Course Updates

http://www.phys.hawaii.edu/~varner/PHYS272-Spr10/physics272.html

Notes for today:

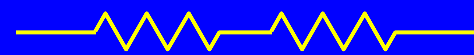
1) Review of Quiz 2 (at end)
2) Assignment 5 (Mastering Physics) online and separate, written problems due Wednesday
3) Review all of Chap 21-24 for Midterm
4) Schedule for next week:
    1) Monday: holiday
    2) Wednesday: review
    3) Friday: Midterm #1

Last Time

Resistors in series:

Current through is same.

Voltage drop across is IR_i

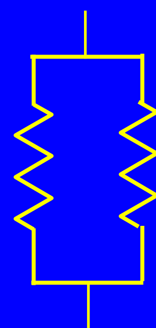


$$R_{effective} = R_1 + R_2 + R_3 + \ldots$$

Resistors in parallel:

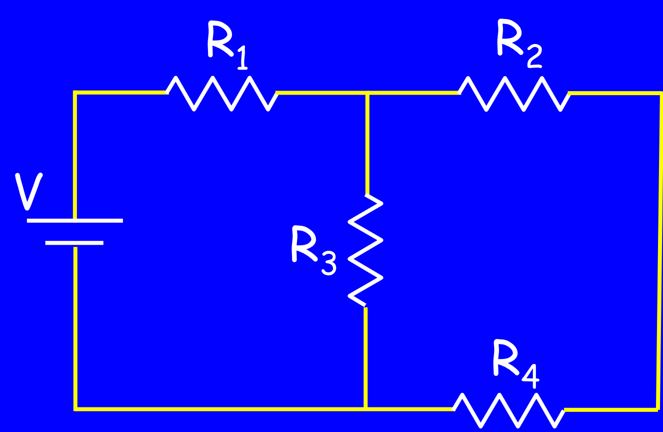
Voltage drop across is same.

Current through is V/R_i



$$\frac{1}{R_{effective}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Solved Circuits



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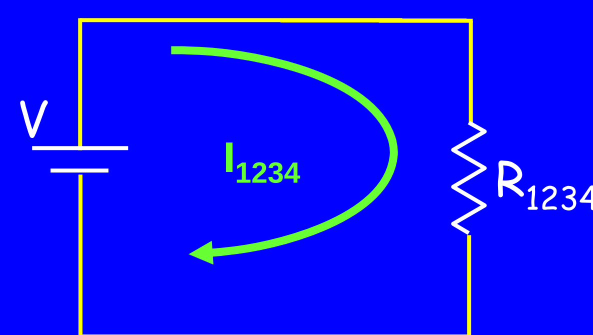
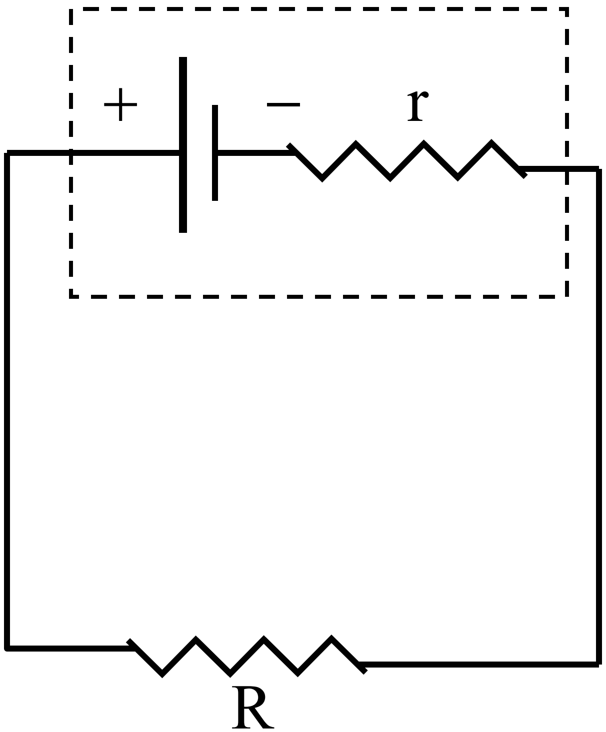
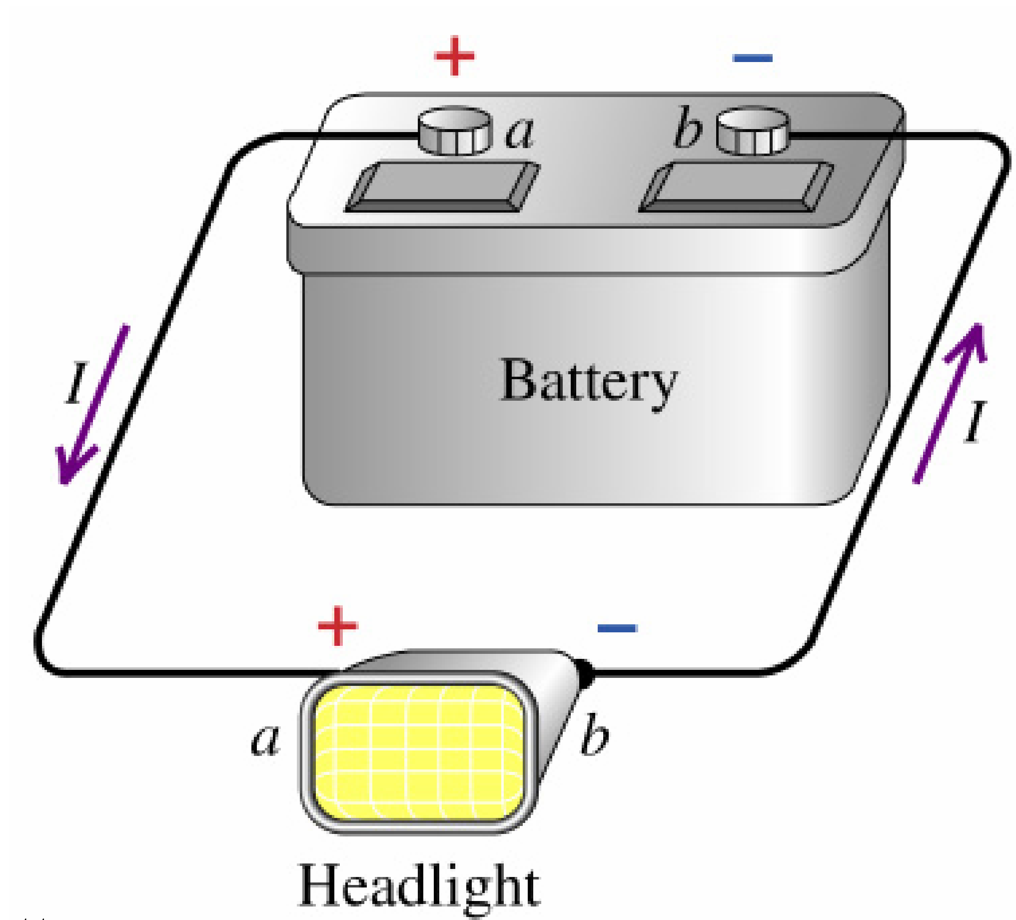


