September 29th

Circuits - Chapter 28

Review of Chpt. 27

- Current, *i*, is defined as amount of charge *q* passing through plane in time *t*

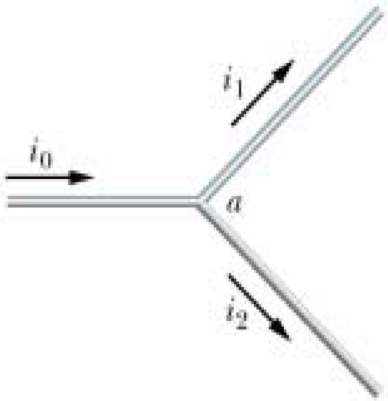
$$i = \frac{dq}{dt}$$

- SI unit ampere, A

$$1A = 1C/s$$

- Charge is conserved

$$i_0 = i_1 + i_2$$



- Current arrow drawn in the direction (+) charge carriers would move (actually it is the electrons that move).

Review of Chpt. 27

- Resistance is defined as
- SI unit is the ohm, Ω

$$R = \frac{V}{i}$$

$$1\Omega = 1V / A$$

- Resistance of conducting wire of length *L*, resistivity *ρ*, and cross section *A*

$$R = \rho \frac{L}{A}$$

- Ohm's Law – *R* is independent of magnitude and polarity of *V*

$$V = iR$$

Review of Chpt. 27

- Power :

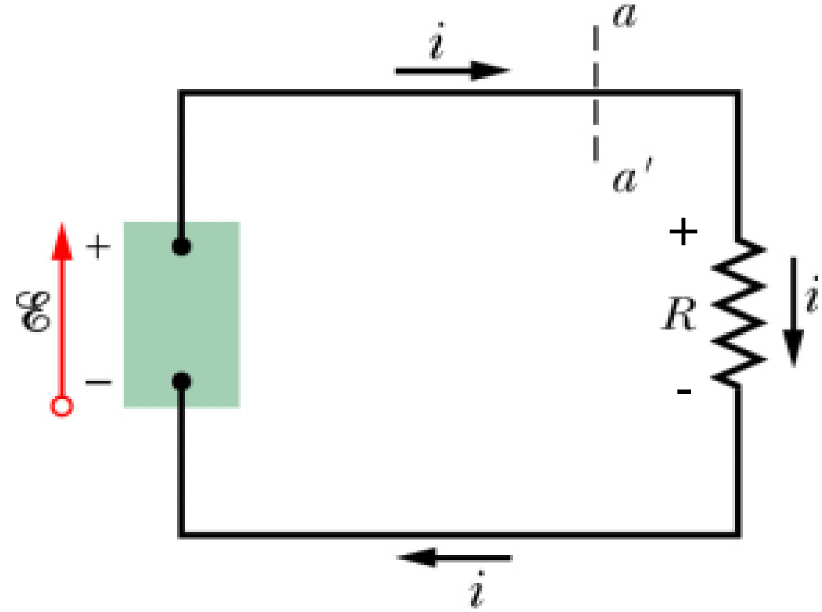
$$P = Vi$$

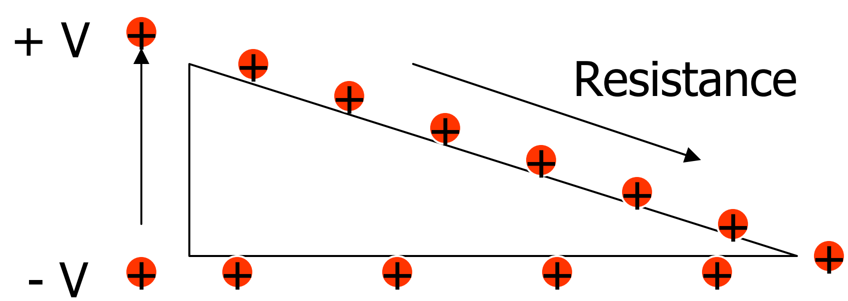
- For a resistive device, the power dissipated in the resistor is:

