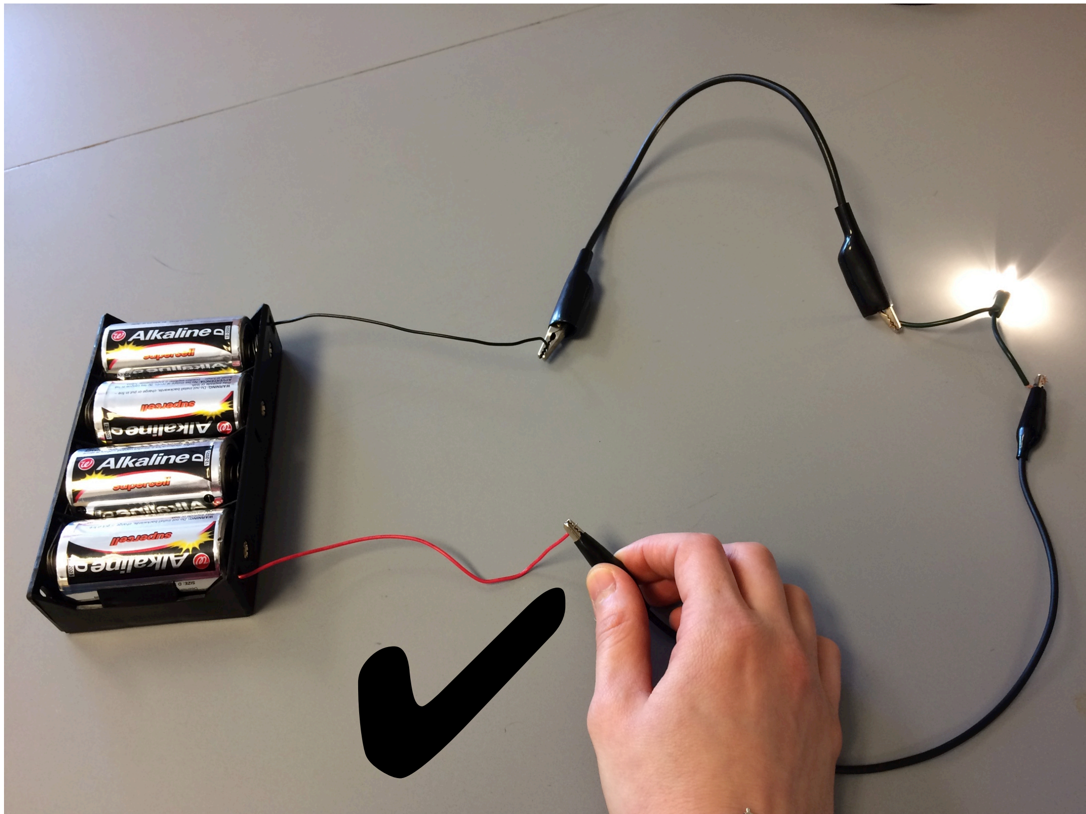
Unit 8 – Static Electricity and Circuits