Real life example of previous circuit is a car battery and a headlamp





R = resistance in headlight
r = internal resistance in battery

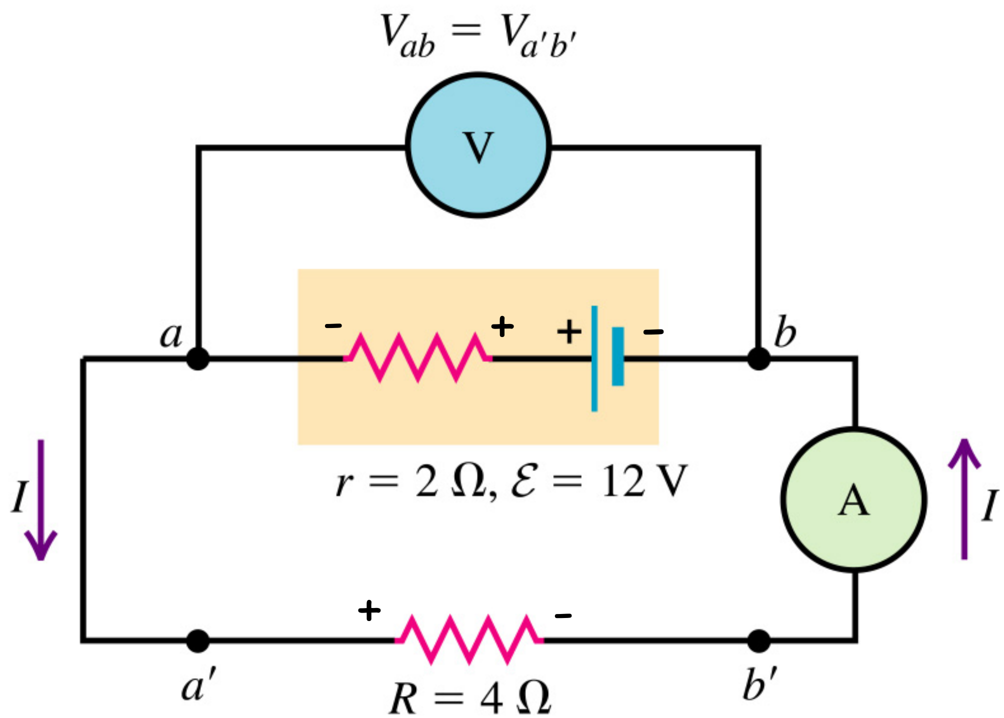
Real Battery with 12volts and an internal resistance of 2 ohms in a circuit with a resistor of 4 ohms

$$\varepsilon - Ir = IR$$

Rearranging:

$$\varepsilon - Ir - IR = 0$$

Can interpret this as the sum of all potential differences around a closed loop must add to zero.



Kirchoff's voltage law or loop rule.