$$P = i^2 R = \frac{V^2}{R}$$

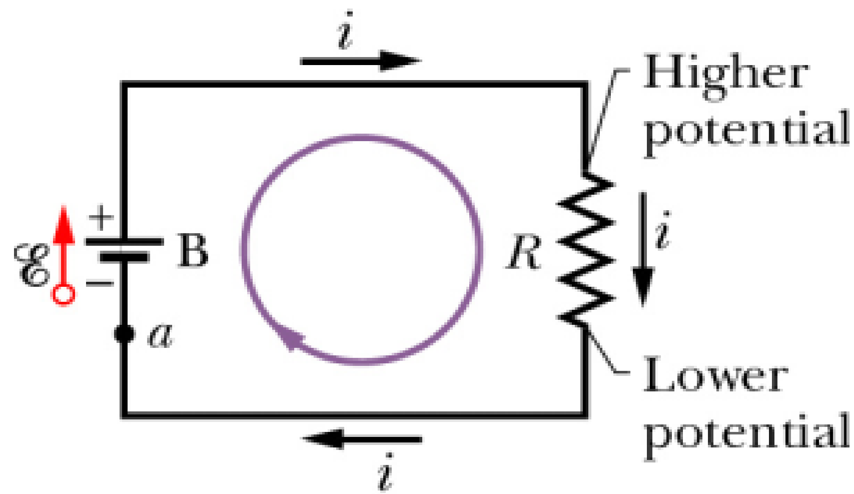
Circuits (Fig. 28-1)

- emf device (label terminal at higher *V* as + and lower *V* as –)
- Draw emf, E, arrow from – to + terminal
- Label the R with a + and -
- + charge carriers are moved against the *Electric* field in emf device from lower (-) to higher (+) *V*. The emf must do work on the charge. Normally this is supplied by chemical energy.





Circuits (Fig. 28-3)

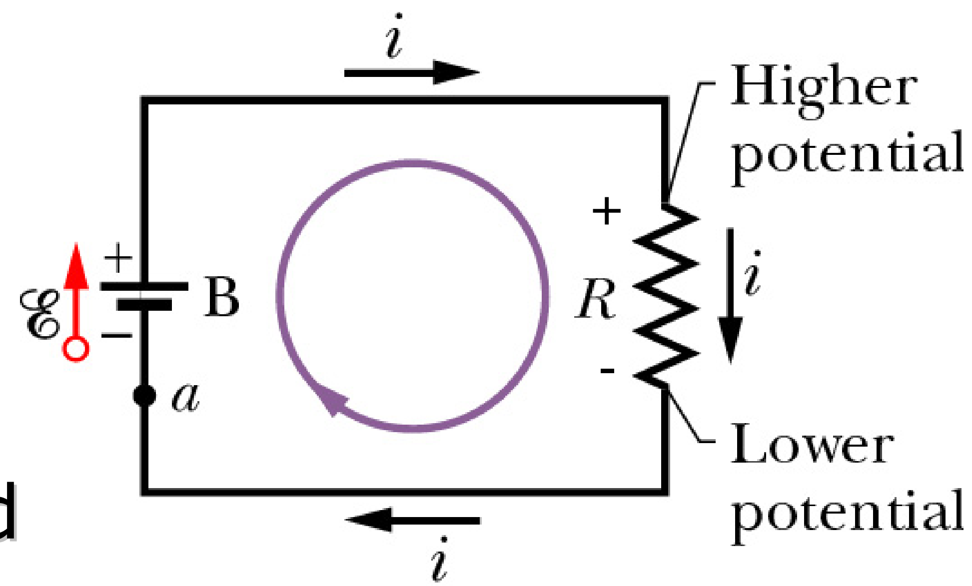


Ohm's Law: $$\mathrm{E} = iR$$

(the ☜ supplies the potential difference V)

