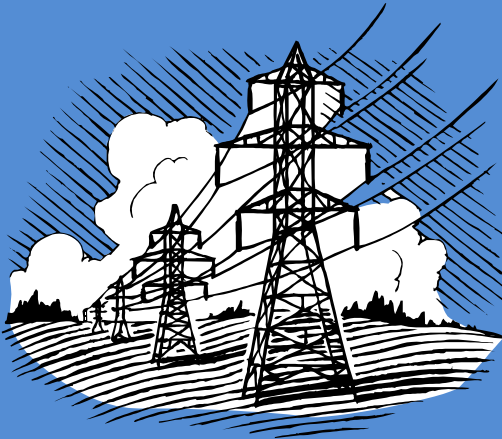


RESIDENTIAL & INDUSTRIAL **ELECTRICITY**



NAME:

DATE:

DATE DUE:

Schuylkill Technology
Center-
South Campus
15 Maple Avenue
Marlin, Pennsylvania 17951
(570) 544-4748

COURSE TITLE: Basic Residential Circuitry

DUTY TITLE: Testing Equipment

DUTY NUMBER: 1200

TASK # 20: Connecting and Reading of Meters in a Circuit

PURPOSE: To Connect Meters in Various Locations of a Circuit and
be able to Read the Desired Electrical Values.

TASKS:

1101	Identify and safely use a multi-meter.
1102	Identify and safely use a continuity tester.
1103	Identify and safely use a plug-in circuit tester.
1104	Identify and safely use a clamp-on ammeter.
1105	Identify and safely use a megger (insulation tester).
1106	Identify and safely use a circuit tracer.

REVISION: 2014

CORE CURRICULUM STANDARDS

ENGLISH LANGUAGE ARTS

- CC.1.2.11-12.J** *Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression*
- CC.1.3.11-12.I** *Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade level reading and content, choosing flexibly from a range of strategies and tools.*
- CC.1.4.11-12.A** *Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately.*

MATH

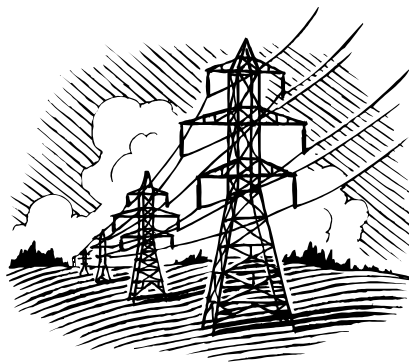
- CC.2.1.HS.F.4** *Use units as a way to understand problems and to guide the solution of multi-step problems.*
- CC.2.1.HS.F.6** *Extend the knowledge of arithmetic operations and apply to complex numbers.*
- CC.2.3.HS.A.11** *Apply coordinate geometry to prove simple geometric theorems algebraically.*

READING IN SCIENCE & TECHNOLOGY

- CC.3.5.11-12.B.** *Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.*
- CC.3.5.11-12.C.** *Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.*

WRITING IN SCIENCE & TECHNOLOGY

- CC.3.6.11-12.E.** *Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.*
- CC.3.6.11-12.F.** *Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation*
- CC.3.6.11-12.H.** *Draw evidence from informational texts to support analysis, reflection, and research.*



ACADEMIC STANDARDS

READING, WRITING, SPEAKING & LISTENING

- 1.1.11.A *Locate various texts, assigned for independent projects before reading.*
- 1.1.11.D *Identify strategies that were most effective in learning*
- 1.1.11.E *Establish a reading vocabulary by using new words*
- 1.1.11.F *Understanding the meaning of, and apply key vocabulary across the various subject areas*
- 1.4.11.D *Maintain a written record of activities*
- 1.6.11.A *Listen to others, ask questions, and take notes*

MATH

- 2.2.11.A *Develop and use computation concepts*
- 2.2.11.B *Use estimation for problems that don't need exact answers*
- 2.2.11.C *Constructing and applying mathematical models*
- 2.2.11.D *Describe and explain errors that may occur in estimates*
- 2.2.11.E *Recognize that the degree of precision need in calculating*
- 2.3.11.A *Selecting and using the right units and tools to measure precise measurements*
- 2.5.11.A *Using appropriate mathematical concepts for multi-step problems*
- 2.5.11.B *Use symbols, terminology, mathematical rules, Etc.*
- 2.5.11.C *Presenting mathematical procedures and results*

SCIENCE

- 3.1.12.A *Apply concepts of systems, subsystems feedback and control to solve complex technological problems*
- 3.1.12.B *Apply concepts of models as a method predict and understand science and technology*
- 3.1.12.C *Assess and apply patterns in science and technology*
- 3.1.12.D *Analyze scale as a way of relating concepts and ideas to one another by some measure*
- 3.1.12.E *Evaluate change in nature, physical systems and man made systems*
- 3.2.12.A *Evaluate the nature of scientific and technological knowledge*
- 3.2.12.B *Evaluate experimental information for appropriateness*
- 3.2.12.C *Apply elements of scientific inquiry to solve multi – step problems*
- 3.2.12.D *Analyze the technological design process to solve problems*
- 3.4.12.A *Apply concepts about the structure and properties of matter*
- 3.4.12.B *Apply energy sources and conversions and their relationship to heat and temperature*
- 3.4.12.C *Apply the principles of motion and force*
- 3.8.12.A *Synthesize the interactions and constraints of science*
- 3.8.12.B *Use of ingenuity and technological resources to solve specific societal needs and improve the quality of life*
- 3.8.12.C *Evaluate the consequences and impacts of scientific and technological solutions*

ECOLOGY STANDARDS

- 4.2.10.A *Explain that renewable and non renewable resources supply energy and material.*
- 4.2.10.B *Evaluate factors affecting availability of natural resources.*
- 4.2.10.C *Analyze the use of renewable and non renewable resources.*
- 4.2.12.B *Analyze factors affecting the availability of renewable and non renewable resources.*
- 4.3.10.A *Describe environmental health issues.*
- 4.3.10.B *Explain how multiple variables determine the effects of pollution on environmental health, natural processes and human practices.*
- 4.3.12.C *Analyze the need for a healthy environment.*
- 4.8.12.A *Explain how technology has influenced the sustainability of natural resources over time.*

CAREER & EDUCATION

- 13.1.11.A *Relate careers to individual interest, abilities, and aptitudes*
- 13.2.11.E *Demonstrate in the career acquisition process the essential knowledge needed*
- 13.3.11.A *Evaluate personal attitudes that support career advancement*

ASSESSMENT ANCHORS

- M11.A.3.1.1 *Simplify expressions using the order of operations*
- M11.A.2.1.3 *Use proportional relationships in problem solving settings*
- M11.A.1.2 *Apply any number theory concepts to show relationships between real numbers in problem solving*

STUDENT

The student will be able to connect meters in various locations of a circuit and read and record the electrical values in that particular area of the circuit.

TERMINAL PERFORMANCE OBJECTIVE

Given all the electrical tools and materials required, the student will read and record various electrical values in a circuit to 100% accuracy.

SAFETY

- Always wear safety glasses while in the shop.
- Make sure power is turned off.
- Make sure you are using the proper meter for the value you are going to read.

RELATED INFORMATION

1. Attend lecture by instructor.
2. Obtain handout.
3. Review chapter in textbook.
4. Define vocabulary words.
5. Complete experiments in this handout and hand in to instructor.
6. Complete K-W-L Literacy Assignment by Picking an Article From the *"Electrical Contractor"* Magazine Located in the Theory Room. You can pick any article you feel is important to the electrical trade.

EQUIPMENT & SUPPLIES

1. Safety glasses
2. Wire strippers
3. Side cutters
4. Screw driver
5. Needle nose pliers
6. Handout
7. Multimeter (digital or analog)
8. #14 THHN wire
9. Light fixtures
10. Light bulbs
11. Wood screws
12. Scientific calculator
13. K-W-L Work Sheet

PROCEDURE

CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems.

CC.3.5.11-12.C. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

1.6.11A Listen to others, ask questions, and take notes

3.4.12.B Apply energy sources and conversions and their relationship to heat and temperature

1. Using all the correct electrical tools and materials, construct the various experiments in this packet.
2. Adjust the multimeter to the desired setting for the measurement needed.
3. Using the multimeter read and record the values specified in this packet for each project.
4. Using the scientific calculator, calculate the readings that cannot be measured with a multimeter. (The packet will specify where this should be done.)
5. When this packet is complete, hand it in to the instructor for final approval.