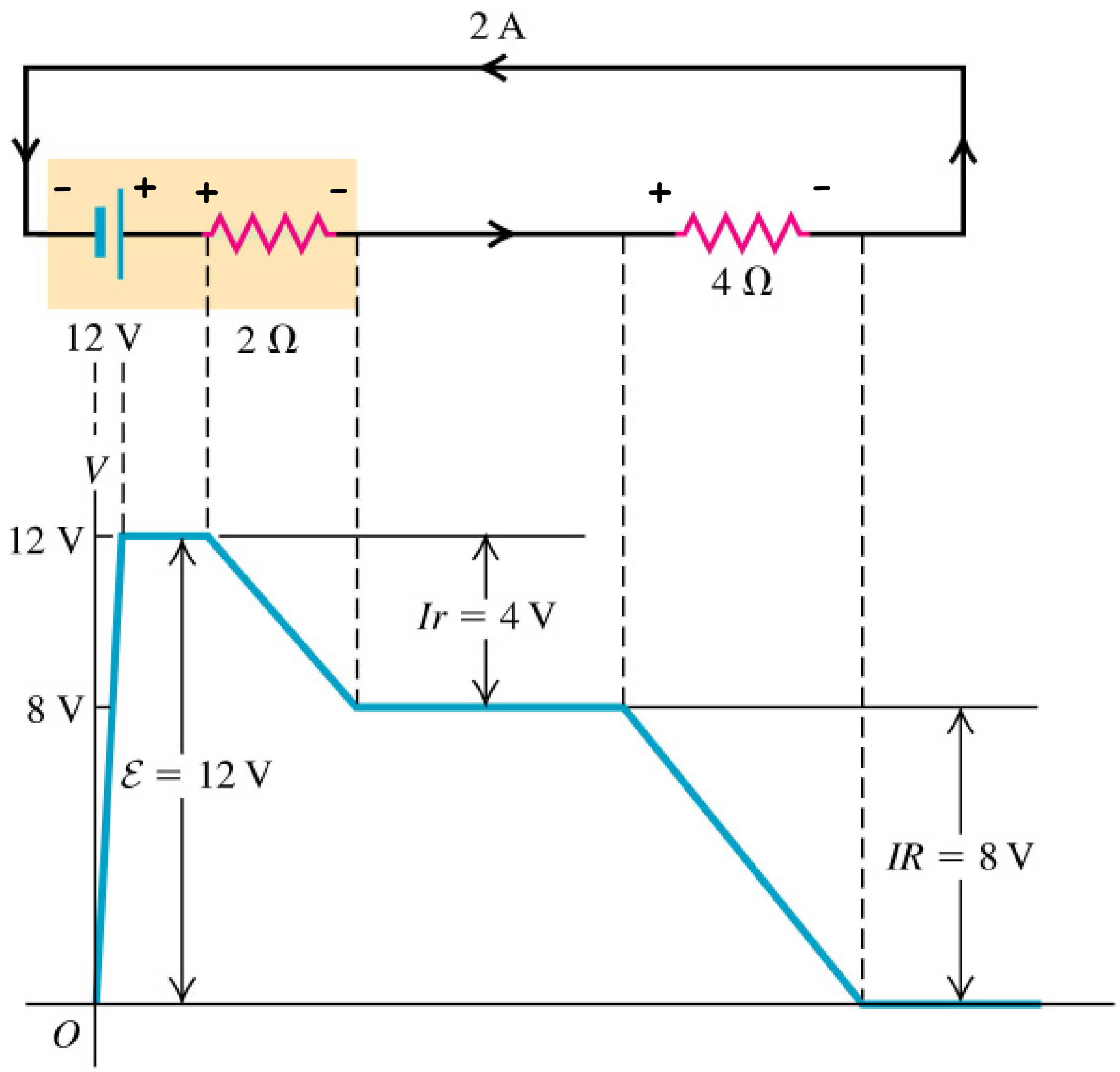
Can define a voltage rise as positive OR a voltage fall as positive.

Electric Potential/Voltage Diagram of the circuit

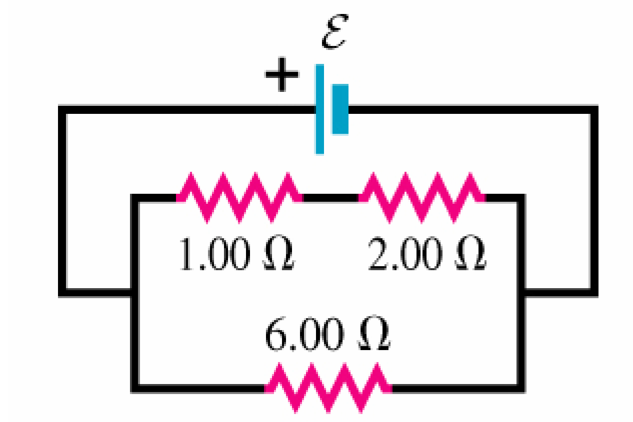
Voltage drop across 2 Ohms is 4 volts

Voltage drop across 4 Ohms is 8 volts

NOTE 4Ω resistor has only 8 of the 12 volts.



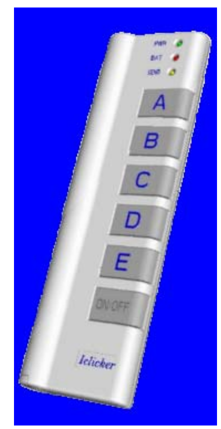
Warm up Exercise



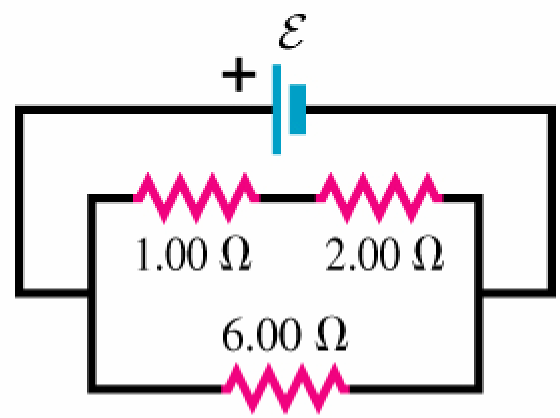
In the circuit shown, the voltage across the 2 Ω resistor is 12 volts .