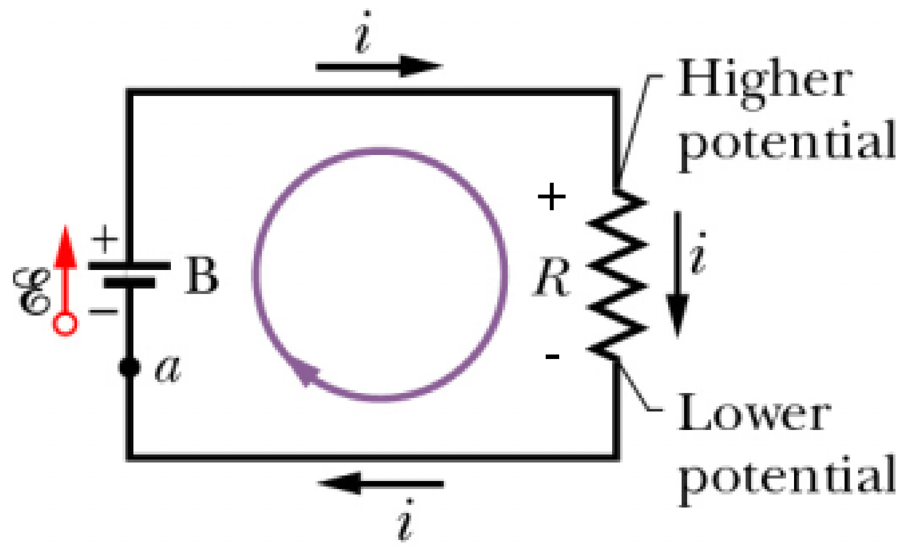
Circuits (Fig. 28-3)

- Calculate the current in single-loop circuit
- Use potential method (as called by the text book).
- Travel around circuit in either direction and algebraically add potential differences



Circuits (Fig. 28-3)

- Start at point a with potential V_a
- Move clockwise around circuit
- Pass through battery moving to higher V, change in V is $+E$
- Neglect resistance of connecting wires

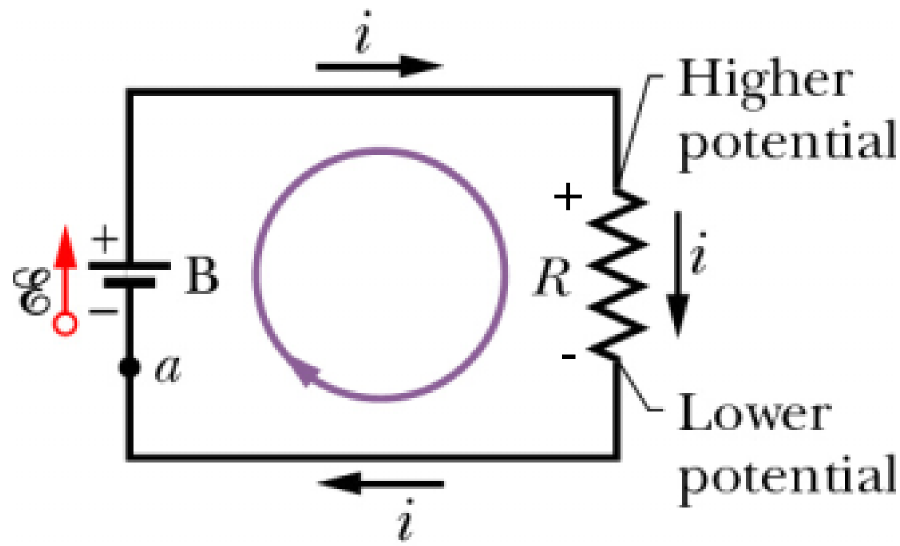


$$V_a + E$$

Circuits (Fig. 28-3)

- Top of resistor at same V as battery
- Pass through resistor V decreases and

$$V = iR$$



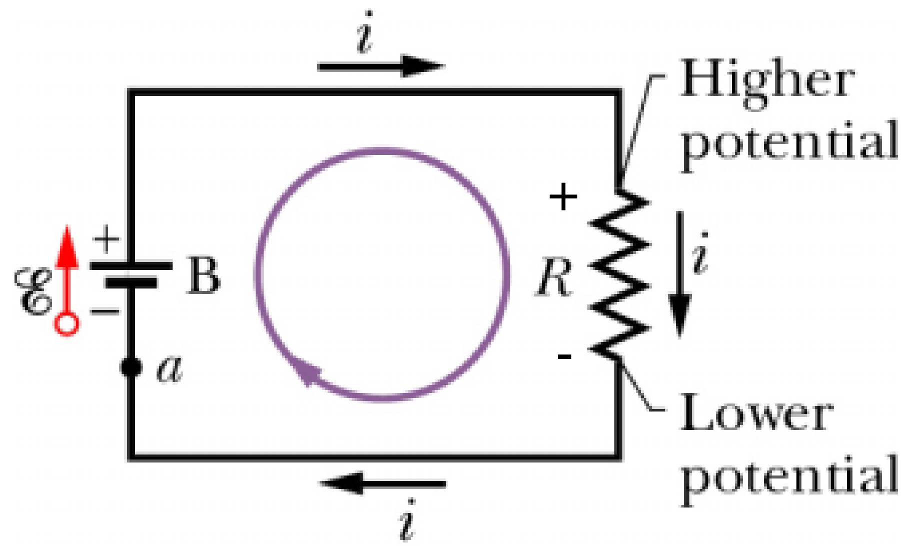
- Return to point a on bottom wire back to potential V_a so