After completing this chapter, the student should be able to:

1. Demonstrate an understanding of continuity testers and how to properly use them.
2. Demonstrate an understanding of the differences between a voltage tester and a voltmeter.
3. Connect and properly use a voltage tester and a voltmeter.
4. Demonstrate an understanding of the differences between an in-line ammeter and a clamp-on ammeter.
5. Connect and properly use an in-line ammeter and a clamp-on ammeter.
6. Demonstrate an understanding of ohmmeters and megohmmeters.
7. Connect and properly use an ohmmeter and megohmmeter.
8. Demonstrate an understanding of how to use a multimeter.
9. Demonstrate an understanding of the uses for a true RMS meter.
10. Demonstrate an understanding of how to read a kilowatt-hour meter.

11. Demonstrate an understanding of safe practices to follow when using test and measurement instruments.

12. Demonstrate an understanding of the proper care and maintenance of test and measurement instruments.

VOCABULARY

CC.1.3.11-12.I Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade level reading and content, choosing flexibly from a range of strategies and tool

CC.3.5.11-12.D. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.

Ammeter (clamp-on) _____

Ammeter (in-line) _____

Analog meter _____

Auto-ranging meter _____

Continuity tester _____

Digital meter _____

DMM _____

Harmonics _____

Kilowatt-hour meter _____

Manual ranging meter _____

Megohmmeter _____

Multimeter _____

Multiwire circuit _____

Noncontact voltage tester _____

Nonlinear loads _____

Ohmmeter _____

Open circuit _____

Polarity _____

Short circuit _____

True RMS meter _____

Voltmeter _____

Voltage tester _____

VOM _____

Wiggy—a trade name for a solenoid type of voltage tester

A. Continuity Tester

1. Test for continuity in electrical conductors
2. Test for faulty fuses
3. Test for malfunctioning switches
4. Identify individual wires in a cable (Figure 4–1)

Never attach a continuity tester to a circuit that is energized.

B. Voltage Tester and Voltmeter

1. Voltage tester

- a. Indicates approximate values of voltage for either direct current (DC) or alternating current (AC) applications

Remember that a voltage tester gives an approximate voltage amount.

- b. Identifies grounded conductor of a circuit
- c. Checks for blown fuses
- d. Distinguishes between alternating current and direct current
- e. Wiggy is most common type
- f. Solenoid-type voltage tester
- g. Digital voltage tester
- h. Noncontact voltage tester

2. Voltmeter

**Always connect a voltmeter across (in parallel with) the load.
Always read and follow the instructions that are supplied with the voltmeter.**

- a. More accurate than voltage tester
- b. Analog

Do not leave an analog meter connected with the polarity reversed.

c. Digital

C. Ammeters

Always read and follow the instructions that are supplied with the ammeter.

1. Measures amounts of current flowing in a circuit
2. Locates overloads and open circuits
3. Balances the loads on multiwire circuits
4. Locates electrical component malfunctions
5. Two types

a. In-line

In-line ammeters should always be connected in series with the circuit or component being tested. If direct current is being measured, always check the polarity.

b. Clamp-on

D. Ohmmeter and Megohmmeter

Always read and follow the instructions that are supplied with the ohmmeter or megohmmeter.

It is very important to be sure that the circuit or component is disconnected from its regular power source before connecting an ohmmeter. Connecting an ohmmeter to a circuit which has not been de-energized can result in damage to the meter and possible injury to the user.

1. Ohmmeter

- a. Measures resistance of a circuit or circuit component
- b. Analog

Remember that the analog ohmmeter scale is read from right to left.

- c. Multiple ranges

2. Megohmmeter (MEGGER)

Never touch the test leads of a megohmmeter while a test is being conducted. Also, isolate whatever it is that you are conducting the test on. High voltage is present and could injure you and/or the item you are testing. Before a megohmmeter is connected to a conductor or a circuit, the circuit must be deenergized. When testing the circuit insulation, the testing is generally done between each conductor and ground. A good ground is a vital part of the testing procedure. The ground connection should be checked with the megohmmeter and with a low-range ohmmeter to ensure good continuity.

- a. Measures very high values of resistance
- b. Can be used to test resistance of the insulation on circuit conductors, transformer windings, and motor windings
- c. Measures resistance in megohms
 - One megohm (MW) equals one million ohms.

E. Multimeter

Always read and follow the instructions that are supplied with the multimeter.

- 1. Measures more than one electrical value
 - a. Analog
 - b. Digital
 - Common icons found on the DMM
- (A digital multimeter is also referred to by its acronym “DMM.”)
- c. True RMS meter

F. Watt-Hour Meter

- 1. Enclosure contains a kilowatt-hour meter
 - a. Measures amount of electrical energy used by the dwelling electrical system

- b. Electrical power measured in watts
- c. One kilowatt-hour equal to one thousand watt-hours

G. Safety and Meters

- 1. Meters used on electrical construction sites tend to lose their accuracy over time
- 2. Meters exposed to hot or cold temperature extremes are likely to become inaccurate over time

SAFETY

- a. Always wear safety glasses
- b. Wear rubber gloves when testing or measuring “live” electrical circuits or equipment
- c. Never work on energized circuits unless absolutely necessary
- d. If you must take measurements on energized circuits, make sure you have been properly trained to work with “live” circuits
- e. Don’t work alone
- f. Keep clothing, hands, feet as dry as possible
- g. Make sure meter has rating equal to or exceeding highest value of electrical quantity you are measuring

H. Meter Care and Maintenance

- 1. Keep meters clean and dry
- 2. Don’t store analog meters next to strong magnets; magnets can cause meters to become inaccurate
- 3. Meters are very fragile; should be handled with care
- 4. Don’t expose meters to large temperature changes; excessive heat or cold can damage meters
- 5. Know the type of circuit (AC or DC) being tested

6. Never let value being measured exceed range of meter
7. Change batteries in multimeters and ohmmeters from time to time
8. Check owner's manuals for when to replace fuses, fuse sizes, and fuse Locations
9. Measuring instruments should be recalibrated once a year

BASIC RECEPTACLE POLARITY CHECKING DEVICE



REMEMBER:

- VOLTAGE = ACROSS THE LINE
- AMPERAGE = IN LINE
- RESISTANCE = **POWER OFF!!!!**

The **amperage meter** must be connected BETWEEN the line and the load. The amp meter reads electron flow. Start with the highest scale then go to a lower scale for accuracy. Check for A.C. or D.C. currents before taking readings.

The **volt meter** reads the difference in charges between two points. The volt meter must be connected ACROSS the load or source to be read. Always check for A.C. or D.C. voltages before taking readings. Start with the highest scale first then go to a lower scale for accuracy.

The **ohm meter** readings must only be read when the POWER IS OFF! The ohm meter uses its own power supply to operate. Start with the highest scale then go to a lower scale for accuracy.

CONSTRUCT THE ABOVE CIRCUIT AND RECORD THE READINGS BELOW

CALCULATE

R _____ 25 WATTS

R _____ 100 WATTS

R _____ 60 WATTS

Ed _____ 25 WATTS

Ed _____ 100 WATTS

Ed _____ 60 WATTS

I _____ 25 WATTS

I _____ 100 WATTS

I _____ 60 WATTS

It = _____ CIRCUIT

METER

Ed _____ 25 WATTS

Ed _____ 100 WATTS

Ed _____ 60 WATTS

I _____ 25 WATTS

I _____ 100 WATTS

I _____ 60 WATTS

It = _____ CIRCUIT

CONSTRUCT THE ABOVE CIRCUIT AND RECORD THE READINGS BELOW

CALCULATE

R _____ 25 WATTS

R _____ 100 WATTS

R _____ 60 WATTS

Ed _____ 25 WATTS

Ed _____ 100 WATTS

Ed _____ 60 WATTS

It = _____ CIRCUIT

METER

Ed _____ 25 WATTS

Ed _____ 100 WATTS

Ed _____ 60 WATTS

It = _____ CIRCUIT

EXPLAIN THE FOLLOWING DIAGRAMS

DO NOT USE CALCULATOR, MATH IS NOT REQUIRED.