Lesson 3: Ohm's Law and Power

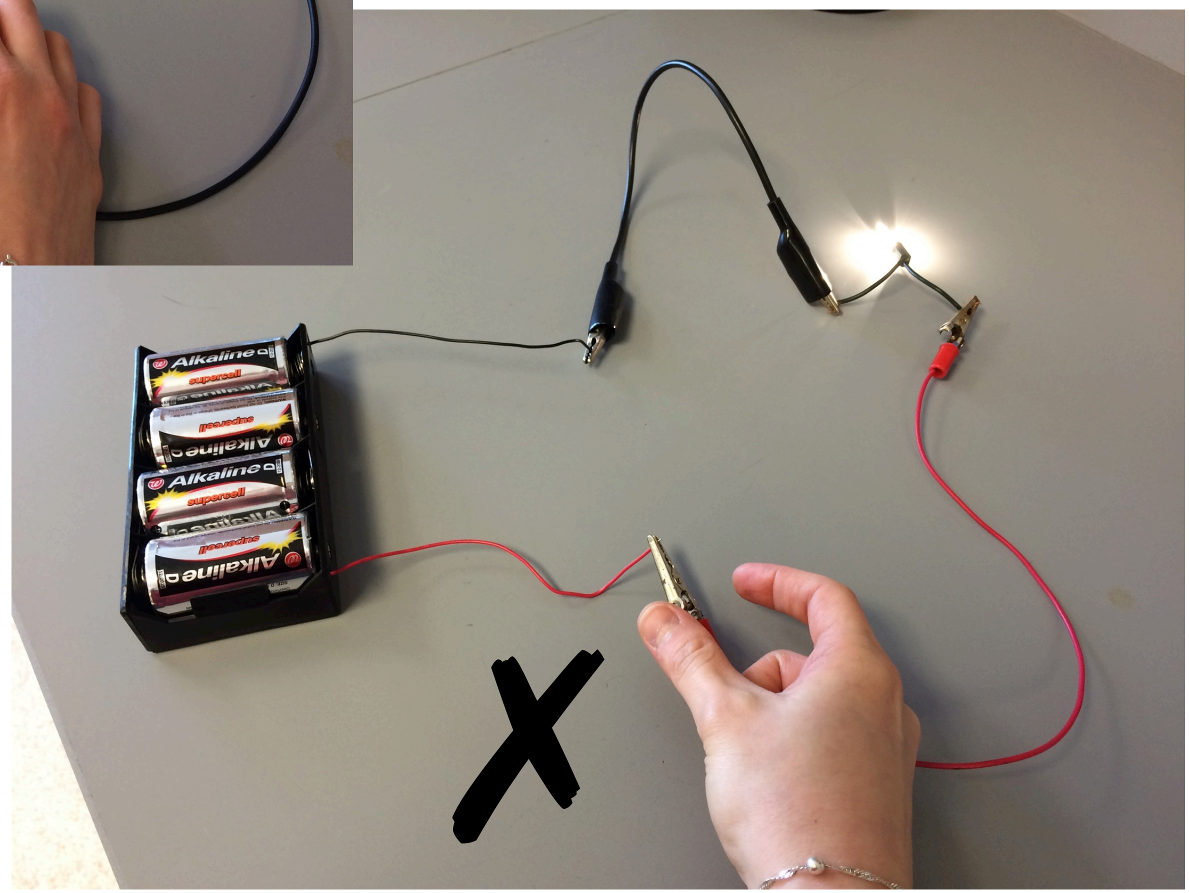
Suggested Readings

- PhysicsClassroom.com -> Tutorial -> Current Electricity -> Lesson 3, c only

- Holt Physics textbook -> Chapter 17 (Electrical Energy and Current) -> Section 3 (pg. 612 - 613)



<= Touch **insulated** wire!!



DON'T touch => exposed metal!!

Voltage-Current-Resistance Lab

For each resistor, what happened to **voltage** across the resistor as you increased the number of batteries?

Voltage-Current-Resistance Lab

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-> voltage increased by the same amount

Why?

Voltage-Current-Resistance Lab

For each resistor, what happened to **voltage** across the resistor as you increased the number of batteries?

-> voltage increased by the same amount

Why?

-> As the voltage gain across the battery increases, the voltage drop across the resistor must also increase!

Voltage-Current-Resistance Lab

Good, so we're still verifying that in a simple circuit, the voltage gained through the battery must **all** be dissipated by the circuit!

(phew)

Voltage-Current-Resistance Lab

Again for each resistor, as you increased the voltage, what happened to the **current** that flowed through the resistor?

Voltage-Current-Resistance Lab

Again for each resistor, as you increased the voltage, what happened to the **current** that flowed through the resistor?

-> It increased!

Why do you think that is?

Voltage-Current-Resistance Lab

Again for each resistor, as you increased the voltage, what happened to the **current** that flowed through the resistor?

-> It increased!

Why do you think that is?

-> The increased voltage creates more motivation for current to flow!

Voltage-Current-Resistance Lab

Conclusion #1:

If we hold resistance constant, how are voltage and current related?

Voltage-Current-Resistance Lab

Conclusion #1:

If we hold resistance constant, how are voltage and current related?

-> They are **directly proportional**

-> In other words, if voltage increases, current increases as well; if voltage decreases, current decreases as well

Voltage-Current-Resistance Lab

For one battery, as you increased the resistance, what happened to the **voltage** across the resistor?

Voltage-Current-Resistance Lab

For one battery, as you increased the resistance, what happened to the **voltage** across the resistor?

-> It stayed the same

Why?

Voltage-Current-Resistance Lab

For one battery, as you increased the resistance, what happened to the **<u>voltage</u>** across the resistor?

-> It stayed the same

Why?