$$V_a + E - iR = V_a$$

Circuits (Fig. 28-3)

- We get back to Ohm's Law

$$\mathcal{E} = iR$$



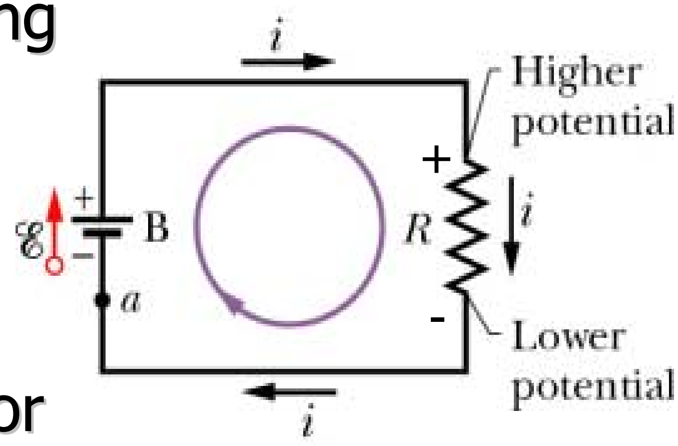
- Could move around circuit counterclockwise

$$V_a - \mathcal{E} + iR = V_a$$

$$\mathcal{E} = iR$$

Circuits (Fig. 28-3)

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



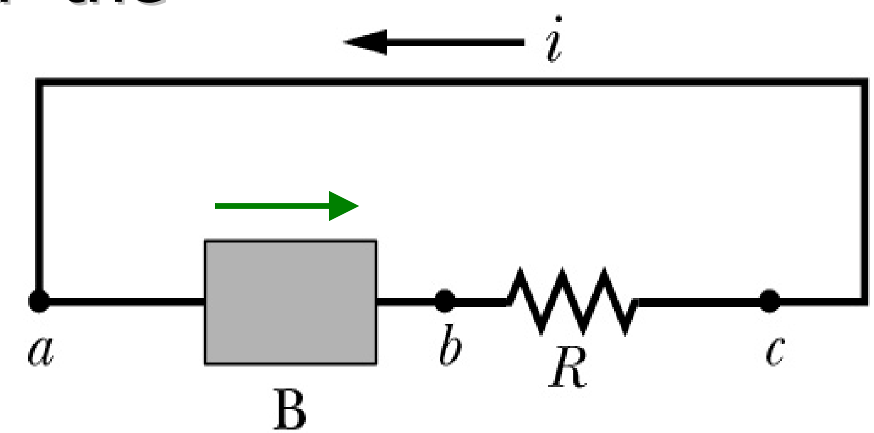
How do we add the changes in V?

- Resistance – Move through resistor in direction of current $V = -iR$ (- because it is down the hill), in opposite direction $V = +iR$ (+ because we move up the hill)
- Emf – Move lower (-) to (+) adds potential and $V = +$E, in the opposite direction $V = -$ E.

Circuits - Checkpoint #1

- A) What direction should the emf arrow point?

  RIGHTWARD



- B) Rank magnitude of current at points a, b, and c.

