Mr. Wright's Math Extravaganza

Physical Sciences

(Chemistry, Physics, Physical Science)

Electromagnetism

Units 07 Static Electricity, 08 Circuits, 09 Magnetism

Average Level for All Three Units

Level 2.0: 70% on test, Level 3.0: 80% on test, Level 4.0: level 3.0 and success on electric motor lab

Score	I Can Statements
4.0	**09 Magnetism** ☐ I can build a device that relies on electric currents producing a magnetic field or changes to a magnetic field producing electric currents to function.
3.5	In addition to score 3.0 performance, partial success at score 4.0 content.
3.0	**07 Static Electricity/09 Magnetism** ☐ I can identify similarities and differences between electrical and magnetic fields. **09 Magnetism** ☐ I can draw conclusions about the ability of electric currents to produce magnetic fields. ☐ I can draw conclusions about the ability of magnetic fields to produce electric currents.
2.5	No major errors or omissions regarding score 2.0 content, and partial success at score 3.0 content.
2.0	**07 Static Electricity** ☐ I can diagram electric fields around various charged objects by drawing appropriate field lines. ☐ I can explain how electric monopoles and dipoles create different electrical fields. **08 Circuits/09 Magnetism** ☐ I can explain the effects of creating a series of loops in a wire carrying electric current. **09 Magnetism** ☐ I can diagram magnetic fields around various charged objects by drawing appropriate field lines. ☐ I can explain how the behavior of north and south poles affects the magnetic field they create. ☐ I can explain the effects of wrapping wire carrying electric current around a core. ☐ I can explain how an electromagnet differs from a permanent magnet. ☐ I can diagram a magnetic field produced by an electric current using the right-hand rule. ☐ I can explain how multiple magnetic fields can be added together to amplify the power of a magnetic field. ☐ I can relate the ability of electric currents to create magnetic fields to the ability of changes in magnetic fields to create electric currents. ☐ I can explain the effects of moving a bar magnet through a coil of copper wire. ☐ I can explain that currents produced by changes in magnetic fields represent systems wanting to avoid change. ☐ I can use the right-hand rule to determine the direction of a current. ☐ I can relate the changes in a magnetic field and the size of the magnetic field to the amount of electric current created. ☐ I can use the Faraday-Lenz law to calculate how the change in magnetic flux generates electromotive force.

1.5	Partial success at score 2.0 content, and major errors or omissions regarding score 3.0 content.
1.0	With help, partial success at score 2.0 content and score 3.0 content.
0.5	With help, partial success at score 2.0 content but not at score 3.0 content.
0.0	Even with help, no success.

Physics 08-01 Ohm's Law	**Name: ________________________**

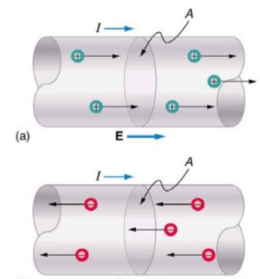
Current

- ______________ of ______________ of ______________
- Amount of ______________ per unit ______________ that crosses one ______________

$$I = \frac{\Delta Q}{\Delta t}$$

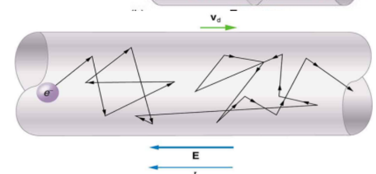
- Symbol: (______________)
- Unit: ______________ (A)

Small computer speakers often have power supplies that give 12 VDC at 200 mA. How much charge flows through the circuit in 1 hour and how much energy is used to deliver this charge?



- Electrons are the ______________ that ______________ through ______________
- Historically thought ______________ charges move
- ________________ current is the ______________ flow of ______________ charges
- Flows from ______________ terminal and into ______________ terminal
- ______________ current flows the ______________ way

Drift Velocity



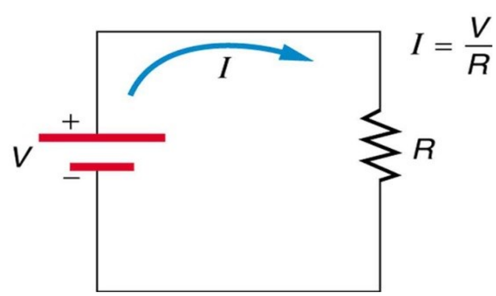
- ______________signals travel near ______________ of ______________, but ______________ travel much ______________
- Each new electron ____________ one ahead of it, so current is actually like ____________

$$I = \frac{\Delta Q}{\Delta t} = qnAv_d$$

  - q = charge of each electron, n = free charge density, A = cross-sectional area, v_d = drift velocity

Ohm's Law

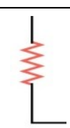
$$I = \frac{V}{R} \text{ or } V = IR$$



- V = emf, I = current, R = resistance
- Unit: V/A = ______________ (Ω)

Resistors

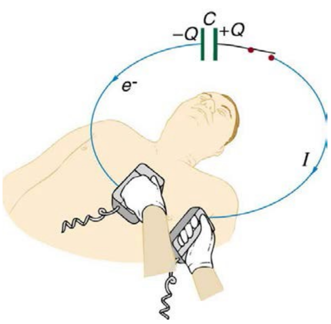
- Device that offers ______________ to ______________ of charges
- ______________ wire has very ______________ resistance
- Symbols used for ______________



Our speakers use 200 mA of current at maximum volume. The voltage is 12V. The current is used to produce a magnet which is used to move the speaker cone. Find the resistance of the electromagnet.