A) What is the emf of the battery?

A) 6V
B) 12V
C) 18V
D) 24V
E) 120V



Warm up Exercise



In the circuit shown, the voltage across the 2 Ω resistor is 12 volts .

A) What is the emf of the battery?

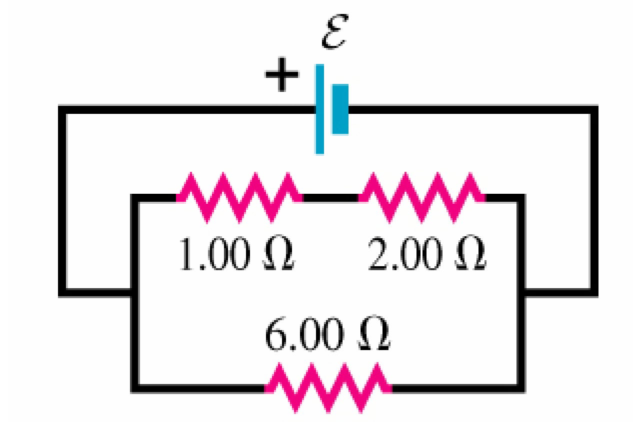
A) 6V
B) 12V
C) 18V
D) 24V
E) 120V

$$I_2 = \frac{V_2}{R_2} = \frac{12V}{2\Omega} = 6A$$

$$V_1 = I_1 R_1 = (6A)(1\Omega) = 6V$$

$$\mathcal{E} = V_1 + V_2 = 18V$$

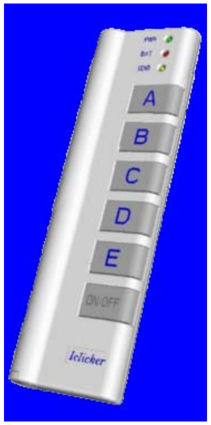
Warm up Exercise



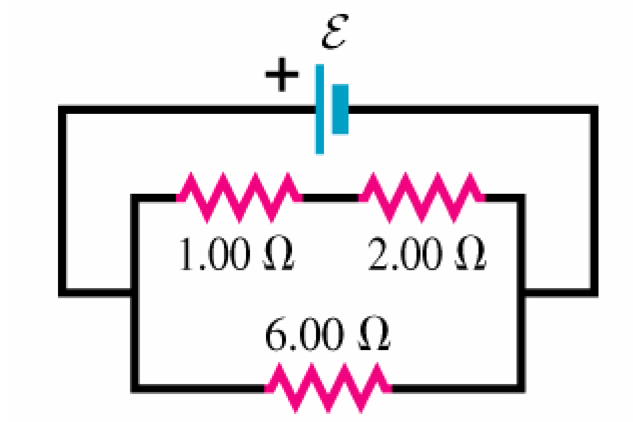
In the circuit shown, the voltage across the 2 Ω resistor is 12 volts .

B) What is the current through the 6.00 ohm resistor?

A) 2A
B) 3A
C) 4A
D) 8A
E) 12A



Warm up Exercise



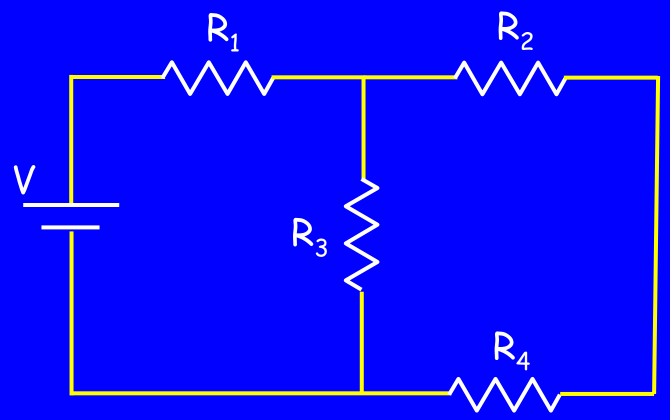
In the circuit shown, the voltage across the 2 Ω resistor is 12 volts .

B) What is the current through the 6.00 ohm resistor?

A) 2A
B) 3A
C) 4A
D) 8A
E) 12A

$$I_6 = \frac{\varepsilon}{R_6} = \frac{18V}{6\Omega} = 3A$$

Calculation 3



In the circuit shown: V = 18V,

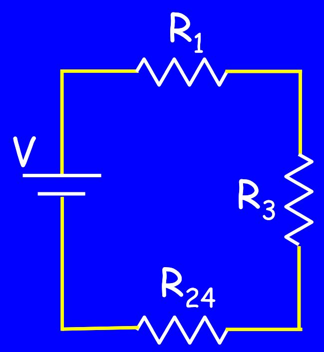
$R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 3\Omega$, and $R_4 = 4\Omega$.