-> Remember, the voltage gain across the battery must equal the voltage drop across the resistor!

Voltage-Current-Resistance Lab

For one battery, as you increased the resistance, what happened to the **current** through the resistor?

Voltage-Current-Resistance Lab

For one battery, as you increased the resistance, what happened to the **current** through the resistor?

-> It decreased

Why do you think that is?

Voltage-Current-Resistance Lab

For one battery, as you increased the resistance, what happened to the **current** through the resistor?

-> It decreased

Why do you think that is?

-> The more "resistance to current flow" there is, the less current can actually flow!

Voltage-Current-Resistance Lab

Conclusion #2:

If we hold voltage constant, how are resistance and current related?

Voltage-Current-Resistance Lab

Conclusion #2:

If we hold voltage constant, how are resistance and current related?

-> They are **inversely proportional**

-> In other words, if resistance increases, current decreases; if resistance decreases, current increases

Voltage-Current-Resistance Lab

What did you find when you graphed ΔV vs. I?

A) What was the shape of the graph?

Voltage-Current-Resistance Lab

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-> Linear!

B) How was the slope related to resistance?

Voltage-Current-Resistance Lab

What did you find when you graphed ΔV vs. I?

A) What was the shape of the graph?

-> Linear!

B) How was the slope related to resistance?

-> They should have been roughly equal

C) What is slope equal in terms of ΔV and I?

Voltage-Current-Resistance Lab

What did you find when you graphed ΔV vs. I?

A) What was the shape of the graph?

-> Linear!

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C) What is slope equal in terms of ΔV and I?

-> ΔV/I

Ohm’s Law

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

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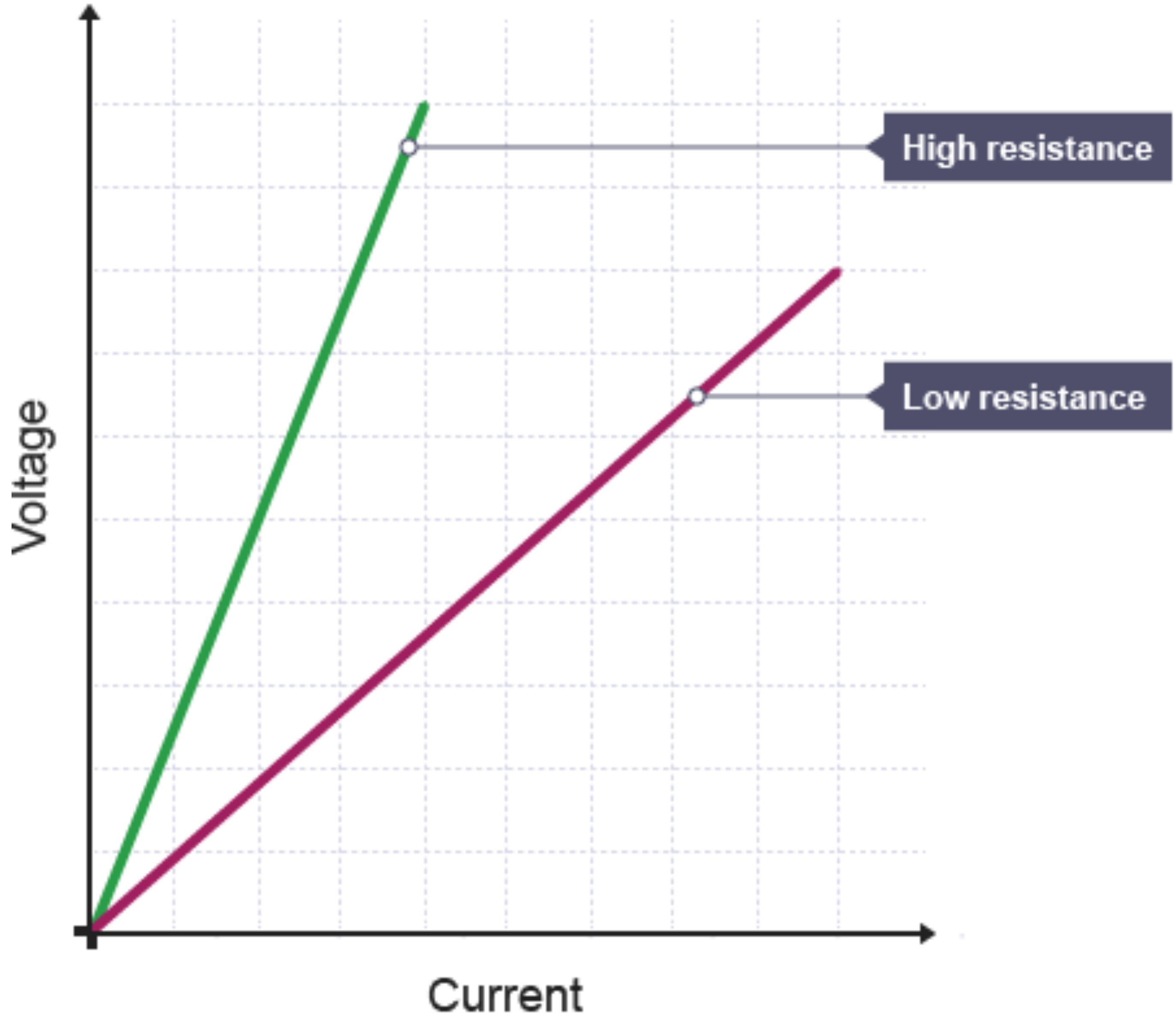