Physics 08-01 Ohm's Law	***Name: ______________________***
Practice Work	

1. Can a wire carry a current and still be neutral—that is, have a total charge of zero? Explain.
2. Car batteries are rated in ampere-hours (A·h). To what physical quantity do ampere-hours correspond (voltage, charge, …), and what relationship do ampere-hours have to energy content?
3. Why are two conducting paths from a voltage source to an electrical device needed to operate the device?
4. In cars, one battery terminal is connected to the metal body. How does this allow a single wire to supply current to electrical devices rather than two wires?
5. The IR drop across a resistor means that there is a change in potential or voltage across the resistor. Is there any change in current as it passes through a resistor? Explain.
6. What is the current in milliamperes produced by the solar cells of a pocket calculator through which 4.00 C of charge passes in 4.00 h? (OpenStax 20.1) **0.278 mA**
7. A total of 600 C of charge passes through a flashlight in 0.500 h. What is the average current? (OpenStax 20.2) **333 mA**
8. What is the current when a typical static charge of 0.250 μC moves from your finger to a metal doorknob in 1.00 μs? (OpenStax 20.3) **0.250 A**
9. Find the current when 2.00 nC jumps between your comb and hair over a 0.500-μs time interval. (OpenStax 20.4) **4.00 mA**
10. A defibrillator sends a 6.00-A current through the chest of a patient by applying a 10,000-V potential as in the figure below. What is the resistance of the path? (OpenStax 20.7a) **1.67 kΩ**
11. During open-heart surgery, a defibrillator can be used to bring a patient out of cardiac arrest. The resistance of the path is 500 Ω and a 10.0-mA current is needed. What voltage should be applied? (OpenStax 20.8) **5.00 V**
12. (a) A defibrillator passes 12.0 A of current through the torso of a person for 0.0100 s. How much charge moves? (b) How many electrons pass through the wires connected to the patient? (See figure.) (OpenStax 20.9) **0.120 C,** $\mathbf{7.50 \times 10^{17}}$ **electrons**



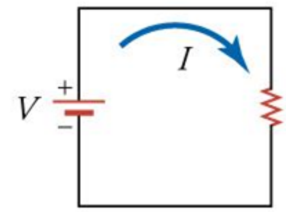
13. A clock battery wears out after moving 10,000 C of charge through the clock at a rate of 0.500 mA. (a) How long did the clock run? (b) How many electrons per second flowed? (OpenStax 20.10) $\mathbf{2.00 \times 10^{7}}$ **s,** $\mathbf{3.13 \times 10^{15}}$ **electrons/s**
14. What current flows through the bulb of a 3.00-V flashlight when its hot resistance is 3.60 Ω? (OpenStax 20.18) **0.833 A**
15. Calculate the effective resistance of a pocket calculator that has a 1.35-V battery and through which 0.200 mA flows. (OpenStax 20.19) **6.75 kΩ**
16. (a) Find the voltage drop in an extension cord having a 0.0600-Ω resistance and through which 5.00 A is flowing. (b) A cheaper cord utilizes thinner wire and has a resistance of 0.300 Ω. What is the voltage drop in it when 5.00 A flows? (c) Why is the voltage to whatever appliance is being used reduced by this amount? What is the effect on the appliance? (OpenStax 20.22) **0.300 V, 1.50 V**
17. A power transmission line is hung from metal towers with glass insulators having a resistance of 1.00×10^{9} Ω. What current flows through the insulator if the voltage is 200 kV? (OpenStax 20.23) **0.200 mA**

Physics 08-02 Series Circuits — Name: ________________________

Electric Circuits

- Must be a complete _____________
- The electric _____________ at battery is high
- The electric charges flow (current) down to the _____________ potential
- Along the way, the electric potential energy is used by the _____________ on the circuit
- When the charges reach the low potential, there is _____________ potential left. It has all been used.
- Without a complete loop, there is no _____________ potential for the charges to be attracted to

- Battery: Long side is _____________ , short side is _____________
  - Provides the potential to make the _____________ flow
- Current flows from _____________ side to _____________ side
- Resistor: Uses the potential to do _____________

_____________  _____________

Series Wiring

- More than _____________ device on _____________
- Same _____________ through _____________ device
- Break in _____________ means _____________ current
- Form one _____________
- The _____________ divide the _____________ between them

$$R_S = R_1 + R_2 + R_3 + \cdots$$

A 5.17 kΩ resistor and a 10.09 kΩ resistor are connected in series. What is the equivalent resistance?

Bathroom vanity lights are often wired in series. V = 120 V and you install 3 bulbs with R = 8 Ω and 1 bulb with R = 12 Ω. What is the current, voltage of each bulb, and the total power used?

Physics 08-02 Series Circuits	*Name: ________________________*
Practice Work	

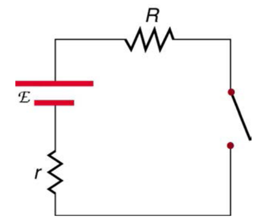
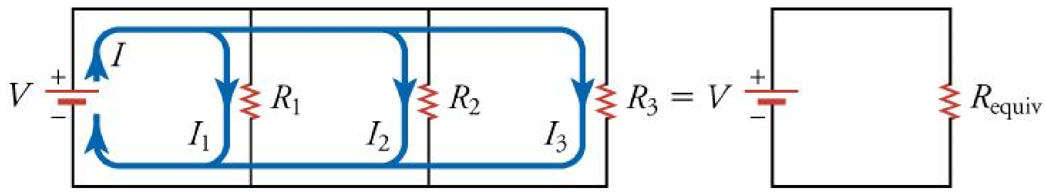