What is V_2, the voltage across R_2?

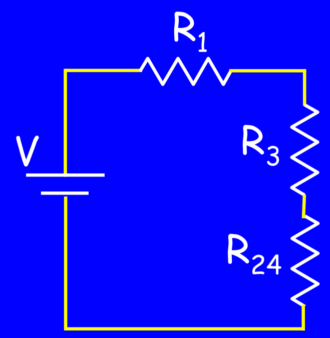
- Combine Resistances:

R_2 and R_4 are connected in series = $R_{24} = 2 + 4 = 6\ \Omega$

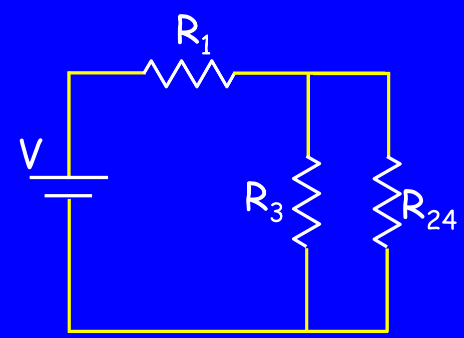
Redraw the circuit using the equivalent resistor R_{24} = series combination of R_2 and R_4.



(A)



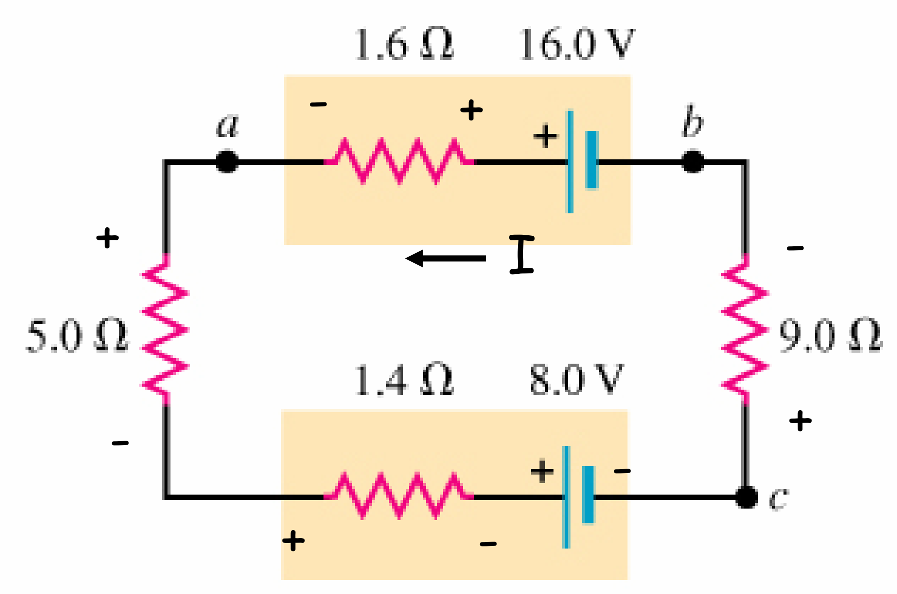
(B)



(C)

Loopy-ness

Kirchoff's Voltage loop law: sum of voltages = 0



Need to determine I

How to know which direction to go around loop?

$$\sum_i V_i = V_{eq}$$

$$\sum_i R_i = R_{eq}$$

$$I = \frac{V_{eq}}{R_{eq}}$$

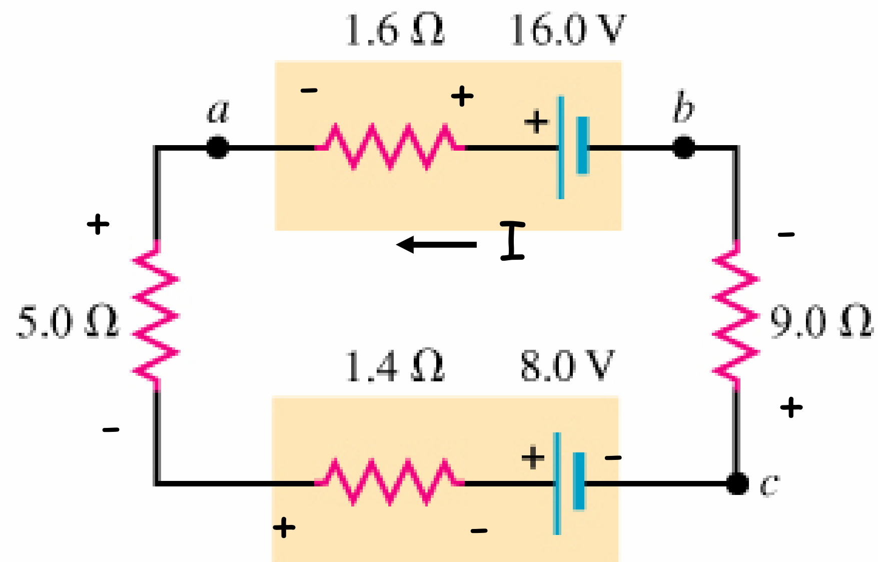
Doesn't matter, because sign of I will tell

Warning!! need Thevenin Equivalence to make General

Y&F 25.36

The circuit shown in the figure contains two batteries, each with an emf and an internal resistance, and two resistors.