http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/electricity_for_gadgets/resisting/revision/2/

Ohm’s Law

How do we put this all together?

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We can rearrange this to form the classic equation, known as **Ohm’s Law**

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$$\boxed{\Delta V = IR}$$

$$\Delta V = IR$$

Notice Ohm's Law has everything we need:

* If we hold resistance constant

    -When voltage goes up, current goes up

    -When voltage goes down, current goes down

* If we hold voltage constant

    -When resistance goes up, current goes down

    -When resistance does down, current goes up

$$\Delta V = IR$$

(I should note that there are some types of electrical circuits where Ohm's Law does NOT hold. However, we are not at all concerned about them in this class.

For this class, Ohm's Law is the law!)

Ohm’s Law

This is a good place to emphasize the role of a **battery**:

* A battery’s job is to provide a constant voltage

* The circuit then draws whatever current it can from it, *depending on the resistance of the circuit!*

Ohm's Law

This is also a good place to emphasize the role of a **resistor**:

* So a resistor is used to regulate and control how much current a circuit uses!

* That way, if the voltage stays fixed, you can still control how much current you use

Dimmer Switch

One of your lamps has a dimmer switch on it. As you turn the dimmer switch up, making the light brighter, what changes occur in these measurements for the entire circuit?

Did ΔV go *up*, *down*, or stay the *same*?

Did R go *up*, *down*, or stay the *same*?

Did I go *up*, *down*, or stay the *same*?

$$\Delta V = IR$$

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Did R go *up*, *down*, or stay the *same*?

Did I go *up*, *down*, or stay the *same*?

Answer: ΔV stayed the same, R went down and I went up

$$\Delta V = IR$$

Ohm's Law Problems

A 1.5 V battery is connected to a small bulb with a resistance of 3.5 Ω. What is the current in the bulb?

$$\Delta V = IR$$

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Answer: I = 0.43 A

$$\Delta V = IR$$

Ohm's Law Problems

A stereo with a resistance of 65 Ω is connected across a potential difference of 120 V. What is the current in this device?

$$\Delta V = IR$$

Ohm's Law Problems

A stereo with a resistance of 65 Ω is connected across a potential difference of 120 V. What is the current in this device?

Answer: I = 1.85 A

$$\Delta V = IR$$

Ohm's Law Problems

The current in a microwave oven is 6.25 A. If the resistance of the oven's circuitry is 17.6 Ω, what is the potential difference across the oven?

$$\boxed{\Delta V = IR}$$

Ohm's Law Problems

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$$\Delta V = IR$$

Answer: $\Delta V = 110$ V

Ohm's Law Problems

A typical color television draws 2.5 A of current when connected across a potential difference of 115 V. What is the resistance of the television set?

$$\Delta V = IR$$

Ohm's Law Problems

A typical color television draws 2.5 A of current when connected across a potential difference of 115 V. What is the resistance of the television set?

Answer: R = 46 Ω

$$\Delta V = IR$$

Ohm's Law Problems

The current in a certain resistor is 0.5 A when it is connected to a potential difference of 110 V. What is the current in this same resistor if:

A) The operating potential difference is 90 V?

B) The operating potential difference is 130 V?

$$\Delta V = IR$$

Ohm's Law Problems

The current in a certain resistor is 0.5 A when it is connected to a potential difference of 110 V. What is the current in this same resistor if:

A) The operating potential difference is 90 V?