Figure 1

1. Why must the circuit be a closed loop?
2. What is the voltage across the open switch Figure 1?
3. There is a voltage across an open switch, such as in Figure 1. Why, then, is the power dissipated by the open switch small?
4. Some strings of holiday lights are wired in series to save wiring costs. An old version utilized bulbs that break the electrical connection, like an open switch, when they burn out. If one such bulb burns out, what happens to the others? If such a string operates on 120 V and has 40 identical bulbs, what is the normal operating voltage of each? Newer versions use bulbs that short circuit, like a closed switch, when they burn out. If one such bulb burns out, what happens to the others? If such a string operates on 120 V and has 39 remaining identical bulbs, what is then the operating voltage of each?
5. What is the resistance of ten 275-Ω resistors connected in series? (OpenStax 21.1) **2.75 kΩ**
6. What is the resistance of a 1.00×10^2-Ω, a 2.50-kΩ, and a 4.00-k Ω resistor connected in series? (OpenStax 21.2) **6.60 kΩ**
7. What is the resistance of 100 5-Ω Christmas light bulbs connected in series? (RW) **500 Ω**
8. Two resistors, one having a resistance of 900 kΩ, are connected in series to produce a total resistance of 0.500 MΩ. (a) What is the value of the second resistance? (b) What is unreasonable about this result? (c) Which assumptions are unreasonable or inconsistent? (OpenStax 21.13) **−400 kΩ**
9. A 50 Ω resistor and a 25 Ω resistor are connected in series with a third resistor. What is the size of the third resistor if the total resistance is 90 Ω? (RW) **15 Ω**
10. A 10 Ω, 12 Ω, and a 15 Ω resistor are connected in series with a 9 V battery. What is the (a) equivalent resistance of the circuit, (b) the current of the circuit, and (c) the voltage drop on each resistor? (RW) **37 Ω; 0.24 A; 2.4 V, 2.9 V, 3.6 V**
11. A 150 Ω and a 200 Ω resistor are connected in series with a 120 V battery. The current through the 150 Ω resistor is 0.343 A. (a) What is the current through the 200 Ω resistor? (b) What is the equivalent resistance of the circuit? (c) What is the total current through the circuit? (RW) **0.343 A; 350 Ω; 0.343 A**

Parallel Wiring

- Same ______________ across ______________ devices
- Break in ______________ has no effect on ______________



- Resistors divide ______________
- Each branch draws ______________ as if the other ______________ there
- Each branch draws ______________ current than the ______________ ______________ gives
    - $R = \frac{V}{I}$: Overall circuit: Large $I \rightarrow$ Small R
    - Smaller ______________ than either ______________

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

A 1004 Ω resistor and a 101 Ω resistor are connected in parallel. What is the equivalent resistance?

If they were connected to a 3 V battery, how much total current would the battery supply?

How much current goes through each resistor?

Practice Work

1. A student in a physics lab mistakenly wired a light bulb, battery, and switch as shown in Figure 2. Explain why the bulb is on when the switch is open, and off when the switch is closed. (Do not try this–it is hard on the battery!)
2. Suppose you are doing a physics lab that asks you to put a resistor into a circuit, but all the resistors supplied have a larger resistance than the requested value. How would you connect the available resistances to attempt to get the smaller value asked for?

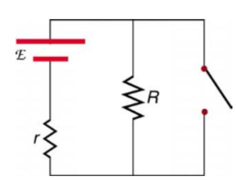


Figure 1

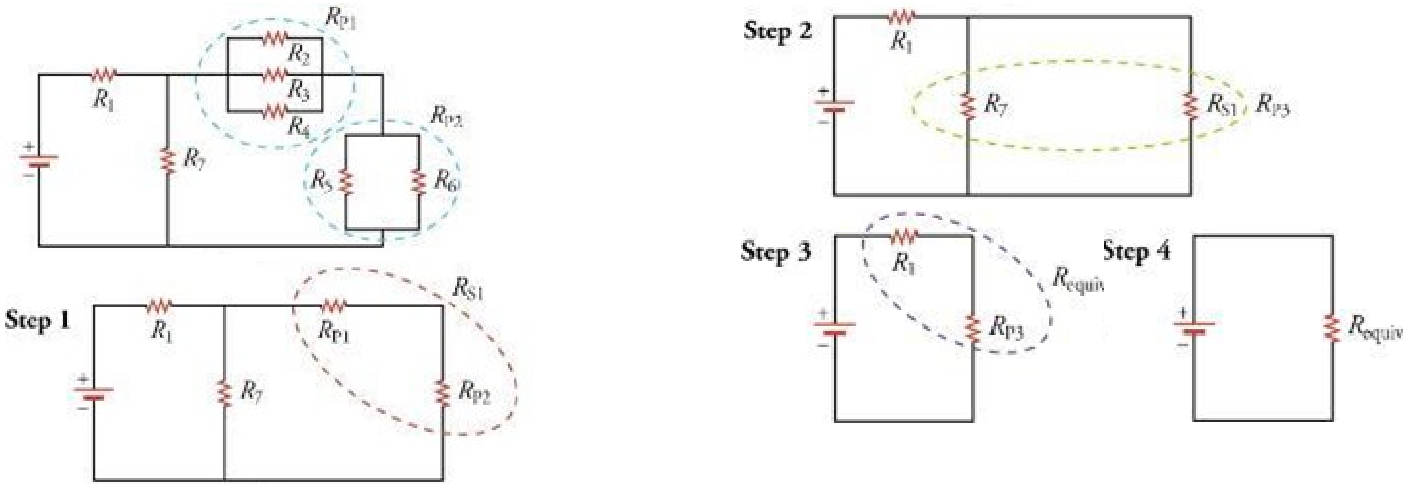
3. What is the resistance of ten 275-Ω resistors connected in parallel? (OpenStax 21.1) **27.5 Ω**
4. What is the resistance of a 1.00×10^2-Ω, a 2.50-kΩ, and a 4.00-kΩ resistor connected in parallel? (OpenStax 21.2) **93.9 Ω**
5. What is the resistance of 100 5-Ω Christmas light bulbs connected in parallel? (RW) **0.05 Ω**

