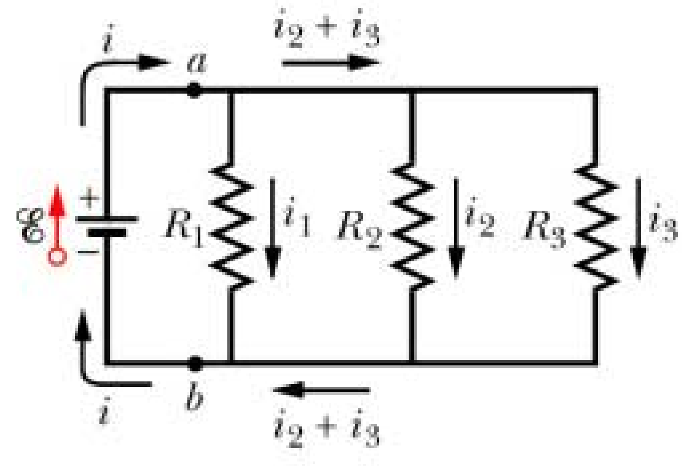


$$i = i_1 + i_2 + i_3$$

$$i = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

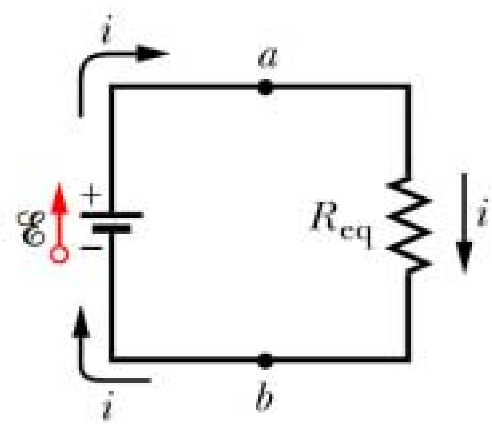
Circuits (Figs. 28-8a,28-8b)

- Resistors in parallel
- Replace 3 resistors with equivalent resistor, R_{eq}



(a)

$$\frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)$$



(b)

Circuits - Checkpoint #4

- Battery with potential V supplies current i to 2 identical resistors
- What is *V* across and *i* through either of the resistors if they are connected in
- A) Series – What is constant?

  i is same, $V_1 = V/2$

- B) Parallel – What is constant?

  V is same, $i_1 = i/2$

$$V = iR$$

Circuits

- Resistors
- Series

$$R_{eq} = \sum_{j=1}^{n} R_j$$

- Parallel

$$\frac{1}{R_{eq}} = \sum_{j=1}^{n} \frac{1}{R_j}$$

- Capacitors
- Series

$$\frac{1}{C_{eq}} = \sum_{j=1}^{n} \frac{1}{C_j}$$

- Parallel

$$C_{eq} = \sum_{j=1}^{n} C_j$$

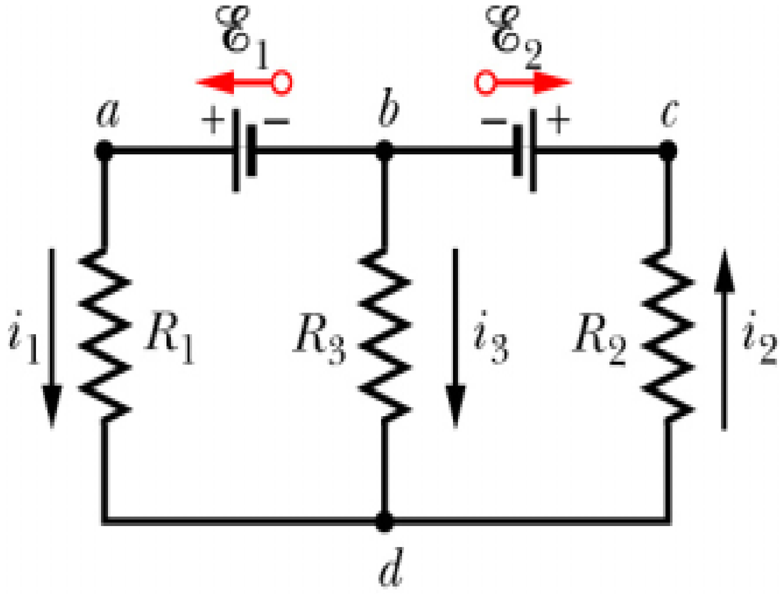
How to Analyze Complex Circuits

- Kirchhoff's junction rule (or current law) –
  - From conservation of charge
  - Sum of currents entering a junction is equal to sum of currents leaving that junction
- Kirchhoff's loop rule (or voltage law) –
  - From conservation of energy
  - Sum of changes in potential going around a complete circuit loop equals zero

Kirchhoff's Rule #1: Circuits (Fig. 28-8a)