  All same

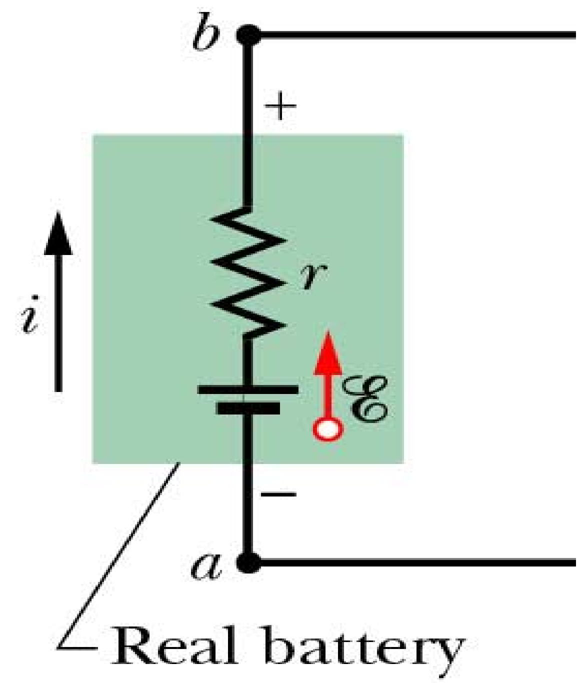
- C) Rank V and U.

  b, then a and c tie

Circuits (Fig. 28-4)

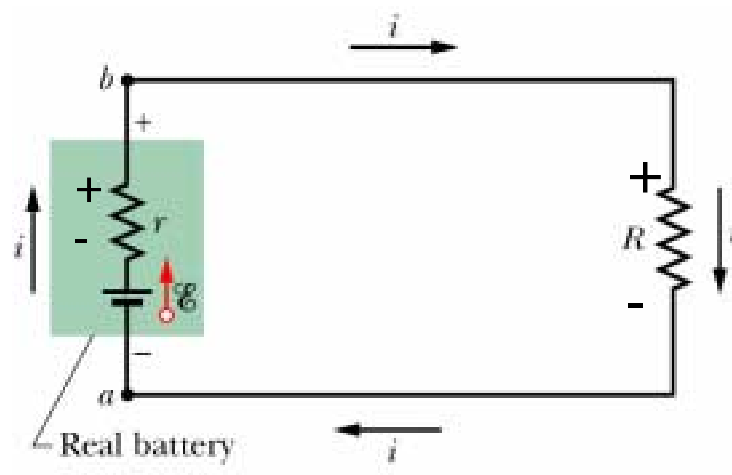
- So far assumed ideal battery – has no internal resistance

- Real battery has internal resistance to movement of charge
- Not in circuit $V = E$ of battery
- If current present $V = E - iR$, where R is the internal resistance of the battery



Circuits (Fig. 28-4a)

- Put real battery in circuit
- Using Kirchhoff's loop rule and starting at point a gives



$$\mathcal{E} - ir - iR = 0$$

$$\mathcal{E} = i(r + R)$$

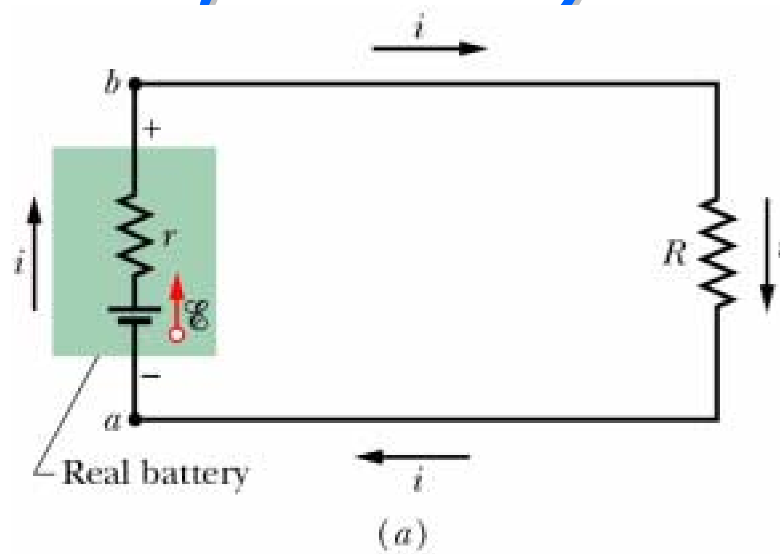
- For ideal battery, r = 0 and we get same as before