6. What are the largest and smallest resistances you can obtain by connecting a 36.0-Ω, a 50.0-Ω, and a 700-Ω resistor together? (OpenStax 21.3) **786 Ω, 20.3 Ω**
7. (a) Given a 48.0-V battery and 24.0-Ω and 96.0-Ω resistors, find the total current for each when connected in series. (b) Repeat when the resistances are in parallel. (OpenStax 21.6) **0.400 A, 2.5 A**
8. Two resistors, one having a resistance of 145 Ω, are connected in parallel to produce a total resistance of 150 Ω. (a) What is the value of the second resistance? (b) What is unreasonable about this result? (c) Which assumptions are unreasonable or inconsistent? (OpenStax 21.12) **–4350 Ω**
9. A 10 Ω, 12 Ω, and a 15 Ω resistor are connected in parallel with a 9 V battery. What is the (a) equivalent resistance of the circuit, (b) the current of the circuit, (c) the voltage drop on each resistor, and (d) the current through each resistor? (RW) **4 Ω; 2.25 A; 9 V, 9 V, 9 V; 0.9 A, 0.75 A, 0.6 A**
10. A 150 Ω and a 200 Ω resistor are connected in parallel with a 120 V battery. (a) What is the voltage over the 200 Ω resistor? (b) What is the equivalent resistance of the circuit? (c) What is the total current through the circuit? (d) What is the current through each resistor? (RW) **120 V; 85.7 Ω; 1.4 A; 0.8 A, 0.6 A**

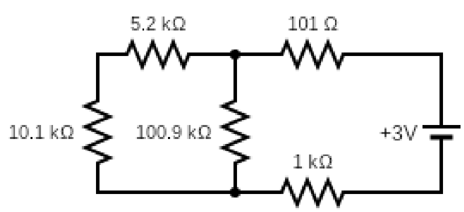
Physics 08-04 Circuits in Parallel and Series **Name: ________________________**

Circuits Wired Partially in Series and Partially in Parallel

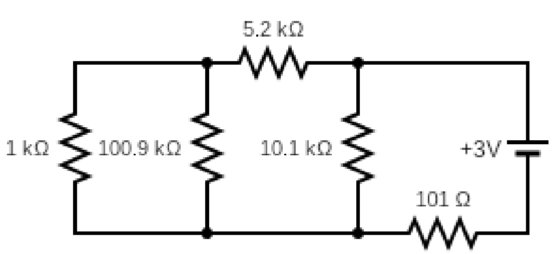
1. Simplify any ______________ portions of each ______________
2. Simplify the ______________ circuitry of the ______________
3. If necessary ______________ any remaining ______________



Find the equivalent resistance and the total current of the following circuit.



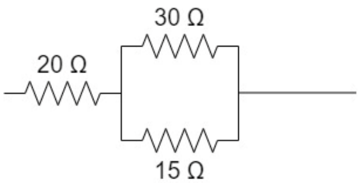
Find the equivalent resistance.



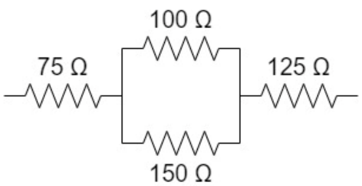
Physics 08-04 Circuits in Parallel and Series **_Name: _________________________**

Practice Work

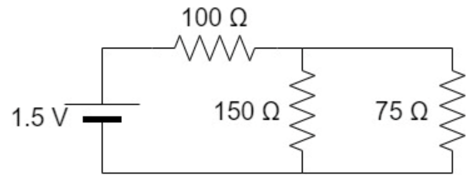
1. How do you know where a branch of the circuit starts and ends?
2. Describe the general process of finding the equivalent resistance of circuits in a combination of series and parallel.
3. Find the equivalent resistance of the circuit. (RW) **30Ω**



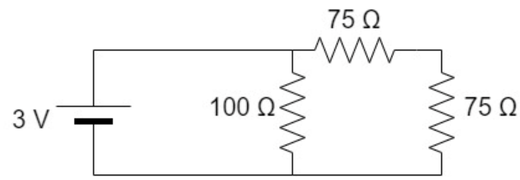
4. Find the equivalent resistance of the circuit. (RW) **260Ω**



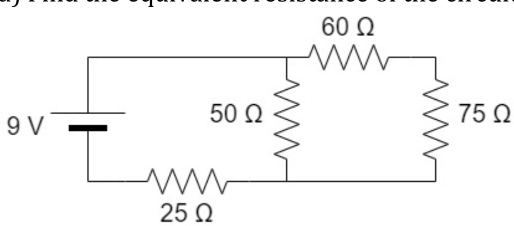
5. Find the equivalent resistance of the circuit. (RW) **150Ω**



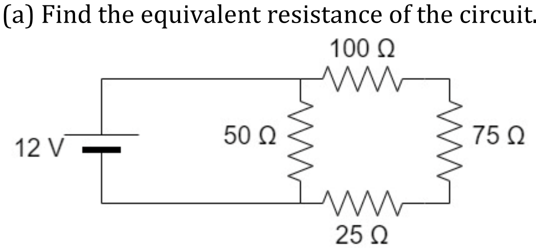
6. Find the equivalent resistance of the circuit. (RW) **60Ω**