- Arbitrarily label currents, using different subscript for each branch
- Using conservation of charge at each junction

$$i_{in} = i_{out}$$



- At point d

$$i_1 + i_3 = i_2$$

- At point b

$$i_1 + i_3 = i_2$$

- At point a

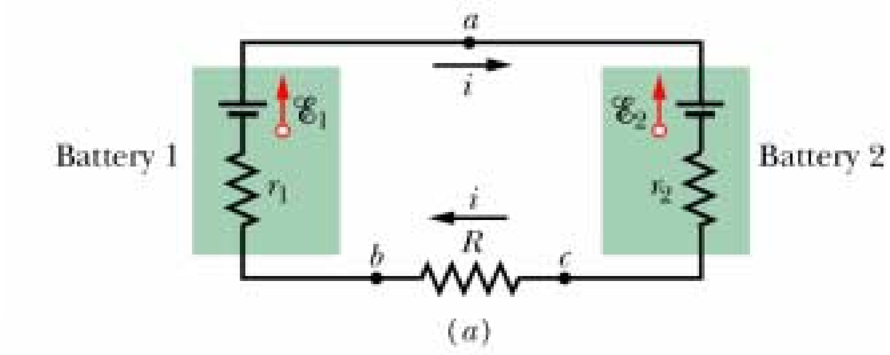
$$i_1 = i_1$$

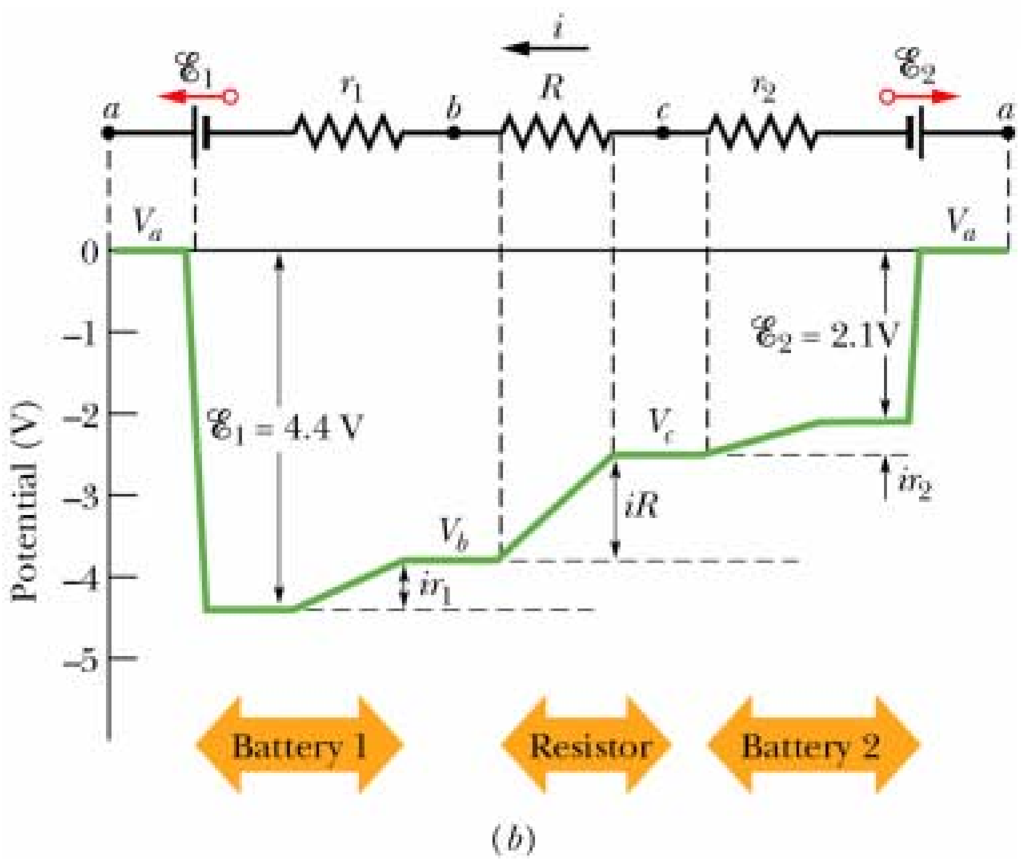
- At point c

$$i_2 = i_2$$

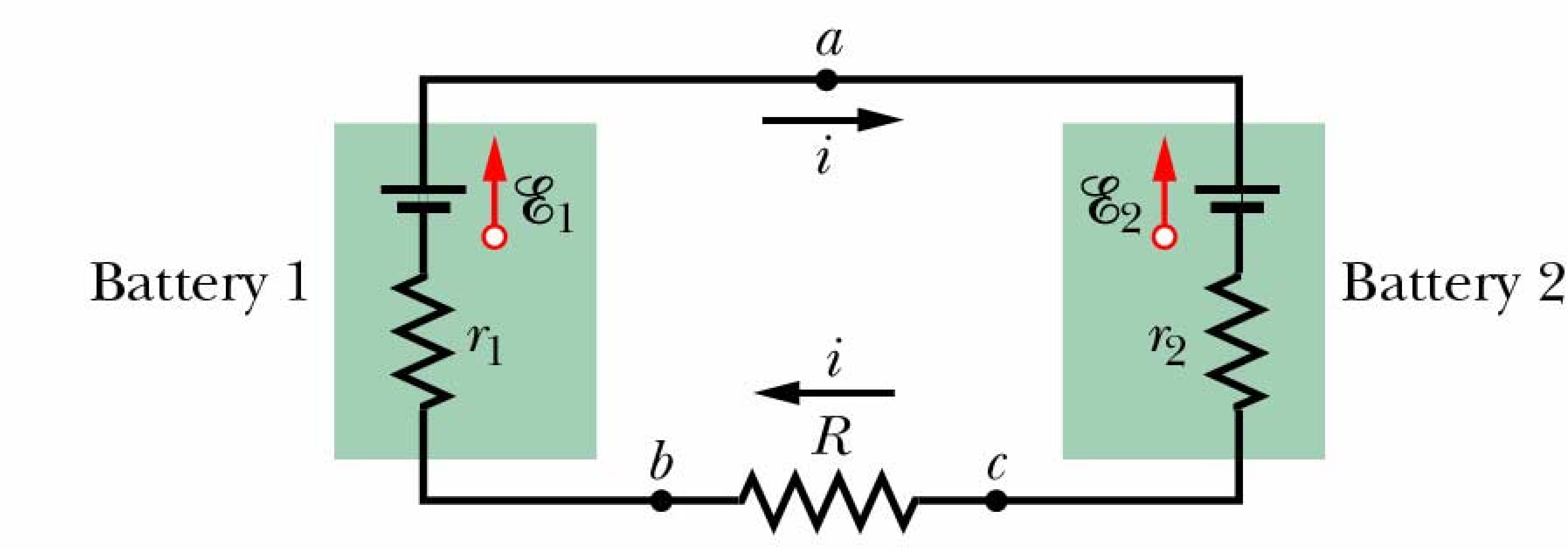
Circuits (Figs. 28-6a, 28-6b)

- What is *i* of the circuit?





- Use Kirchhoff's loop rule



- Clockwise from point a gives

$$-\text{☜}_2 - ir_2 - iR - ir_1 + \text{☜}_1 = 0$$

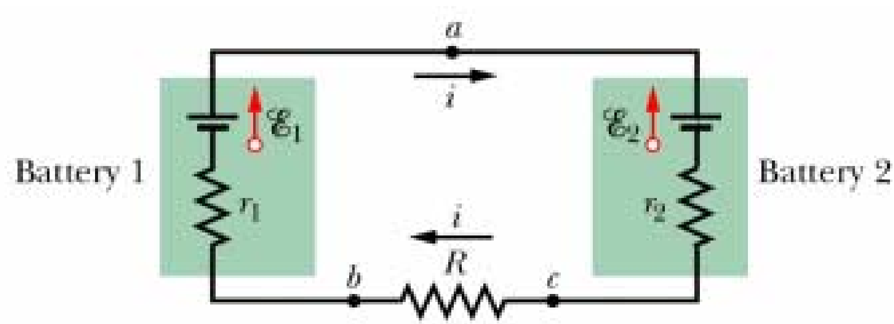
- Counterclockwise from point a gives

$$-\text{☜}_1 + ir_1 + iR + ir_2 + \text{☜}_2 = 0$$