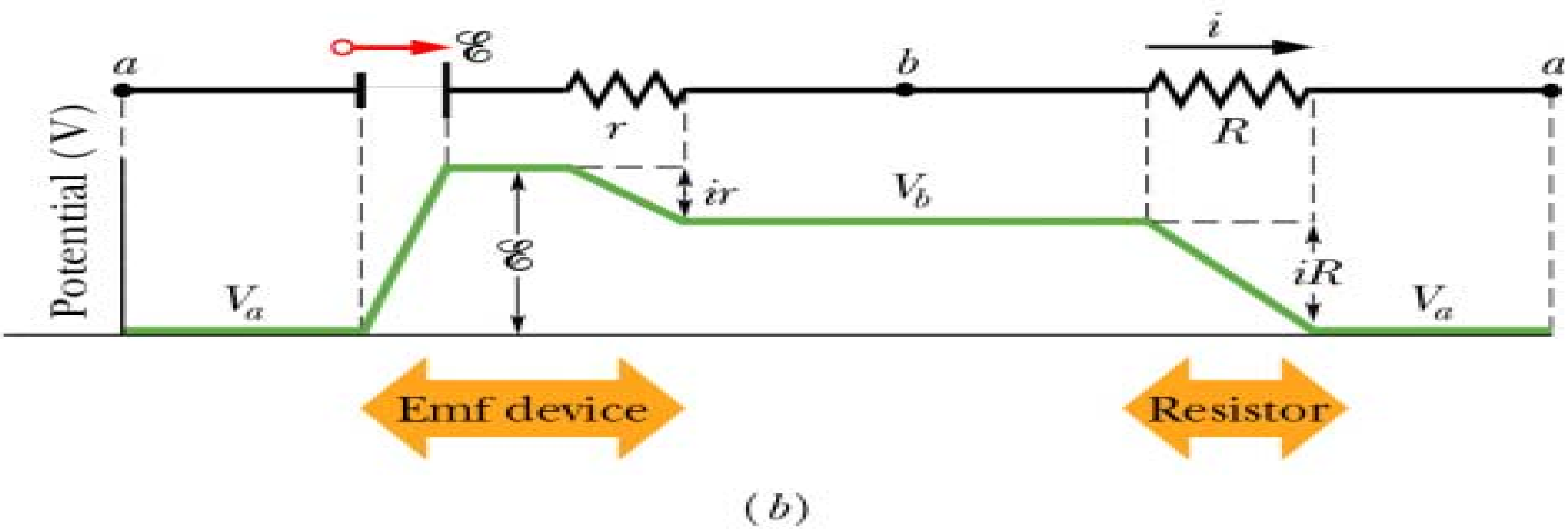
$$\mathcal{E} = iR$$

Circuits (Figs. 28-4a, 28-4b)

- Can represent changes in potential graphically

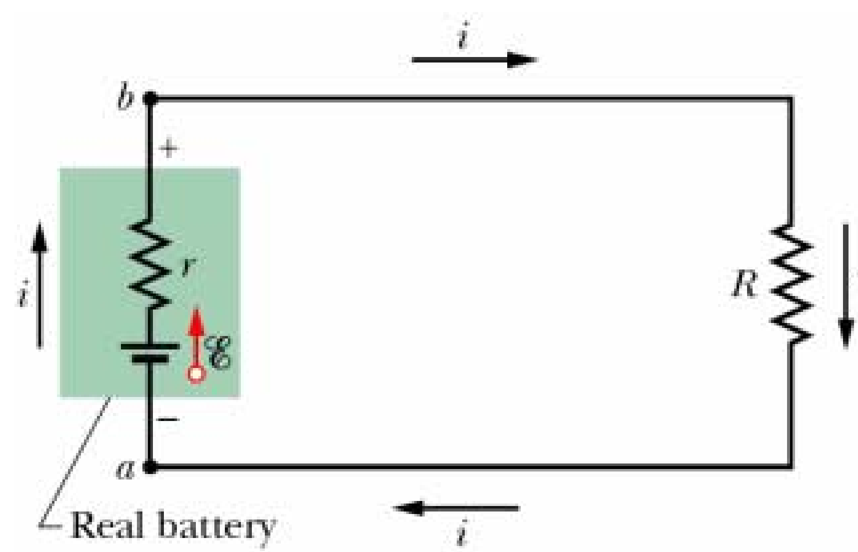
$$E - ir - iR = 0$$





Circuits (Fig. 28-4a)