B) The operating potential difference is 130 V?

Answer: A) I = 0.41 A
B) I = 0.59 A

$$\Delta V = IR$$

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We define power as the amount of energy transferred (dissipated) per unit time

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We have not defined how to calculate electric potential energy (because it is not covered in AP Physics 1), so just trust me when I tell you that it is

$$\underline{\mathbf{PE = q(\Delta V)}}$$

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$$\underline{\mathbf{PE = q(\Delta V)}}$$

So this is the energy lost or gained by a charge as it experiences a potential difference of ΔV

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So power would be $PE/\Delta t$

Power = $(q\Delta V)/\Delta t$

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$$\text{Power} = (q\Delta V)/\Delta t = (q/\Delta t)(\Delta V)$$

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Power

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Power = $(q\Delta V)/\Delta t = (q/\Delta t)(\Delta V) = I(\Delta V)$

Thus, we say that Power:

$$\mathbf{P = I\,\Delta V}$$

Power

The unit of Power is Joules/second = **Watt (W)**

Power

Which light bulb is going to be brighter when plugged into a 120V outlet?

A. 60 W
B. 100 W
C. Same
D. Can’t be determined

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So more power => more energy dissipated per unit time => brighter bulb

Power

Use Ohm's Law ($\Delta V = IR$) to re-write the basic power equation, $P = I \Delta V$ in terms of I and R only.

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Use Ohm's Law ($\Delta V = IR$) to re-write the basic power equation, $P = I\,\Delta V$ in terms of I and R only.

$$\boxed{\mathbf{P = I^2\,R}}$$

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Use Ohm's Law ($\Delta V = IR$) to re-write the basic power equation, $P = I\,\Delta V$ in terms of ΔV and R only.

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

Power

To calculate power…	… if you have these variables
$P = I \Delta V$	Current and voltage, but NOT resistance
$P = I^2 R$	Current and resistance, but NOT voltage
$P = (\Delta V)^2/R$	Voltage and resistance, but NOT current

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Only one you get on the AP test; you should be comfortable deriving the others with the help of Ohm's Law ($\Delta V = IR$)

$P = I \Delta V$

$P = I^2 R$

$P = (\Delta V)^2/R$

Power

What would cause the Power of an appliance to increase?

i. If voltage stayed the same and resistance increased
ii. If voltage stayed the same and resistance decreased
iii. If resistance stayed the same and voltage increased
iv. If resistance stayed the same and voltage decreased

A. i & iii
B. i & iv
C. ii & iii
D. ii & iv

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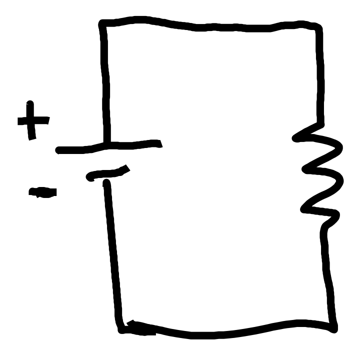
Power

In a simple circuit where a resistor is connected to a battery, what would happen to the Power dissipated by the resistor if its resistance increased?



A. Increase
B. Decrease
C. Stay the same
D. Can't be determined

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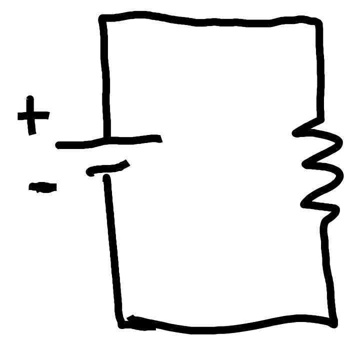

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Power

You have a simple flashlight circuit with a single 6 V battery. You try two different bulbs. Bulb #1 glows brightly. Bulb #2 glows dimly. Which bulb has the larger resistance? (The brightness is an indicator of Power dissipated by light bulb.)

A. Bulb #1
B. Bulb #2
C. Can't be determined

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Electric Bill

You left a 60 W porch light on continually for a month. If the electric company charges 9¢ per kW·hr, how much would you be charged just for the porch light? (Assume 30 days in a month.)

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Answer: $3.89

Electric Bill

What do Electric Companies sell us?

A. Power
B. Energy
C. Current
D. Voltage
E. All of these

Electric Bill

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B. Energy
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