Circuits (Fig. 28-6a)

- Solve for *i* $-\mathcal{E}_1 + ir_1 + iR + ir_2 + \mathcal{E}_2 = 0$

$$i = \frac{\mathcal{E}_1 - \mathcal{E}_2}{R + r_1 + r_2}$$



$\mathcal{E}_1 = 4.4V$ $\mathcal{E}_2 = 2.1V$

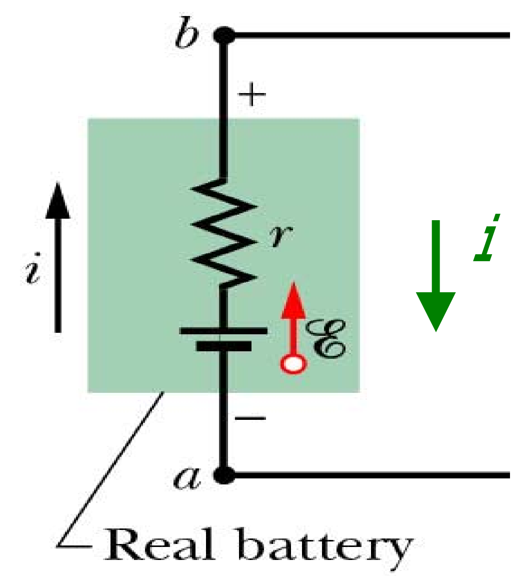
$r_1 = 2.3\Omega$ $r_2 = 1.8\Omega$

$R = 5.5\Omega$

$$i = 0.2396A \approx 240mA$$

Checkpoint #3 (Fig. 28-4a)

- A real battery has E =12V and *r* = 2Ω. Is the V across the terminals greater than, less than or equal to 12V if the current in the battery is



- A) from – to + terminal

LESS THAN

$$V_a + \mathrm{E} - ir = V_b$$

- B) from + to -

GREATER THAN

$$V_a + \mathrm{E} + ir = V_b$$

- C) i = 0

EQUAL TO 12V