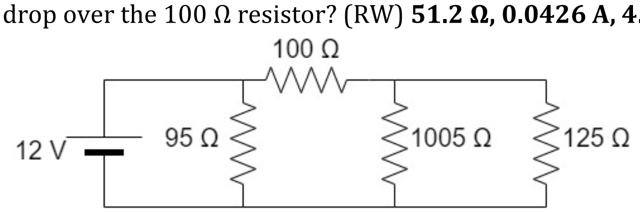
7. (a) Find the equivalent resistance of the circuit. (b) What is the total current in the circuit? (RW) **61.5 Ω, 0.146 A**



8. (a) Find the equivalent resistance of the circuit. (b) What is the current through the 50 Ω resistor? (RW) **40 Ω, 0.24 A**

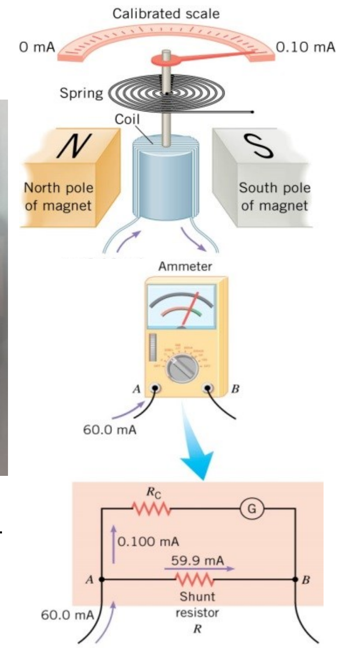


9. (a) Find the equivalent resistance of the circuit. (b) What is the current through the 100 Ω resistor? (c) What is the voltage drop over the 100 Ω resistor? (RW) **51.2 Ω, 0.0426 A, 4.26 V**



Physics 08-05 Voltmeters and Ammeters   *Name:* ____________________

DC Voltmeters and Ammeters

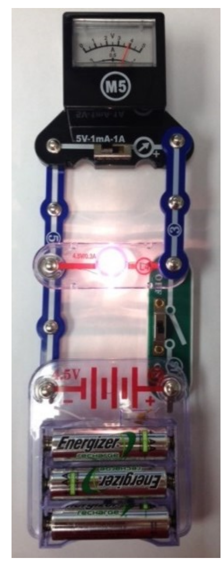


- ____________ (non-digital) meters
- Main component → ____________

Ammeters

- Measures ____________
- Inserted into ____________ so ____________ passes ____________ it
- Connected in ____________
- Coil usually measures only ____________ current
- Has ____________ ____________ connected in ____________ to galvanometer so excess current can ____________
- A __________ lets you __________ which shunt resistor is __________
- Problems with Ammeters
    - The ____________ of the coil and shunt ____________ add to the ____________ of the circuit
    - This ____________ the ____________ in the circuit
    - ____________ ammeter has ____________ resistance
    - Real-life good ____________ have ____________ resistance so as only cause a ____________ change in current

Voltmeters



- Connected in ____________ to ____________ since parallel has same ____________
- The coil works just like in the ____________
- Given the ____________ and the ____________ of the coil → ____________
- To give more range, a ____________ resistor is connected in ____________ with the coil
- Problems with Voltmeters
    - The voltmeter takes some the ____________ out of the ____________
    - ____________ voltmeter would have ____________ ____________ resistance as to draw ____________ current
    - Good voltmeter has large ____________ resistance as to make the ____________ draw (and voltage drop) ____________

Practice Work

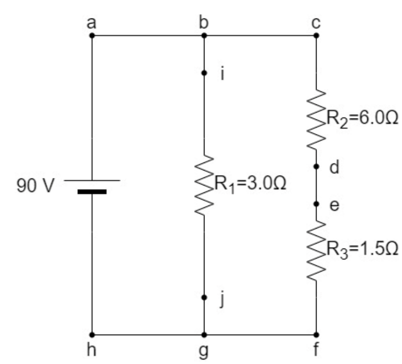


Figure 1

1. Suppose you are using a multimeter (one designed to measure a range of voltages, currents, and resistances) to measure current in a circuit and you inadvertently leave it in a voltmeter mode. What effect will the meter have on the circuit? What would happen if you were measuring voltage but accidentally put the meter in the ammeter mode?
2. Specify the points to which you could connect a voltmeter to measure the following potential differences in Figure 1: (a) the potential difference of the voltage source; (b) the potential difference across R_1; (c) across R_2; (d) across R_3; (e) across R_2 and R_3. Note that there may be more than one answer to each part.
3. To measure currents in Figure 1, you would replace a wire between two points with an ammeter. Specify the points between which you would place an ammeter to measure the following: (a) the total current; (b) the current flowing through R_1; (c) through R_2; (d) through R_3. Note that there may be more than one answer to each part.
4. What is the sensitivity of the galvanometer (that is, what current gives a full-scale deflection) inside a voltmeter that has a 1.00-MΩ resistance on its 30.0-V scale? (OpenStax 21.42) **30.0 μA**

5. What is the sensitivity of the galvanometer (that is, what current gives a full-scale deflection) inside a voltmeter that has a 25.0-k Ω resistance on its 100-V scale? (OpenStax 21.43) **4.00 mA**