1) WHAT IS WRONG WITH THE ABOVE CIRCUIT?

2) WHAT IS WRONG WITH THE ABOVE CIRCUIT?

3) WHAT IS WRONG WITH THE ABOVE CIRCUIT?

4) WHAT IS WRONG WITH THE ABOVE CIRCUIT?

5) WHAT IS WRONG WITH THE ABOVE CIRCUIT?

**CONSTRUCT THIS CIRCUIT USING VARIOUS LIGHT BULB WATTAGES AND
RECORD THE INFORMATION REQUIRED USING CALCULATIONS AND
MULTIMETERS.**

LIGHT 1

I _____ M _____
E _____ M _____

LIGHT 2

I _____ M _____
E _____ M _____

LIGHT 3

I _____ M _____
E _____ M _____

LIGHT 4

I _____ M _____
E _____ M _____

LIGHT 5

I _____ M _____
E _____ M _____

**CONSTRUCT THIS CIRCUIT USING VARIOUS LIGHT BULB WATTAGES AND
RECORD THE INFORMATION REQUIRED USING CALCULATIONS AND
MULTIMETERS.**

THE 25 WATT BULB REPRESENTS THE LINE RESISTANCE.

- 1. LEAVE “L2” ON BUT LEAVE “L3, L4, AND L5” OFF.**
- 2. TAKE THE TOTAL CURRENT READINGS, RIGHT BEFORE THE 25 WATT BULB.**
- 3. TURN ON “L3” AND TAKE CURRENT READINGS AGAIN.
WHAT HAPPENED AND WHY?**

- 4. TURN ON “L4” AND TAKE CURRENT READINGS AGAIN.
WHAT HAPPENED AND WHY?**

- 5. TURN ON THE LAST BULB, “L5” AND RECORD CURRENT AGAIN.
WHAT HAPPENED AND WHY?**

- 6. REPEAT STEPS 1 – 6 AND PUT A MULTIMETER ACROSS THE 25 WATT LIGHT BULB AND NOTICE THE VOLTAGE DROPS AS YOU TURN ON THE VARIOUS BULBS AND THE INCREASE IN CURRENT DRAW.**
- 7. WRITE AN EXPLANATION OF WHAT HAPPENED TO THE TOTAL CURRENT AS YOU INCREASED THE LOAD AND WHY THE VOLTAGE DROPPED ACROSS THE 25 WATT BULB.**

EXPERIMENT NOTE:

- **THE STUDENTS ARE REQUIRED TO CALCULATE THE ANSWERS USING THE OHM'S LAW FORMULAS AND COMPARE THEIR FINDINGS FOR EACH EXPERIMENT WITH THE READINGS ON THE MULTIMETERS.**
- **IF A STUDENT USES DIFFERENT LIGHT BULB WATTAGES RATHER THAN THE ONES SUGGESTED, THE WATTAGES SHOULD BE INSERTED INTO THE PROJECT SHEET. THIS SHOULD ONLY BE DONE IF THE SUGGESTED BULB WATTAGES ARE NOT AVAILABLE.**
- **STUDENTS ARE RESPONSIBLE FOR THE METERS USED DURING THESE EXPERIMENTS. ALWAYS MAKE SURE THE METERS ARE TURNED OFF AFTER USE.**
- **STUDENTS CAN USE A.C. OR D.C. VOLTAGES FOR THESE EXPERIMENTS.**
- **STUDENTS MAY WORK IN TEAMS TO PERFORM THESE EXPERIMENTS.**
- **ALWAYS WEAR SAFETY GLASSES WHILE PERFORMING THESE EXPERIMENTS.**
- **ALWAYS BE CAREFUL OF WHERE YOUR HANDS ARE WHEN TAKING "LIVE POWER" READINGS.**

CONSTRUCT THE FOLLOWING CIRCUITS AND RECORD THE DATA.

1. WHAT IS THE VOLTAGE ACROSS “L1”? _____
2. WHAT IS THE VOLTAGE ACROSS “L2”? _____
3. WHAT IS THE VOLTAGE ACROSS “L3”? _____
4. WHAT IS THE VOLTAGE ACROSS “L1 AND L2”? _____
5. WHAT IS THE VOLTAGE APPLIED TO THE CIRCUIT? _____

1. WHAT IS THE VOLTAGE ACROSS “L1”? _____
2. WHAT IS THE VOLTAGE ACROSS “L2”? _____
3. WHAT IS THE VOLTAGE ACROSS “L3”? _____
4. WHAT IS THE SUM OF ALL THE VOLTAGE DROPS? _____

CONSTRUCT THE FOLLOWING CIRCUITS AND RECORD THE DATA.

1. WHAT IS THE CURRENT FLOW IN THIS CIRCUIT? _____

2. WHAT IS THE CURRENT FLOW IN THIS CIRCUIT? _____

3. WHAT IS THE CURRENT FLOW IN THIS CIRCUIT? _____

****EXPLAIN IN YOUR OWN WORDS THE CONCLUSION OF THIS
EXPERIMENT: _____**

CONSTRUCT THE FOLLOWING CIRCUIT AND RECORD THE DATA.

1. MEASURE THE TOTAL CURRENT FLOW: $I_t =$ _____
2. WHAT IS THE VOLTAGE ACROSS “L1”? _____
3. WHAT IS THE CURRENT FLOW THROUGH “L2”? _____
4. WHAT IS THE CURRENT FLOW THROUGH “L3”? _____
5. WHAT IS THE VOLTAGE DROP ACROSS “L3”? _____
6. WHAT IS THE VOLTAGE DROP ACROSS “L2”? _____
7. CALCULATE THE RESISTANCE OF EACH LIGHT WITH THE EXISTING
VOLTAGES AND CURRENTS:

RL1 _____

RL2 _____

RL3 _____

WHAT IS “RIGHT” OR “WRONG” WITH THIS CIRCUIT?