A) Find the direction and magnitude of the current in the circuit
B) Find the terminal voltage Vab of the 16.0-V battery.
C) Find the potential difference Vbc of point b with respect to point c .



A.) Use Kirchoff's loop law:

$$16V - 1.6\Omega I - 5.0\Omega I - 1.4\Omega I - 8V - 9.0\Omega I = 0$$

$$8V - 17\Omega I = 0$$

$$I = \frac{8}{17}A = 0.471A$$

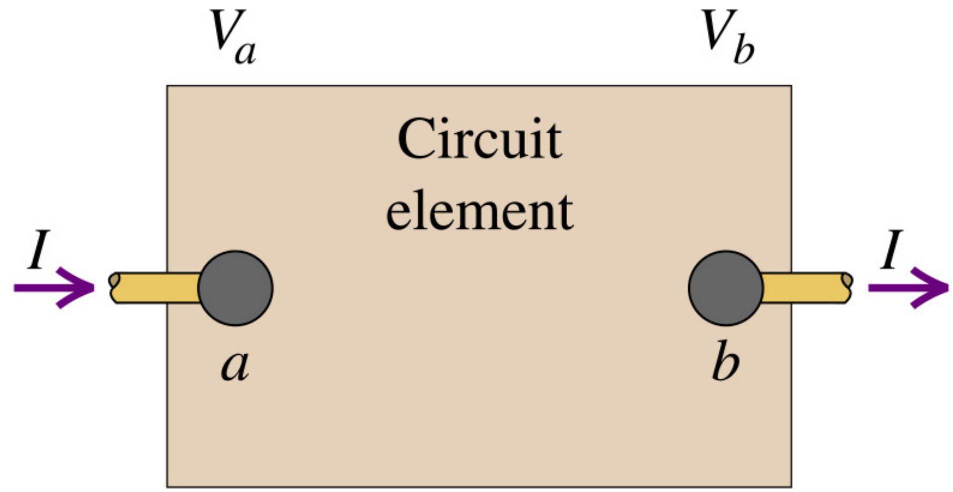
B.) V_{ab} = 16V – I(1.6 Ω) = 16V – (0.471 A)(1.6 Ω) = 15.2 V

C.) V_{bc} = – I(9.0 Ω) = – (0.471 A)(9.0 Ω) = -4.24 V

Power

Very important use of electricity.

Suppose we have a circuit element that has a voltage drop of $V_{ab} = V_a - V_b$ and a current flow of I.



What is the change in potential energy in this circuit element?

$$dU = (V_{ab})dq$$

What is the time rate change in potential energy in this circuit element?

$$P = \frac{dU}{dt} = (V_{ab})\frac{dq}{dt} = (V_{ab})\ I$$

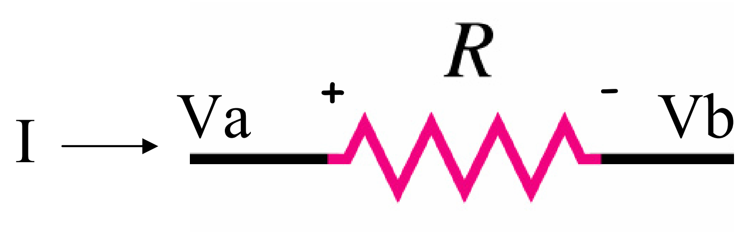
Power, P, is the time rate change in energy and equals voltage $\times$ current

$$P = (V_{ab})\ I$$

Units = voltage-amps = Watts

Power

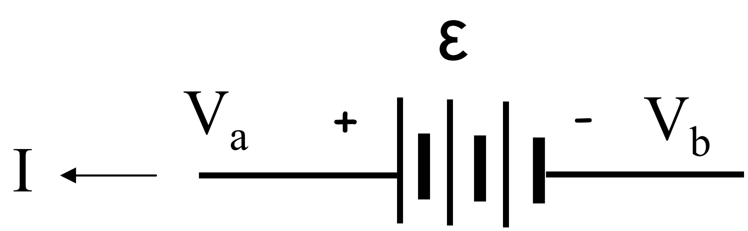
Resistor



Power $P = I\,(Va - Vb) = IV = I\,(IR) = I^2R = V^2/R$

Electrical power converted to Joule heat.

EMF



Power $P = I\,(Va - Vb) = I\,\varepsilon$

Electrical power can be + or –
depending on direction of I.