6. Find the resistance that must be placed in series with a 25.0-Ω galvanometer having a 50.0-μA sensitivity to allow it to be used as a voltmeter with a 0.100-V full-scale reading. (OpenStax 21.44) **1.98 kΩ**

7. Find the resistance that must be placed in series with a 25.0-Ω galvanometer having a 50.0-μA sensitivity to allow it to be used as a voltmeter with a 3000-V full-scale reading. Include a circuit diagram with your solution. (OpenStax 21.45) $\mathbf{6.00 \times 10^{7}\ \Omega}$

8. Find the resistance that must be placed in parallel with a 25.0-Ω galvanometer having a 50.0-μA sensitivity to allow it to be used as an ammeter with a 10.0-A full-scale reading. Include a circuit diagram with your solution. (OpenStax 21.46) $\mathbf{1.25 \times 10^{-4}\ \Omega}$

9. Find the resistance that must be placed in parallel with a 25.0-Ω galvanometer having a 50.0-μA sensitivity to allow it to be used as an ammeter with a 300-mA full-scale reading. (OpenStax 21.47) $\mathbf{4.17 \times 10^{-3}\ \Omega}$

Physics 08-06 Electric Power and AC/DC Currents Name: ________________________

Electric Power

$P = IV$

- Unit: ____________ (W)
- Other ____________ for electrical ____________

$$P = I^2R$$

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

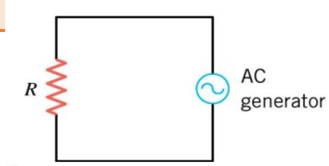
Let's say an electric heater has a resistance of 1430 Ω and operates at 120V. What is the power rating of the heater? How much electrical energy does it use in 24 hours?

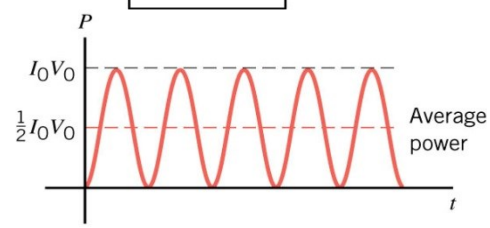
Kilowatt hours

- Electrical ____________ ____________ you for the amount of electrical ____________ you use
- Measured in ____________ ____________ (kWh)

If electricity costs $0.15 per kWh how much does it cost to operate the previous heater (P = 10.1 W) for one month?

Alternating Current





- Charge flow ____________ direction __________________
- Due to way that ____________ plants ____________ power
- Simple circuit
- Periodicity
  - ____________, ____________, and ____________ ____________ with time
  - So we usually talk about the ____________

Average Power

- DC

$$P = IV$$

- AC

$$P_{ave} = \frac{1}{2}I_0V_0$$

  - Often P is used to represent ____________ power in ____________ AC circuits.

Root Mean Square (rms)

$$P_{ave} = \frac{1}{2}I_0V_0 = \left(\frac{I_0}{\sqrt{2}}\right)\left(\frac{V_0}{\sqrt{2}}\right) = I_{rms}V_{rms}$$

- I_{rms} and V_{rms} are called ____________ ____________ ____________ current and voltage
- Found by dividing the ____________ by ____________

$$I_{rms} = \frac{I_0}{\sqrt{2}} \qquad V_{rms} = \frac{V_0}{\sqrt{2}}$$

Physics 08-06 Electric Power and AC/DC Currents *Name: ________________________*

Convention in USA

- V_0 = 170 V, V_{rms} = _____________V
- _____________ electronics specify 120 V, so they really mean _____________
- We will always (unless noted) use _____________ _____________, and root mean square _____________ and _____________
- Thus all _____________ learned equations _____________!

A 60 W light bulb operates on a peak voltage of 156 V. Find the V_{rms}, I_{rms}, and resistance of the light bulb.

Why are you not supposed to use extension cords for devices that use a lot of power like electric heaters?

Practice Work

1. Give an example of a use of AC power other than in the household. Similarly, give an example of a use of DC power other than that supplied by batteries.
2. Why do voltage, current, and power go through zero 120 times per second for 60-Hz AC electricity?
3. You are riding in a train, gazing into the distance through its window. As close objects streak by, you notice that the nearby LED christmas lights make dashed streaks. Explain.
4. What is the power of a 1.00×10^2 MV lightning bolt having a current of 2.00×10^4 A? (OpenStax 20.40) $\mathbf{2.00 \times 10^{12}}$ **W**
5. What power is supplied to the starter motor of a large truck that draws 250 A of current from a 24.0-V battery hookup? (OpenStax 20.41) **6.00 kW**
6. A charge of 4.00 C of charge passes through a pocket calculator's solar cells in 4.00 h. What is the power output, given the calculator's voltage output is 3.00 V? (OpenStax 20.42) $\mathbf{8.33 \times 10^{-4}}$ **W**
7. How many watts does a flashlight that has 6.00×10^2 C pass through it in 0.500 h use if its voltage is 3.00 V? (OpenStax 20.43) **1.00 W**
8. Find the power dissipated in each of these extension cords: (a) an extension cord having a 0.0600-Ω resistance and through which 5.00 A is flowing; (b) a cheaper cord utilizing thinner wire and with a resistance of 0.300 Ω. (OpenStax 20.44) **1.50 W, 7.50 W**
9. An electric water heater consumes 5.00 kW for 2.00 h per day. What is the cost of running it for one year if electricity costs 12.0 cents/kW·h? (OpenStax 20.50) **$438/y**
10. With a 1200-W toaster, how much electrical energy is needed to make a slice of toast (cooking time = 1 minute)? At 9.0 cents/kW·h, how much does this cost? (OpenStax 20.51) **0.02 kWh, 0.18 cents**
11. What is the hot resistance of a 25-W light bulb that runs on 120-V AC? (OpenStax 20.72) **580 Ω**
12. Certain heavy industrial equipment uses AC power that has a peak voltage of 679 V. What is the rms voltage? (OpenStax 20.73) **480 V**
13. A certain circuit breaker trips when the rms current is 15.0 A. What is the corresponding peak current? (OpenStax 20.74) **21.2 A**
14. What is the peak power consumption of a 120-V AC microwave oven that draws 10.0 A? (OpenStax 20.79) **2.40 kW**
15. What is the peak current through a 500-W room heater that operates on 120-V AC power? (OpenStax 20.80) **5.89 A**