- What is the potential difference, *V*, between points a and b?
- To find *V* between any 2 points in circuit
  - Start at one point and traverse circuit to other following any path
  - Add changes in V algebraically

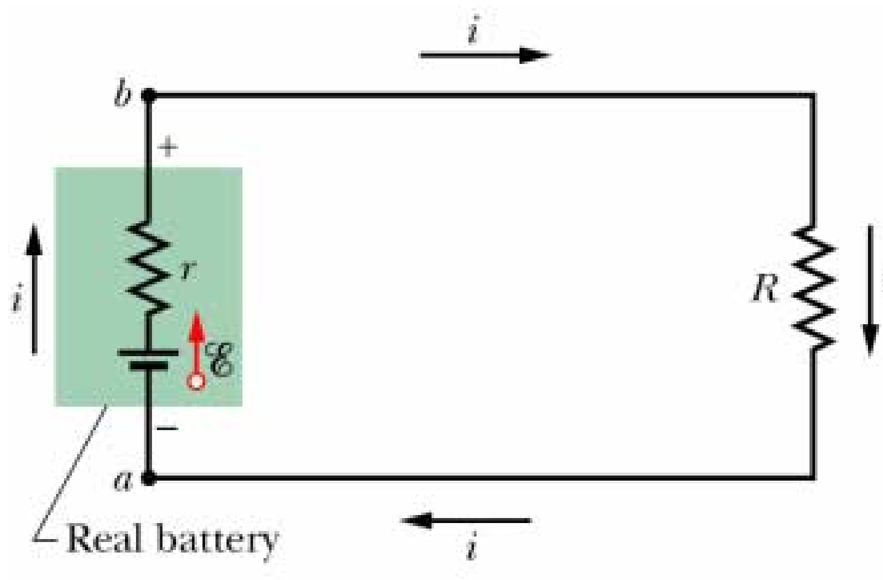


Circuits (Fig. 28-4a)

- Moving from b to a clockwise gives

$$V_b - iR = V_a$$

$$V_b - V_a = iR$$



- From loop rule know

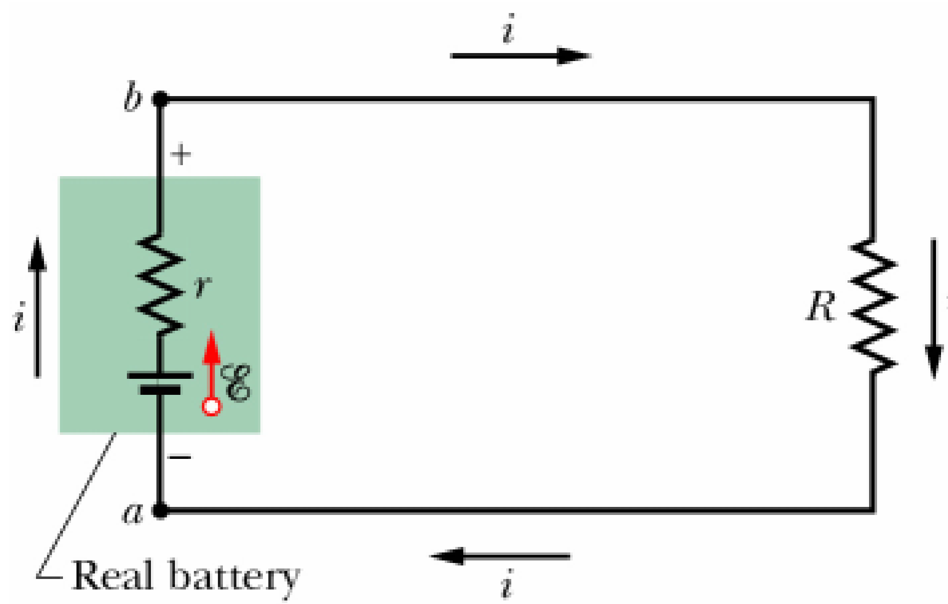
$$\mathcal{E} - ir - iR = 0$$

$$i = \frac{\mathcal{E}}{r + R}$$

Circuits (Fig. 28-4a)