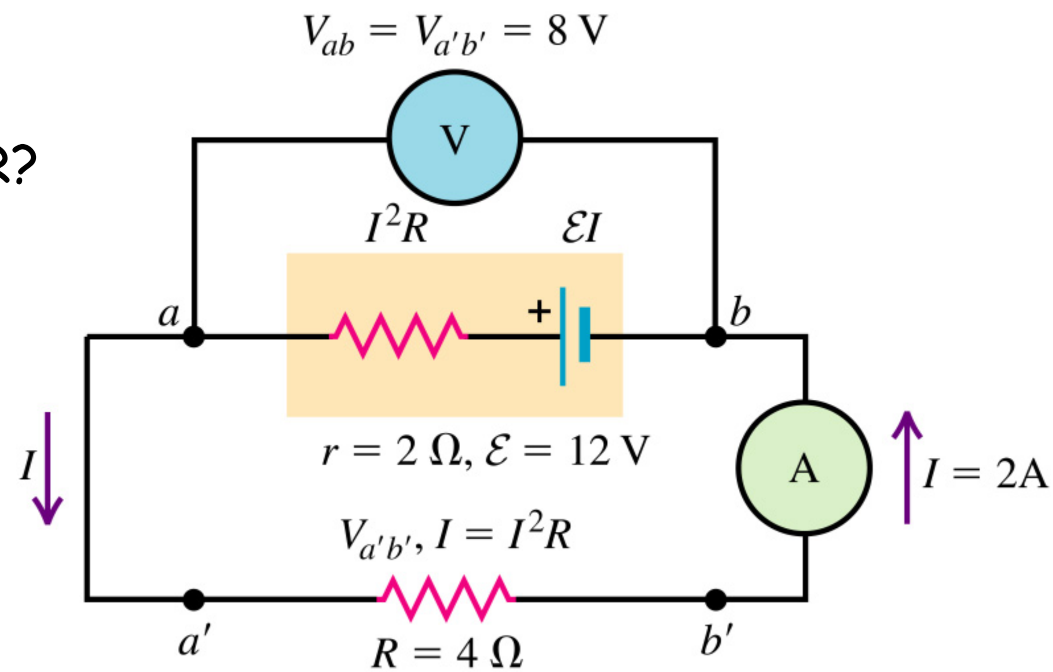
Power Example of Battery and resistor

What is the power in resistor R?

$$I^2R = 2*2 * 4 = 16W$$

What is the power in internal resistance r?

$$I^2 r = 2*2 * 2 = 8W$$



What is the rate of energy conversion of the battery?

$$\mathcal{E} I = 12 * 2 = 24 W$$

=> Energy conversion rate equals sum of power in both R and r

Y&F Problem 25.47

The capacity of a storage battery in your car is rated in amp-hours. A 12 volt battery rated at 50·A · h, can supply a 50 amps for 1 hour at 12 volts or 25 amps for 2 hours etc.

A.) What is the total energy supplied by this battery?

$$P = \frac{dU}{dt} = IV = (50A)(12V) = 600W$$

$$U = Pt = (600W)(1hr)(3600s/hr) = 2.16MJ$$

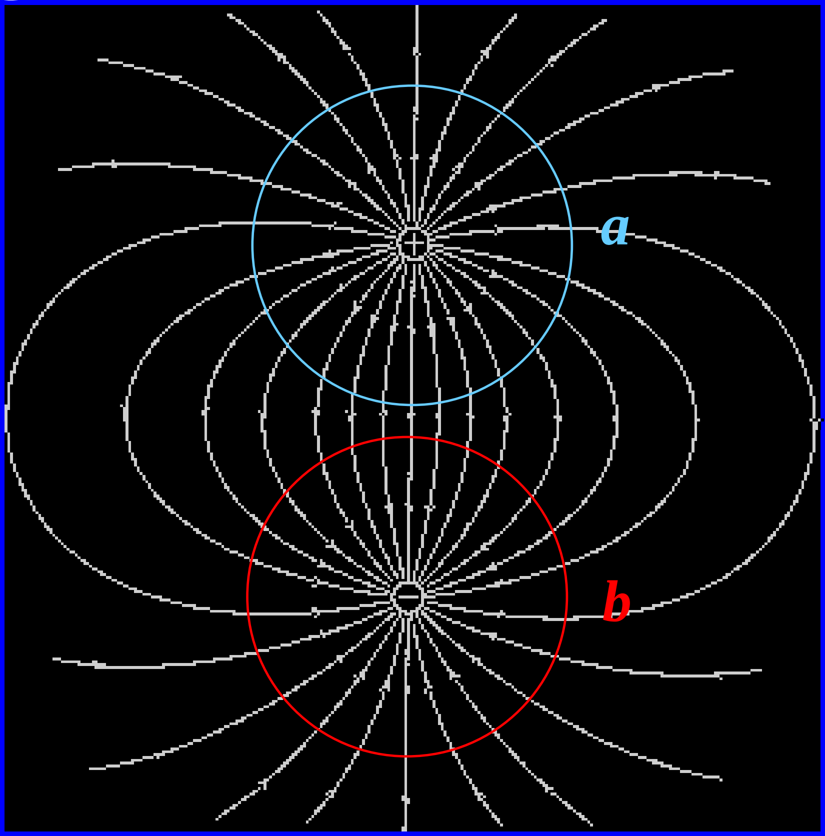
B.) if a electric battery charger supplies 0.45 kW, how long does it take to fully charge a dead battery?