Physics 08-07 Electricity and the Human Body — *Name: ________________________*

Electric Hazards

Thermal Hazards

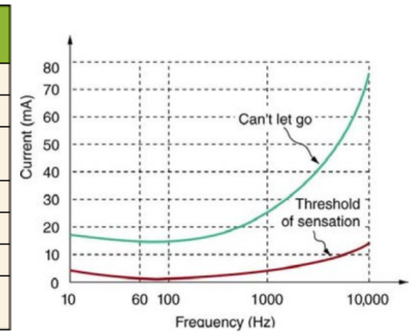
- _____________ energy converted to _____________ energy _____________ than can be _____________
- Happens in _____________ circuits where electricity _____________ between two parts of _____________ bypassing the _____________ load
    - $P = \frac{V^2}{R}$
    - Low _____________ so high _____________
    - Can start _____________
    - _____________ _____________ or _____________ try to stop
- Or _____________ wires that have
    - _____________ resistance (_____________)
    - Or are _____________ so _____________ can't _____________

Shock Hazards

- Factors
    - _____________ of _____________
    - _____________ of current
    - _____________ of shock
    - _____________ of current
- Human body mainly _____________, so decent _____________
- _____________ are controlled by _____________ impulses in nerves
    - A shock can cause _____________ to _____________
    - Cause _____________ to close around _____________ (muscles to close, stronger than to open)
    - Can cause _____________ to _____________
- Body most sensitive to _____________Hz

Table 20.3 Effects of Electrical Shock as a Function of Current[3]

Current (mA)	Effect
1	Threshold of sensation
5	Maximum harmless current
10–20	Onset of sustained muscular contraction; cannot let go for duration of shock; contraction of chest muscles may stop breathing during shock
50	Onset of pain
100–300+	Ventricular fibrillation possible; often fatal
300	Onset of burns depending on concentration of current
6000 (6 A)	Onset of sustained ventricular contraction and respiratory paralysis; both cease when shock ends; heartbeat may return to normal; used to defibrillate the heart



Practice Work

1. What are the two major hazards of electricity?
2. Why isn't a short circuit a shock hazard?
3. What determines the severity of a shock? Can you say that a certain voltage is hazardous without further information?
4. Some devices often used in bathrooms, such as hairdryers, often have safety messages saying "Do not use when the bathtub or basin is full of water." Why is this so?
5. We are often advised to not flick electric switches with wet hands, dry your hand first. We are also advised to never throw water on an electric fire. Why is this so?
6. Before working on a power transmission line, linemen will touch the line with the back of the hand as a final check that the voltage is zero. Why the back of the hand?
7. (a) How much power is dissipated in a short circuit of 240-V AC through a resistance of 0.250 Ω? (b) What current flows? (OpenStax 20.85) **230 kW, 960 A**

8. What voltage is involved in a 1.44-kW short circuit through a 0.100-Ω resistance? (OpenStax 20.86) **12 V**

9. Find the current through a person and identify the likely effect on her if she touches a 120-V AC source: (a) if she is standing on a rubber mat and offers a total resistance of 300 kΩ; (b) if she is standing barefoot on wet grass and has a resistance of only 4500 Ω. (OpenStax 20.87) **0.400 mA (no effect), 26.7 mA (muscular contraction)**

10. While taking a bath, a person touches the metal case of a radio. The path through the person to the drainpipe and ground has a resistance of 4000 Ω. What is the smallest voltage on the case of the radio that could cause ventricular fibrillation? (OpenStax 20.88) **400 V**

11. Foolishly trying to fish a burning piece of bread from a toaster with a metal butter knife, a man comes into contact with 120-V AC. He does not even feel it since, luckily, he is wearing rubber-soled shoes. What is the minimum resistance of the path the current follows through the person? (OpenStax 20.89) $\mathbf{1.20 \times 10^5\ \Omega}$

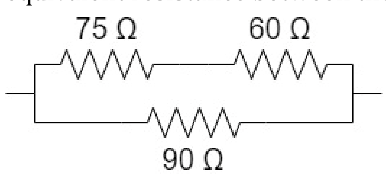
12. (a) During surgery, a current as small as 20.0 μA applied directly to the heart may cause ventricular fibrillation. If the resistance of the exposed heart is 300 Ω, what is the smallest voltage that poses this danger? (b) Does your answer imply that special electrical safety precautions are needed? (OpenStax 20.90) **6.00 mV**

13. (a) What is the resistance of a 220-V AC short circuit that generates a peak power of 96.8 kW? (b) What would the average power be if the voltage was 120 V AC? (OpenStax 20.91) **1.00 Ω, 14.4 kW**