$$V_b - V_a = iR$$

$$i = \frac{\mathrm{E}}{r + R}$$



- Substituting for *i* gives

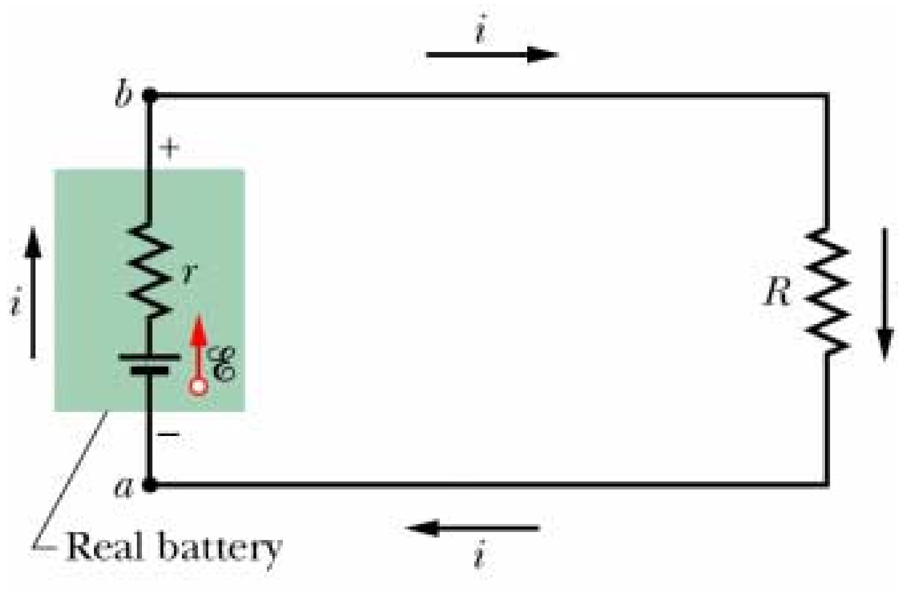
$$V_b - V_a = \mathrm{E}\frac{R}{R + r}$$

Circuits (Fig. 28-4a)

- Now move from b to a counterclockwise

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

$$V_b - V_a = \mathcal{E} - ir$$



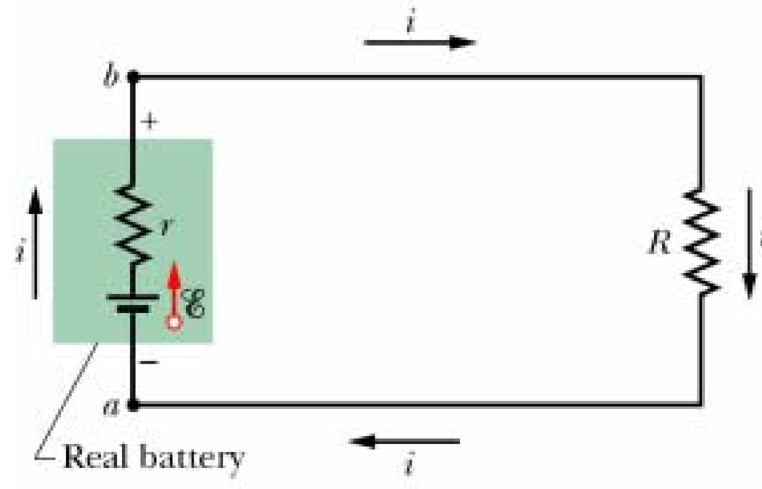
- Substituting *i* from loop rule

$$i = \frac{\mathcal{E}}{r + R}$$

$$V_b - V_a = \mathcal{E}\frac{R}{R + r}$$

Circuits (Fig. 28-4a)

- Suppose *E* = 12V, R=10 Ω and r=2Ω
- Potential across battery's terminals is



$$V_b - V_a = \mathrm{E}\frac{R}{R+r} = (12V)\frac{10\Omega}{10\Omega + 2\Omega} = 10V$$

- *V* across terminals only equal to *E* if no internal resistance (*r* =0) or no current (*i* =0)