$$U = Pt$$

$$t = U/P = (2.16MJ)/0.45kW)$$

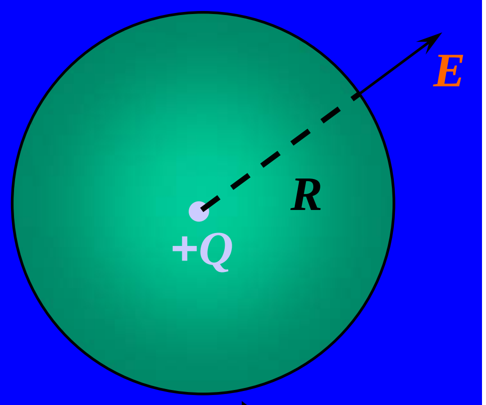
$$= 4680s = 78m$$

Gauss' Law



$$\oint \vec{E} \bullet d\vec{A} = \Phi_E = \frac{q_{enclosed}}{\varepsilon_0}$$

Gauss $\Rightarrow$ Coulomb



- **We now illustrate this for the field of the point charge and prove that Gauss' Law implies Coulomb's Law.**
- **Symmetry $\Rightarrow$ *E*-field of point charge is radial and spherically symmetric**
- **Draw a sphere of radius *R* centered on the charge.**
- **Why?**

  E **normal to every point on the surface**

  $\Rightarrow \vec{E} \bullet d\vec{A} = E\,dA$

  E **has same value at every point on the surface**

  $\Rightarrow$ **can take *E* outside of the integral!**

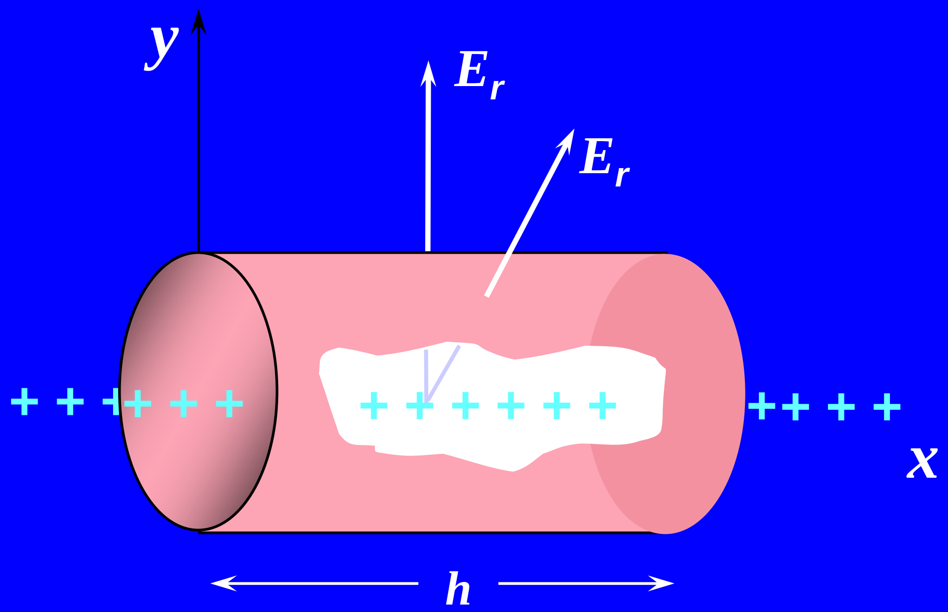
- **Therefore,** $\oint \vec{E} \bullet d\vec{A} = \oint E dA = E \oint dA = 4\pi R^2 E$ **!**
  - **Gauss' Law** $\varepsilon_0 4\pi R^2 E = Q$

    $$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{R^2}$$

  - **We are free to choose the surface in such problems… we call this a "Gaussian" surface**

Infinite Line of Charge

- **Symmetry ⇒ *E*-field must be ⊥ to line and can only depend on distance from line**
- **Therefore, CHOOSE Gaussian surface to be a cylinder of radius *r* and length *h* aligned with the *x*-axis.**



•Apply Gauss' Law:

- **On the ends,** $\vec{E} \bullet d\vec{A} = 0$
- **On the barrel,** $\oint \vec{E} \bullet d\vec{A} = 2\pi r h E$ **AND** $q = \lambda h \Rightarrow$

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

NOTE: we have obtained here the same result as we did last lecture using Coulomb's Law. The symmetry makes today's derivation easier.

Gauss' Law: Help for the Homework Problems

Midterm

- **Gauss' Law is ALWAYS VALID!**

$$\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = q_{enclosed}$$

- **What Can You Do With This?**

  If you have (a) spherical, (b) cylindrical, or (c) planar symmetry AND:

  - **If you know the charge (RHS), you can calculate the electric field (LHS)**
  - **If you know the field (LHS, usually because E=0 inside conductor), you can calculate the charge (RHS).**

- **Spherical Symmetry: Gaussian surface = sphere of radius r**

  LHS: $\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = 4\pi\varepsilon_0 r^2 E$

  RHS: q = ALL charge inside radius r

  $$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

- **Cylindrical symmetry: Gaussian surface = cylinder of radius r**

  LHS: $\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = \varepsilon_0 2\pi r L E$

  RHS: q = ALL charge inside radius r, length L

  $$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

- **Planar Symmetry: Gaussian surface = cylinder of area A**

  LHS: $\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = \varepsilon_0 2 A E$

  RHS: q = ALL charge inside cylinder =σA

  $$E = \frac{\sigma}{2\varepsilon_0}$$

Prez Day Weekend Fun

- HW #5 → due next Wednesday

- Now is time to resolve any questions you may have about previous HW, Quiz

- Office Hours usually after this class (9:30 – 10:00) in WAT214 – today (1-1:30pm)