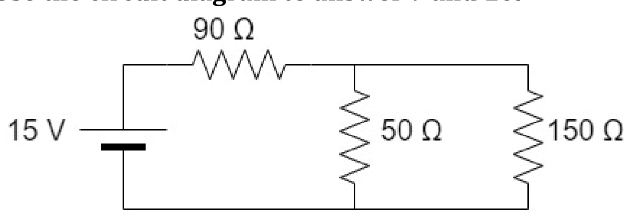
14. A heart defibrillator passes 10.0 A through a patient's torso for 5.00 ms in an attempt to restore normal beating. (a) How much charge passed? (b) What voltage was applied if 500 J of energy was dissipated? (c) What was the path's resistance? (OpenStax 20.92) $\mathbf{5.00 \times 10^{-2}}$ **C, 10.0 kV, 1.00 kΩ**

Physics Unit 8: Circuits Review

1. Know about charge, current, potential, voltage, resistance, resistors, circuit diagrams, series, parallel, ammeters, voltmeters, power, kWh, AC/DC, thermal hazards, shock hazards
2. A 15-A current is maintained in a simple circuit with a total resistance of 2000 Ω. What net charge passes through any point in the circuit during a 2-second interval?
3. When a light bulb is connected to a 24 V battery, a current of 0.2 A passes through the bulb filament. What is the resistance of the filament?
4. Three resistors, 100-Ω, 125-Ω, 150-Ω, are connected in series in a circuit. What is the equivalent resistance of this combination of resistors?
5. Ten 50-Ω and five 25-Ω light bulbs and a 9 V battery are connected in a series circuit. What is the current that passes through each bulb?
6. Three resistors, 100-Ω, 125-Ω, 150-Ω, are connected in parallel in a circuit. What is the equivalent resistance of this combination of resistors?
7. Two resistors, 50-Ω and 25-Ω, are connected in parallel with a 24 V battery. What is the total current in the circuit?
8. Three resistors are connected as shown in the figure. The potential difference between points A and B is 12 V. What is the equivalent resistance between the points A and B?



Use the circuit diagram to answer 9 and 10.



9. What is the equivalent resistance of the circuit?
10. What is the current in the 90 Ω resistor?
11. A 15-A current is maintained in a simple circuit with a total resistance of 1500 Ω. How much energy is dissipated in 5 seconds?
12. A 15-A current is maintained in a simple circuit that consists of a resistor between the terminals of an ideal battery. If the battery supplies energy at a rate of 75 W, how large is the resistance?
13. An AC current has a peak value of 8.49 A. Determine the rms value of the current.

Physics Unit 8: Circuits Review

Answers

2. $I = \frac{Q}{t}$
   $15\ A = \frac{Q}{2\ s}$
   $Q = \mathbf{30\ C}$

3. $V = IR$
   $24\ V = (0.2A)R$
   $R = \mathbf{120\ \Omega}$

4. $R_{eqv} = 100\ \Omega + 125\ \Omega + 150\ \Omega = \mathbf{375\ \Omega}$

5. Series has same current through all bulbs.
   $R_{eqv} = 10(50\ \Omega) + 5(25\ \Omega) = 625\ \Omega$
   $V = IR_{eqv}$
   $9\ V = I(625\ \Omega)$
   $I = \mathbf{0.0144\ A}$

6. $\frac{1}{R_{eqv}} = \frac{1}{100\ \Omega} + \frac{1}{125\ \Omega} + \frac{1}{150\ \Omega}$
   $\frac{1}{R_{eqv}} = 0.02467 \frac{\square}{\Omega}$
   $R_{eqv} = \mathbf{40.5\ \Omega}$

7. $\frac{1}{R_{eqv}} = \frac{1}{50\ \Omega} + \frac{1}{25\ \Omega}$
   $\frac{1}{R_{eqv}} = 0.06 \frac{\square}{\Omega}$
   $R_{eqv} = 16.7\ \Omega$
   $V = IR_{eqv}$
   $24\ V = I(16.7\ \Omega)$
   $I = \mathbf{1.44\ A}$

8. Do the series part first (most inside).
   $R_{series} = 75\ \Omega + 60\ \Omega$
   $R_{sereis} = 135\ \Omega$
   Combine the parallel branches.
   $\frac{1}{R_{eqv}} = \frac{1}{135\ \Omega} + \frac{1}{90\ \Omega}$
   $\frac{1}{R_{eqv}} = 0.0185 \frac{\square}{\Omega}$
   $R_{eqv} = \mathbf{54\ \Omega}$

9. Combine the parallel branches.
   $\frac{1}{R_{parallel}} = \frac{1}{50\ \Omega} + \frac{1}{150\ \Omega}$
   $\frac{1}{R_{parallel}} = 0.0267 \frac{\square}{\Omega}$
   $R_{parallel} = 37.5\ \Omega$
   Combine that in series.
   $R_{eqv} = 90\ \Omega + 37.5\ \Omega$
   $R_{eqv} = \mathbf{127.5\ \Omega}$

10. All the current from the battery goes through the 90 Ω resistor.
    $V = IR_{eqv}$
    $15\ V = I(127.5\ \Omega)$
    $I = \mathbf{0.118\ A}$

11. $P = I^2R$
    $P = (15\ A)^2(1500\ \Omega)$
    $P = 337500\ W$
    $P = \frac{W}{t}$
    $337500\ W = \frac{W}{5\ s}$
    $W = \mathbf{1.69 \times 10^6\ J}$

12. $P = I^2R$
    $75\ W = (15\ A)^2R$
    $R = \mathbf{0.333\ \Omega}$

13. $I_{rms} = \frac{I_0}{\sqrt{2}}$
    $I_{rms} = \frac{8.49\ A}{\sqrt{2}}$
    $I_{rms} = \mathbf{6.00\ A}$