= AMP METER

= VOLT METER

= OHM METER

1. _____ 9. _____

2. _____ 10. _____

3. _____ 11. _____

4. _____ 12. _____

5. _____ 13. _____

6. _____ 14. _____

7. _____ SWITCH “T” _____

8. _____

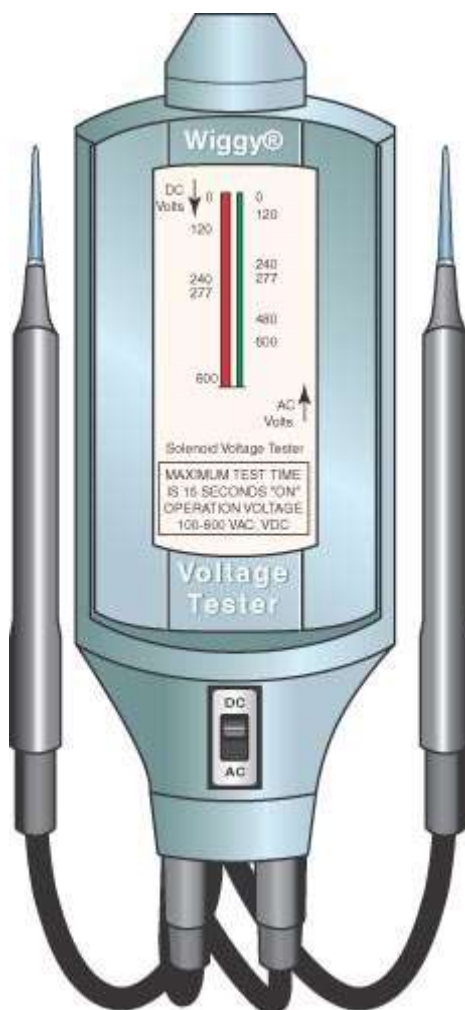
- WHAT METER IS THIS? _____

- WHAT IS ITS FUNCTION? _____



- **WHAT METER IS THIS?** _____

- **WHAT IS ITS FUNCTION?** _____



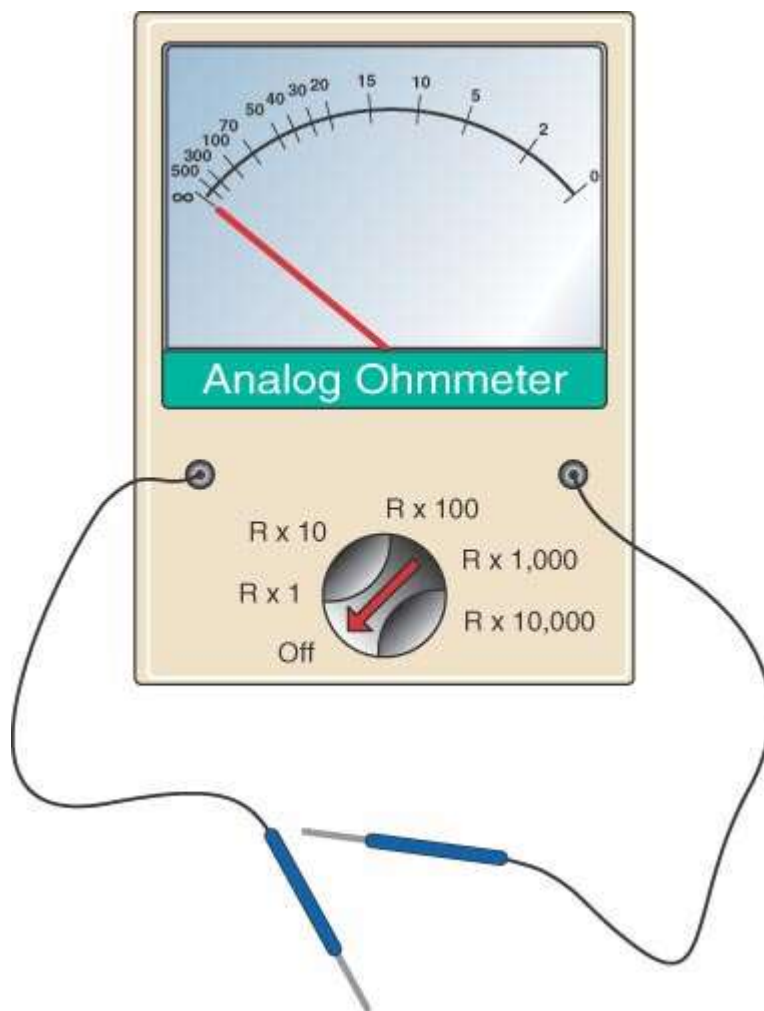
• WHAT METER IS THIS? _____

• WHAT IS ITS FUNCTION? _____



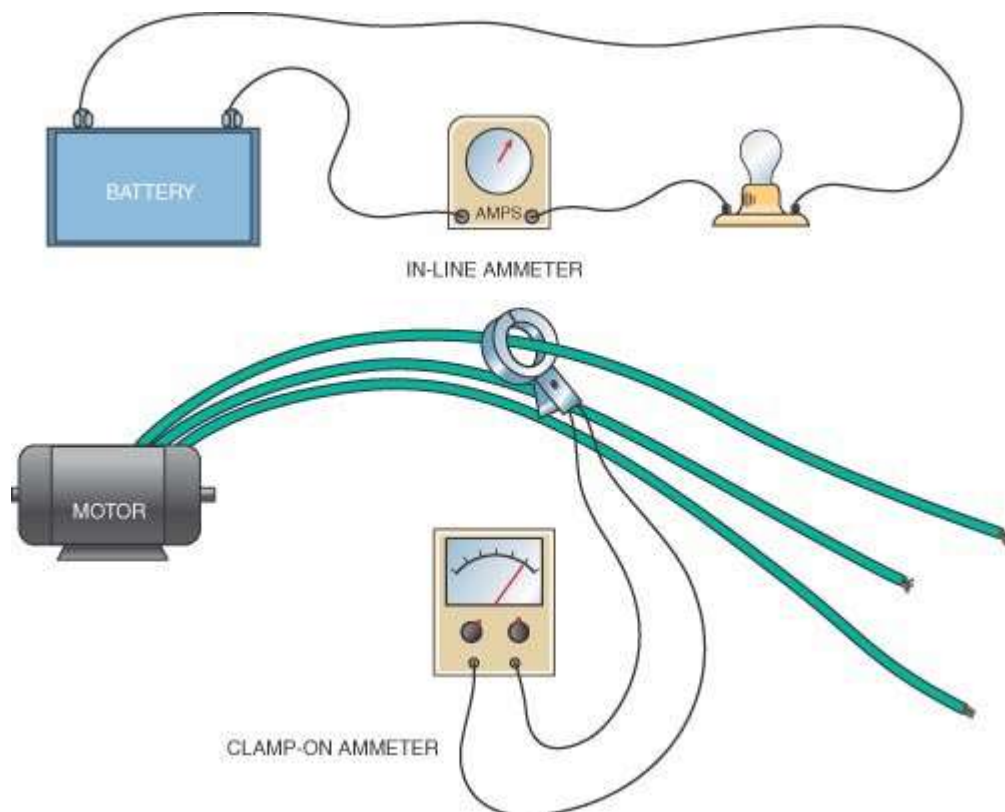
• **WHAT METER IS THIS?** _____

• **WHAT IS ITS FUNCTION?** _____



• WHAT METER IS THIS? _____

• WHAT IS ITS FUNCTION? _____



- WHAT METER IS THIS? _____

- WHAT IS ITS FUNCTION? _____



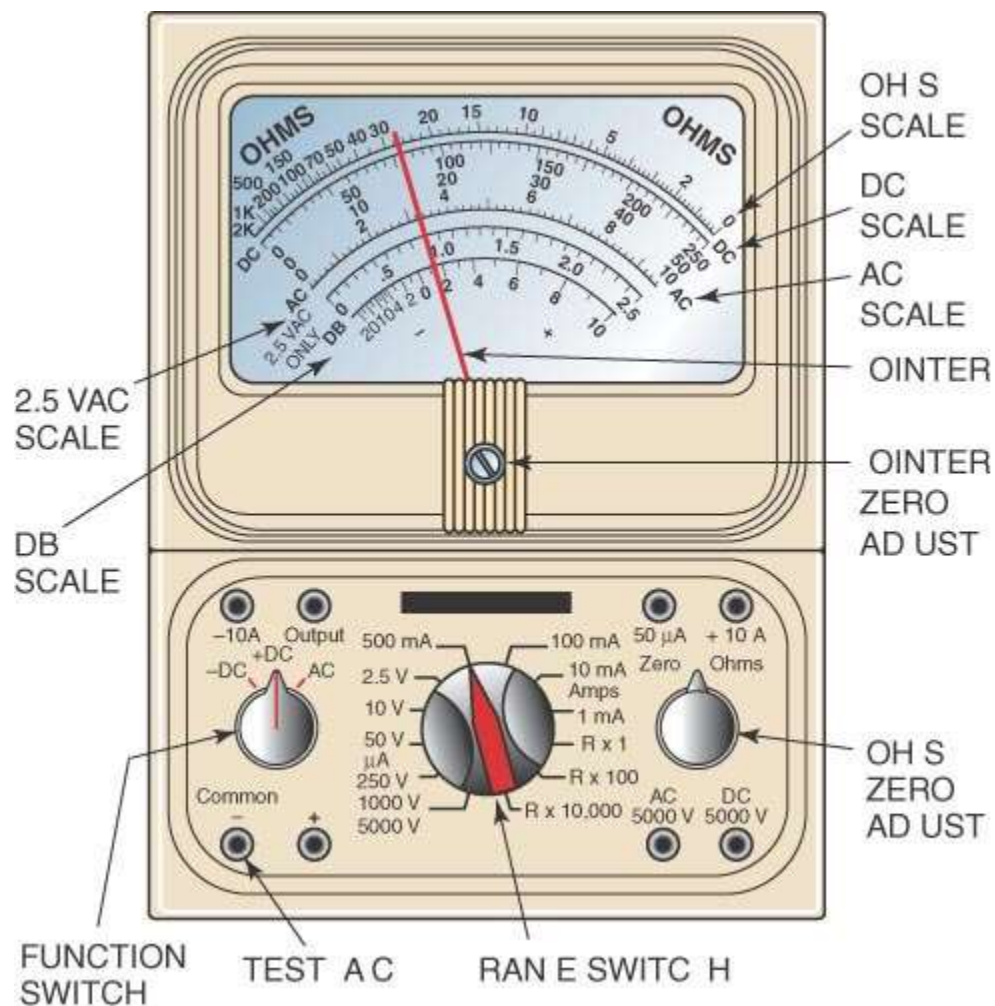
• WHAT METER IS THIS? _____

• WHAT IS ITS FUNCTION? _____



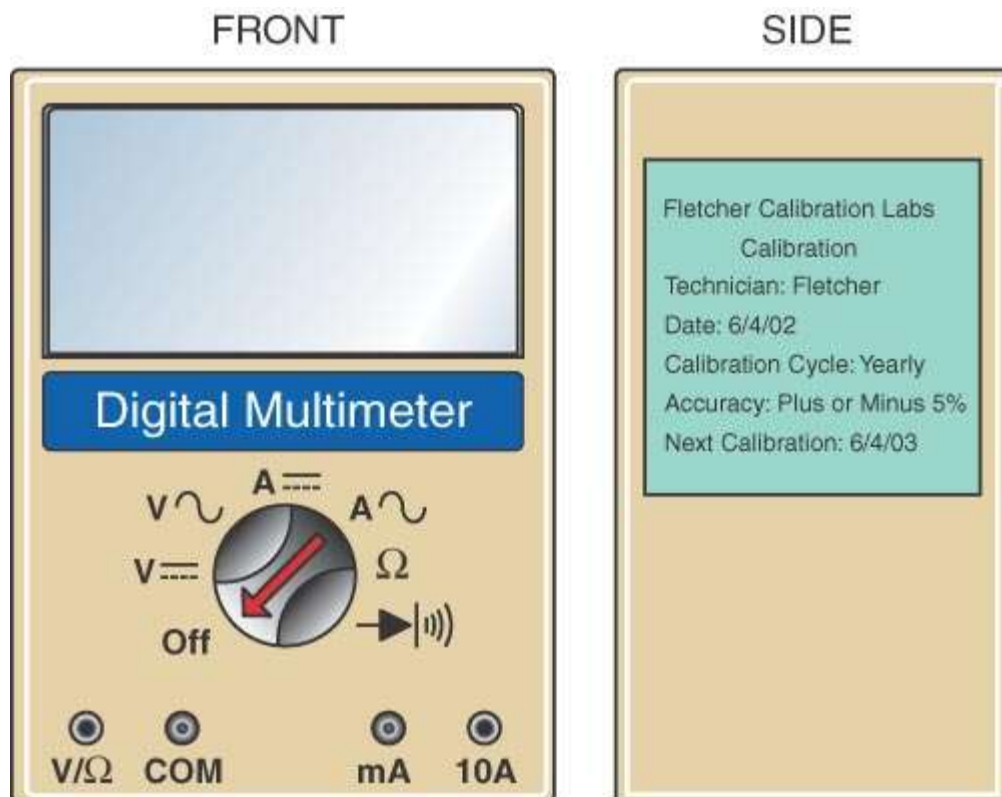
- WHAT METER IS THIS? _____

- WHAT IS ITS FUNCTION? _____

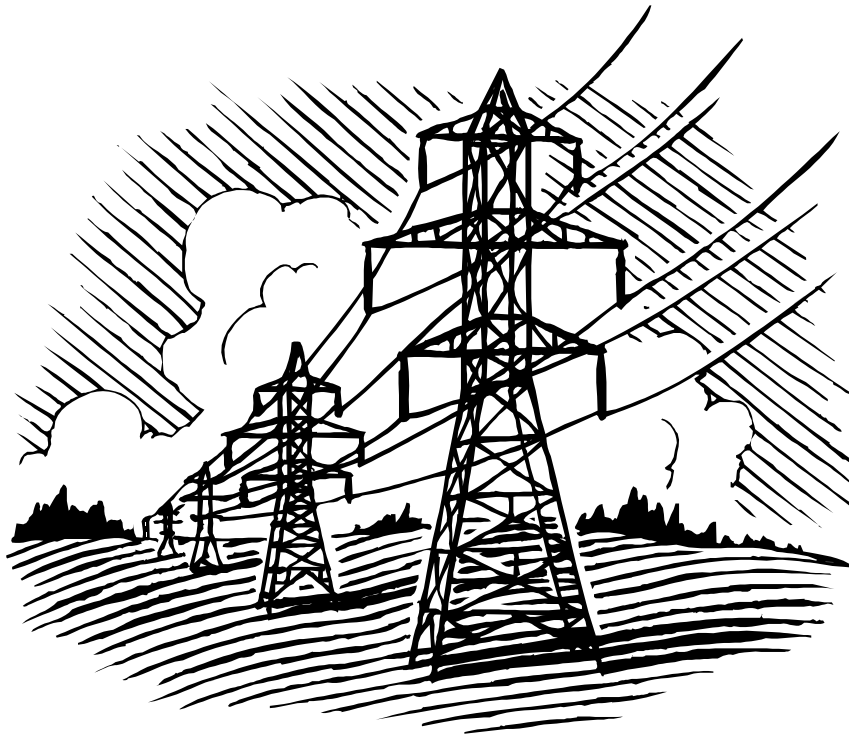


• WHAT METER IS THIS? _____

• WHAT IS ITS FUNCTION? _____



REFERENCE PAGES

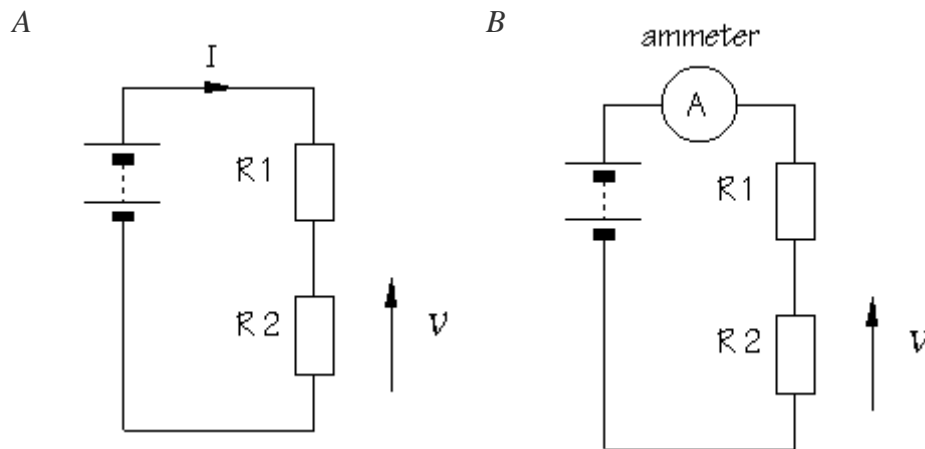


How to Use A Multi-meter

What do meters measure?

A meter is a measuring instrument. An ammeter measures current, a voltmeter measures the potential difference (voltage) between two points, and an ohmmeter measures resistance. A multimeter combines these functions, and possibly some additional ones as well, into a single instrument.

Before going in to detail about multimeters, it is important for you to have a clear idea of how meters are connected into circuits. Diagrams *A* and *B* below show a circuit before and after connecting an ammeter:

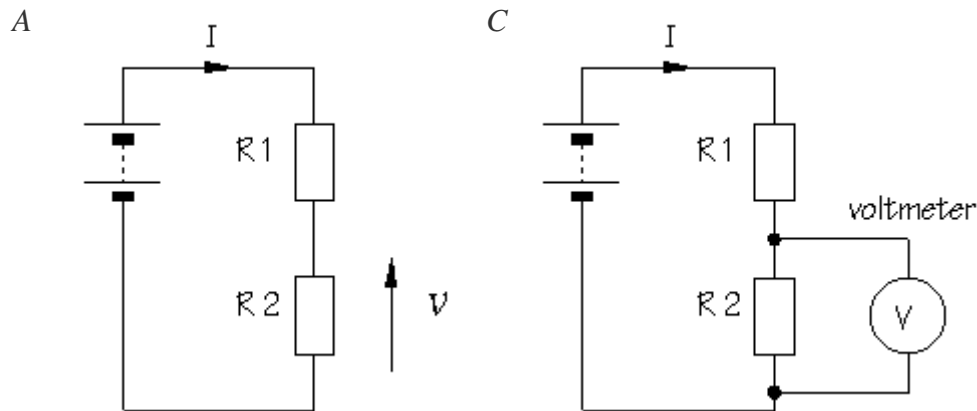


To measure current, the circuit must be broken to allow the ammeter to be connected in series

Ammeters must have a LOW resistance

Think about the changes you would have to make to a practical circuit in order to include the ammeter. To start with, you need to *break the circuit* so that the ammeter can be connected in series. All the current flowing in the circuit must pass through the ammeter. Meters are not supposed to alter the behaviour of the circuit, or at least not significantly, and it follows that an ammeter must have a very LOW resistance.

Diagram C shows the same circuit after connecting a voltmeter:



To measure potential difference (voltage), the circuit is not changed:

The voltmeter is connected in parallel

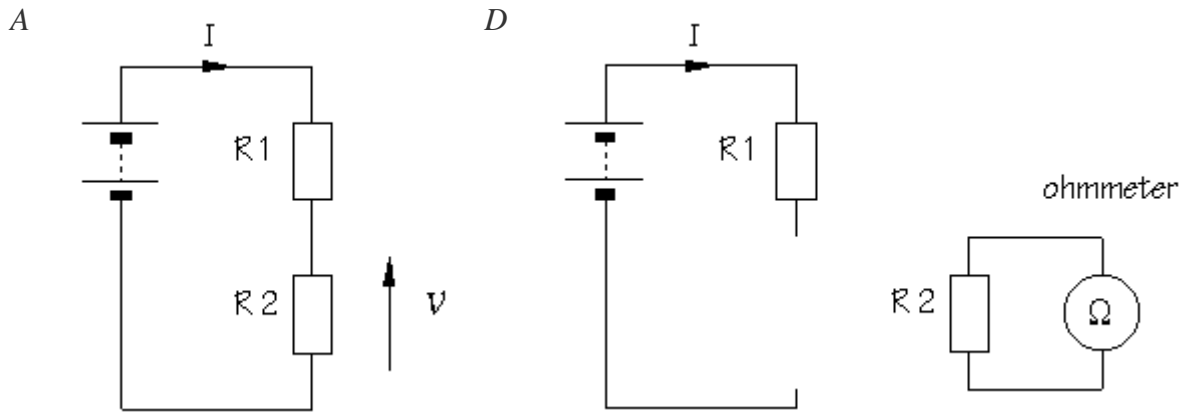
Voltmeters must have a HIGH resistance

This time, you do not need to break the circuit. The voltmeter is connected in parallel between the two points where the measurement is to be made. Since the voltmeter provides a parallel pathway, it should take as little current as possible. In other words, a voltmeter should have a very HIGH resistance.

Which measurement technique do you think will be the more useful? In fact, voltage measurements are used much more often than current measurements.

The processing of electronic signals is usually thought of in voltage terms. It is an added advantage that a voltage measurement is easier to make. The original circuit does not need to be changed. Often, the meter probes are connected simply by touching them to the points of interest.

An ohmmeter does not function with a circuit connected to a power supply. If you want to measure the resistance of a particular component, you must take it out of the circuit altogether and test it separately, as shown in diagram *D*:



To measure resistance, the component must be removed from the circuit altogether

Ohmmeters work by passing a current through the component being tested

Ohmmeters work by passing a small current through the component and measuring the voltage produced. If you try this with the component connected into a circuit with a power supply, the most likely result is that the meter will be damaged. Most multimeters have a fuse to help protect against misuse.

For circuits with power supplies of up to 20 V, which includes all the circuits you are likely to build, the 20 V DC voltage range is the most useful. DC ranges are indicated by $V=$ on the meter. Sometimes, you will want to measure smaller voltages, and in this case, the 2 V or 200 mV ranges are used.

What does DC mean? DC means direct current. In any circuit which operates from a steady voltage source, such as a battery, current flow is always in the same direction. Every constructional project described in Design Electronics works in this way.

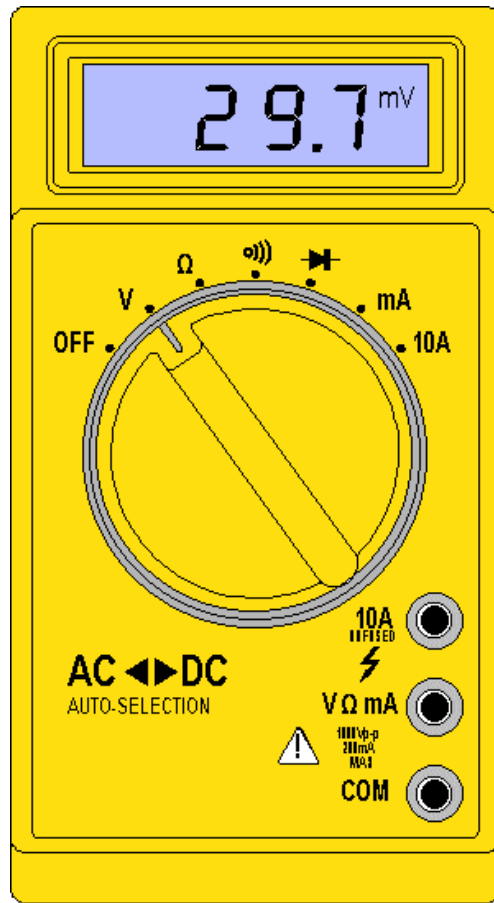
AC means alternating current. In an electric lamp connected to the domestic mains electricity, current flows first one way, then the other. That is, the current reverses, or alternates, in direction. With UK mains, the current reverses 50 times per second.

MAINS VOLTAGE

For safety reasons, you must NEVER connect a multimeter to the mains supply.

You are not at all likely to use the AC ranges, indicated by $V\sim$, on your multimeter.

An alternative style of multimeter is the autoranging multimeter:



Autoranging multimeter

The central knob has fewer positions and all you need to do is to switch it to the quantity you want to measure. Once switched to V, the meter automatically adjusts its range to give a meaningful reading, and the display includes the unit of measurement, V or mV. This type of meter is more expensive, but obviously much easier to use.

Where are the two meter probes connected? The black lead is always connected into the socket marked COM, short for COMMON. The **red** lead is connected into the socket labelled VΩmA. The 10A socket is very rarely used.

Analogue multimeters

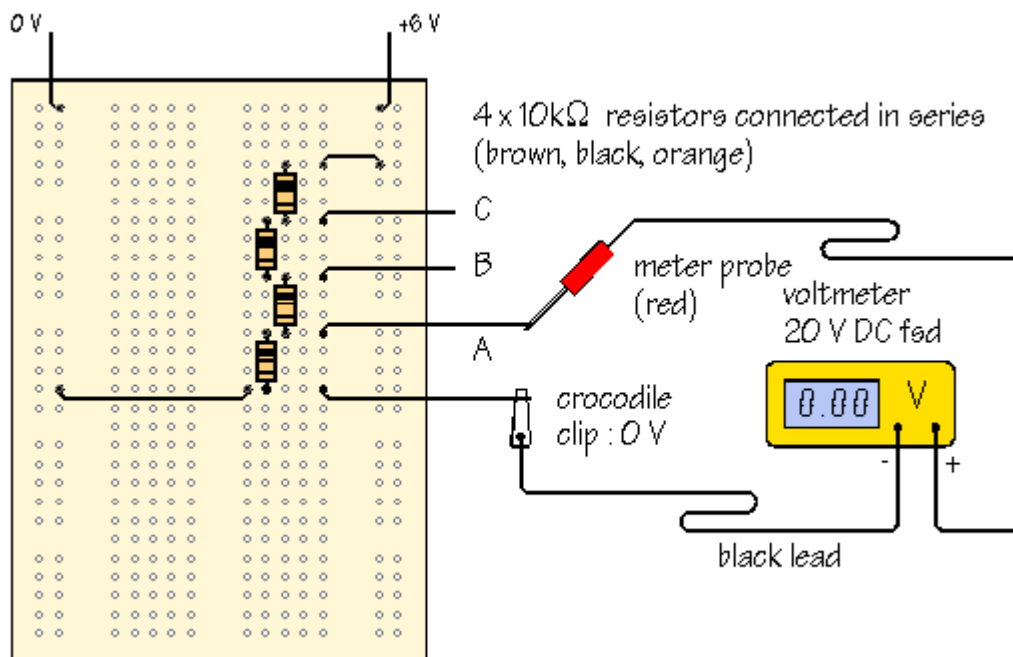
An analogue meter moves a needle along a scale. Switched range analogue multimeters are very cheap but are difficult for beginners to read accurately, especially on resistance scales. The meter movement is delicate and dropping the meter is likely to damage it!

Each type of meter has its advantages. Used as a voltmeter, a digital meter is usually better because its resistance is much higher, $1\text{ M}\Omega$ or $10\text{ M}\Omega$, compared to $200\text{ k}\Omega$ for an analogue multimeter on a similar range. On the other hand, it is easier to follow a slowly changing voltage by watching the needle on an analogue display.

Used as an ammeter, an analogue multimeter has a very low resistance and is very sensitive, with scales down to $50\text{ }\mu\text{A}$. More expensive digital multimeters can equal or better this performance.

Most modern multimeters are digital and traditional analogue types are destined to become obsolete.

1. Voltage measurements:

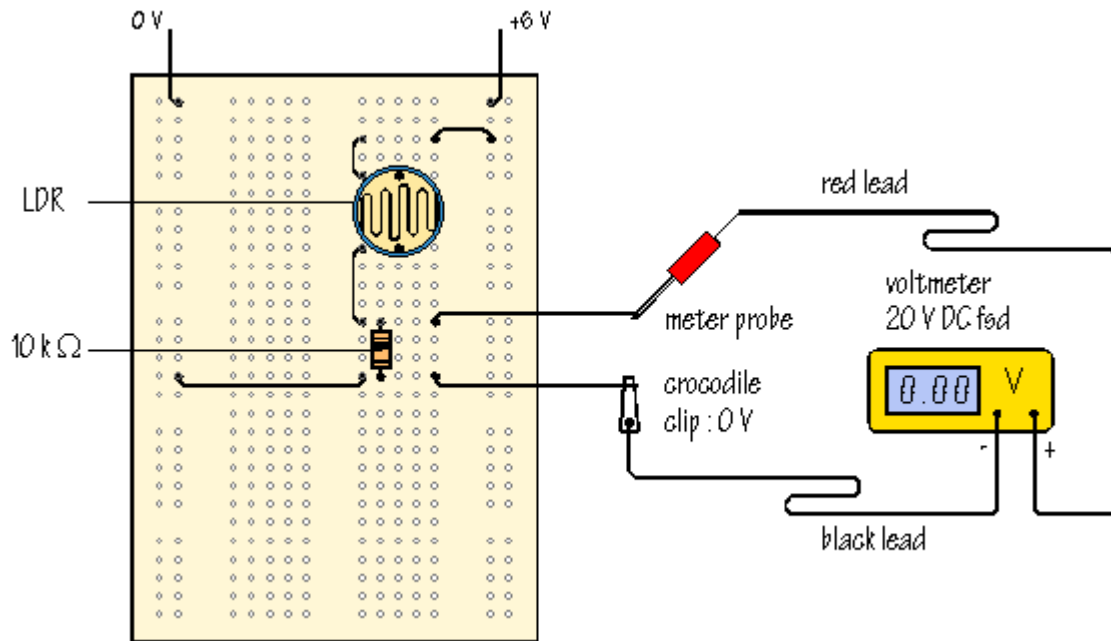


Using the multimeter as a voltmeter, measure the power supply voltage and then measure the voltages at points A, B and C.

The four resistors are connected in series, making a chain known as a potential divider, or voltage divider. The total voltage is shared between the four resistors and, allowing for tolerance, each resistor receives an equal share. (You will find out a lot more about potential dividers in the next Chapter.)

Modify the circuit, replacing one or more of the $10\text{ k}\Omega$ resistors with $1\text{ k}\Omega$ or $100\text{ k}\Omega$ values. Are the results as you expect?

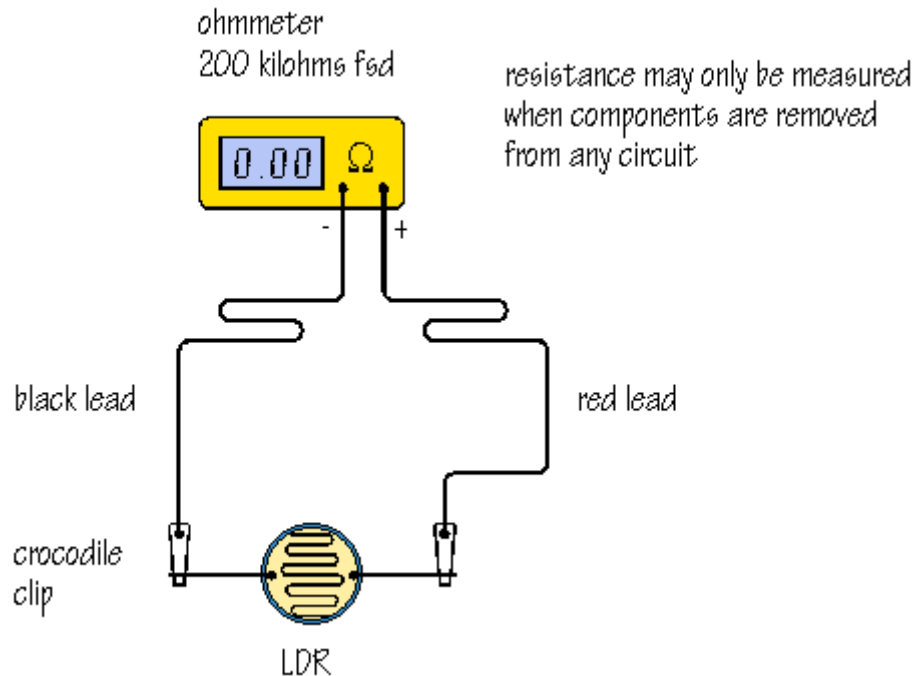
The diagram below shows a light sensor circuit built in a similar way:




The circuit uses an LDR, or light dependent resistor. The resistance of the LDR changes with illumination. In the dark, the resistance is high, up to $1\text{ M}\Omega$ or more. When light shines on the LDR, the light energy increases the number of charge carriers available to transfer current, and the resistance falls. In bright light, the resistance can be as little as $100\ \Omega$.

2. Resistance measurements:

Remove the LDR from the circuit and measure its resistance, as follows:



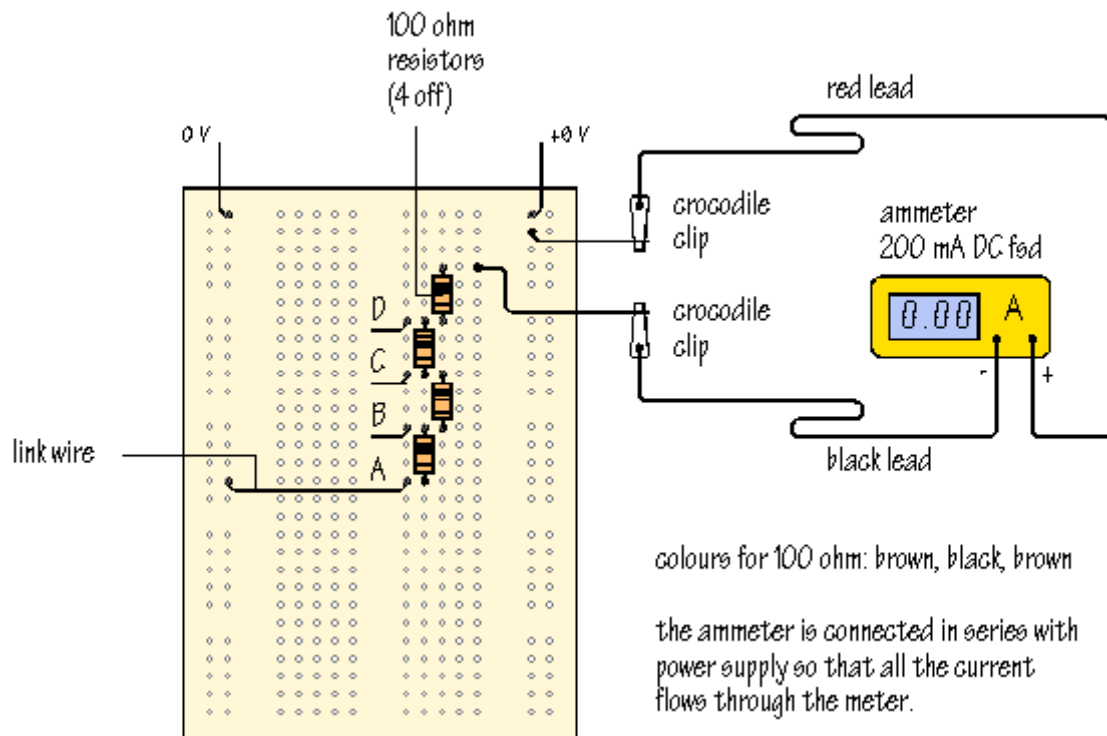
To get the multimeter to function as an ohmmeter, you will need to select a resistance range. With a switched range meter, the 200 k position is usually suitable. You will see the resistance measurement change as the light level changes. Covering the LDR with your hand increases the resistance of the LDR.

If the meter reads  this means that the resistance is more than the maximum which can be measured on this range and you may need to switch to a new position, 2000 k, to take a reading. (How many megohms is 2000 k?)

You can check the value of any fixed value resistor in the same way, and confirm that you have worked out the color code correctly. Don't forget that the [colour code convertor](#) program is available to help you.

3. Current measurements:

The diagram below shows a prototype board set up for the measurement of current:



NAME: _____ LEVEL: _____ DATE: _____

CHECK LIST FOR METER CIRCUITS

STEPS/TASKS	MEETS STANDARDS	NEEDS IMPROVEMENT
1) THE STUDENT COMPLETED ALL VOCABULARY TO 100% ACCURACY.		
2) THE STUDENT COMPLETED ALL WRITTEN WORK TO 100% ACCURACY.		
3) THE STUDENT COMPLETED PROJECT# 1		
4) THE STUDENT COMPLETED PROJECT # 2		
5) THE STUDENT COMPLETED PROJECT # 3		
6) THE STUDENT COMPLETED PROJECT # 4		
7) THE STUDENT COMPLETED PROJECT # 5		
8) THE STUDENT COMPLETED PROJECT # 6		
9) THE STUDENT COMPLETED PROJECT # 7		
10) THE STUDENT COMPLETED PROJECT # 8		
11) THE STUDENT COMPLETED PROJECT # 9		
12) THE STUDENT COMPLETED PROJECT # 10		
13) THE STUDENT COMPLETED PROJECT # 11		
14) THE STUDENT COMPLETED PROJECT # 12		
15) THE STUDENT COMPLETED PROJECT # 13		
16) THE STUDENT COMPLETED PROJECT # 14		
17) THE STUDENT COMPLETED PROJECT # 15		
18) THE STUDENT COMPLETED PROJECT # 16		
19) THE STUDENT IDENTIFIED ALL METERS TO 100% ACCURACY.		
20) THE STUDENT COMPLETED THE WRITTEN ASSESSMENT TO 80% ACCURACY.		

*** ALL STEPS/TASKS MUST MEET THE STANDARDS IN ORDER TO ACHIEVE MASTERY.***

COMMENTS: _____

INSTRUCTOR SIGNATURE: _____ DATE: _____

NAME: _____ DATE: _____

METER PACKET Post Test

True/False

Indicate whether the sentence or statement is true or false.

- _____ 1. A voltage tester gives only approximate voltage measurements.
- _____ 2. An analog ohmmeter scale is read from left to right.
- _____ 3. A voltage tester is considered to be a very accurate meter when compared to a voltmeter.

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

- _____ 4. An instrument used to measure values of resistance is called a(n) _____.
 - a. ammeter
 - b. ohmmeter
 - c. voltmeter
 - d. wattmeter
- _____ 5. The letters VOM are an abbreviation for volt, ohm, and _____.
 - a. milliamps
 - b. meter
 - c. milliammeter
 - d. measurement
- _____ 6. A meter that uses a moving pointer or needle to indicate a value on a scale is called a(n) _____ meter.
 - a. LCD
 - b. analog
 - c. digital
 - d. parallax
- _____ 7. Which of the following test instruments must be used when the circuit is not energized?
 - a. Ammeter
 - b. Ohmmeter
 - c. Voltmeter
 - d. Wattmeter

- ____ 8. One megohm is equal to _____ ohms.
- a. one hundred
 - b. one thousand
 - c. one million
 - d. one billion
- ____ 9. _____ are load types where the load impedance is not constant.
- a. Harmonics
 - b. Linear loads
 - c. Non-linear loads
 - d. True RMS
- ____ 10. _____ are frequencies that are multiples of the fundamental frequency, usually 60 Hertz.
- a. Harmonics
 - b. Linear loads
 - c. Non-linear loads
 - d. True RMS
- ____ 11. _____ meters provide accurate measurements of AC values in environments where the basic AC waveform is distorted.
- a. Harmonic
 - b. Linear load
 - c. Non-linear load
 - d. True RMS
- ____ 12. Electrical power is measured in _____.
- a. amps
 - b. ohms
 - c. volts
 - d. watts
- ____ 13. A voltmeter is used to measure _____.
- a. ammeter
 - b. megohmmeter
 - c. continuity tester
 - d. None of the above
- ____ 14. A Wiggy is an electrical trade name for a _____.
- a. voltmeter
 - b. voltage tester
 - c. ammeter
 - d. ohmmeter

- ____ 15. Kilowatt-hour meters are used to measure _____.
a. electrical power
b. electrical energy
c. large amounts of voltage
d. large amounts of amperage
- ____ 16. _____ is a frequency that is a multiple of the standard 60 Hertz
a. LCD
b. Harmonics
c. RMS
d. Auto-ranging
- ____ 17. A break in an electrical conductor or cable is called a(n) _____ circuit.
a. linear
b. non-linear
c. open
d. short

Completion

Complete each sentence or statement.

18. The abbreviation for a digital multimeter is _____.
19. A _____ tester is a device used to indicate whether there is a continuous path for current flow in an electrical circuit or electrical device.
20. A voltmeter is connected in _____ with the circuit or component being tested.
21. A(n) _____ is designed to measure the amount of current flowing in a circuit.
22. In-line ammeters are always connected in _____ with the circuit or circuit component being tested.
23. A(n) _____ ammeter surrounds the conductor, picks up the strength of the magnetic field that is set up around the conductor, and converts it into a proportional value of current.
24. An ohmmeter is used to measure the _____ of a circuit or circuit component.
25. A VOM can measure DC and AC voltages, DC and AC current, and _____.
26. The _____ meter measures the amount of electrical energy used by the dwelling electrical system.

27. One _____-hour is equal to one thousand watt-hours.
28. The two basic types of ammeters are 'in-line' and _____.
29. When using an analog ohmmeter as a continuity tester, a reading of zero indicates a(n) _____.

Short Answer

30. Explain what a Megohmmeter is used for. _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

CC.3.6.11-12.H. Draw evidence from informational texts to support analysis, reflection, and research.

Residential & Industrial Electricity
K-W-L WORKSHEET

NAME: _____ LEVEL: _____ DATE: _____

ARTICLE TITLE: _____

TIME START: _____ TIME FINISH: _____

<u>K</u> What do I already <u>KNOW</u> about this topic?	
<u>W</u> What do I <u>WANT</u> to know about this topic?	
<u>L</u> What did I <u>LEARN</u> after reading ABOUT this topic?	

I checked the following before reading:

- Headlines and Subheadings
- *Italic*, **Bold**, and Underlined words
- Pictures, Tables, and Graphs
- Questions or other key information

I made predictions **AFTER** previewing the article.

Comments: _____

- Instructor Signature: _____
- Instructional Aide Signature: _____

CC.1.3.11-12.I Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade level reading and content, choosing flexibly from a range of strategies and tools.

Residential & Industrial Electricity

Pre/Post Learning Concept Check

Name: _____ Date: _____ Level: _____

Lesson Objective: _____

+ / -	Key Vocabulary Terms	+ / -
	Conductor	
	Insulator	
	Pigtail Splice	
	Western Union Splice	
	T Tap Splice	
	Romex	
	A.W.G. (American Wire Gage)	
	N.E.C. (National Electrical Code)	

Lesson Conclusion: _____

NAME: _____ DATE: _____

METER PACKET Pre Test

True/False

Indicate whether the sentence or statement is true or false.

- _____ 1. A voltage tester gives only approximate voltage measurements.
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- _____