Basic Electricity – Course Structure

Basic Electricity

Topic Units

1. Safety
2. Units, Calculator Use, and Scientific Notation
3. Atomic Structure, Insulators, Conductors, Semi-Conductors, Charge, Voltage, Current Flow, Resistance, Electrical Circuit, Closed Circuit, Open Circuit, and Short Circuit
4. Generating Electricity, Conductor Sizing, Fuses and Circuit Breakers, Resistor Color Code, and Schematic Diagrams
5. Ohm's Law, Series Circuit Fundamentals, Parallel Circuit Fundamentals, Combination Circuit Fundamentals, Ground Reference, Test Equipment, and Circuit Construction and Troubleshooting
6. Other Basic Circuit Fundamentals. Voltage Dividers, Current Dividers, Potentiometers, Wheatstone Bridge Circuit, Variable Resistance Sensors
7. Magnetism, Coils, Relays, and Solenoids
8. AC Characteristics, Sine Wave, Peak, Peak-To-Peak, RMS, Average, Frequency, and Time
9. Oscilloscope, Function Generator, Voltage Measurement, Time Measurement, Resistors and AC Voltage
10. Capacitance, Construction, Physical Characteristics, Unit of Measure, Electric Field, Dielectric, Charge, Discharge, RC Time Constant, Capacitors in Series, and Capacitors in Parallel
11. Phase Angles, Trigonometric Functions
12. Capacitors and AC Voltage, Capacitive Reactance, and Phase Angle
13. Inductors, Construction, Physical Characteristics, Unit of Measure, Magnetic Field, Turns, Charge, Discharge, RL Time Constant, Inductors in Series, Inductors in Parallel, and Troubleshooting Inductors
14. Inductors and AC Voltage, Inductive Reactance, Phase Angle
15. Transformers, Magnetic Coupling, Primary Winding, Secondary Winding, Phase Relationship, Step Up, Step Down, Isolation, Turns Ratio, Core Material, Center Tap, Voltage, Current and Power Ratio
16. Resistors, Capacitors, Inductors and AC Voltage
17. Parallel AC Circuits
18. Thevenin's Circuit Analysis
19. Troubleshooting

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TOPIC UNIT 1: Safety

I. Electric Shock
- A. Current through the body
  1. Voltage must be present to send current through the body.
  2. The resistance of the body
  3. The effects of current on the body
- B. Safety precautions
  1. Body contact
  2. Power cords
     a. 3 prong plugs
     b. condition
- C. Other safety issues
  1. Insulation on hand tools
  2. Safety glasses
  3. Working alone
  4. Jewelry
  5. Knowledge of equipment
  6. Capacitors
  7. Metal floors, catwalks
  8. Wet floors
  9. Shoes

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TOPIC UNIT 2: Units, Calculator Use, and Scientific Notation

I. Electrical, Magnetic, Light and Sound Units
- A. Quantities and their units
  1. Electrical quantities and their units
  2. Magnetic quantities and their units
  3. Quantities of light and their units
  4. Quantities of sound and their units
- B. Calculators
  1. Dedicated calculators
  2. Phone apps
- C. Scientific Notation
  1. Powers of ten
- D. Engineering Notation
  1. Metyric prefixes
  2. Metric prefix conversion

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TOPIC UNIT 3: Atomic Structure, Insulators, Conductors, Semi-Conductors, Charge, Voltage, Current Flow, Resistance, Electrical Circuit, Closed Circuit, Open Circuit, and Short Circuit

I. Atomic Structure
- A. Matter
  - 1. Elements
    - a. Atoms
      - (1) Protons
      - (2) Neutrons
      - (3) Electrons
- B. Atomic Number
- C. Electron Orbits
  - 1. $2n^2$
- D. Valence Electrons
- E. Ions
- F. Conductors
  - 1. Copper
  - 2. Other metals
- G. Insulators
- H. Semiconductors

II. Electrical Charge
- A. Unit of charge
  - 1. Positive charge
  - 2. Negative charge
  - 3. Unit of charge Q

III. Voltage
- A. Potential difference in charge
- B. Quantity Unit = Volt = V
- C. Formula
  - 1. V= W/Q = Energy (W) in Joules per unit charge (Q)

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IV. Current
- A. Movement of electrons
- B. Free Electrons
- C. Rate of movement of electrons
- D. Quantity unit = Amp
- E. Formula
    1. I=Q/t = number or amount of electrons (Q) per unit time (t)
- F. Direction of current flow in a conductor

V. Resistance
- A. Restriction of electrons
- B. Quantity unit = Ohm
- C. Formula
    1. one Ohm = V/I = Volts (V) / Amps (I)

VI. Electric Circuits
- A. Closed Circuit
- B. Open Circuit
- C. Short Circuit

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TOPIC UNIT 4: Generating Electricity, Conductor Sizing, Fuses and Circuit Breakers, Resistor Color Code, and Schematic Diagrams

I. Voltage Sources
   A. Battery (chemical)
   B. Solor cell (light)
   C. Thermocouple
   D. Generator (magnetic)
   E. Piezo device

II. Conductor sizing
   A. Wire gauge
      1. AWG (American Wire Gauge)
      2. Cross sectional area
      3. Resistance

III. Fuse Rating and Circuit Breakers
   A. Wire protection
   B. Excess current
   C. Schematic symbol

IV. Electrical Circuit
   A. Schematic diagrams
   B. Closed circuit definition
   C. Open circuit definition
   D. Short circuit definition
   E. Supply voltage
   F. Wire conductor
      1. Resistance
   G. Load
   H. Fuse
   I. Ground

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V. Resistor Color Code
- A. Fixed resistors
- B. 5%, 10% and 20% tolerance
  1. 4 band color code
     - a. four color bands around resistor closer to one end
     - b. Band closest to the end is 1st band and 1st number in the resistor value
     - c. 2nd Band closest to the end is the 2nd band and 2nd number in the resistor value
     - d. 3rd band is the multiplier. Number of zeros after the second number.
     - e. 4th band is tolerance band
  2. 5 band color code
     - a. precision resistor
     - b. 1%, 2% or less tolerance value
     - c. Band closest to the end is 1st band and 1st number in the resistor value
     - d. 2nd Band closest to the end is the 2nd band and 2nd number in the resistor value
     - e. 3rd Band closest to the end is the 3rd band and 3rd number in the resistor value
     - f. 4th band is the multiplier. Number of zeros after the third number.
       - (1) multiply by .1 = gold
       - (2) multiply by .01 = silver
     - g. 5th band is tolerance band
       - (1) +/- 2% = red
       - (2) +/- 1% = brown
       - (3) +/- .5% = green
       - (4) +/- .25% = blue
       - (5) +/- .1% = violet
     - h. Reliability Band

VI. Schematic Diagrams
- A. Schematic symbols

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TOPIC UNIT 5: Ohm's Law, Series Circuit Fundamentals, Parallel Circuit Fundamentals, Combination Circuit Fundamentals, Ground Reference, Test Equipment, and Circuit Construction and Troubleshooting

I. What is Ohm's Law?
- A. Linear relationship
- B. Voltage
- C. Current
- D. Resistance
- E. Pie chart
- F. Sample Calculations

II. Circuit Analysis
- A. Closed Circuit
  1. Voltage in a closed circuit
  2. Current in a closed circuit
  3. Resistance in a closed circuit
  4. Power in a closed circuit
  5. Sample circuit
- B. Open Circuit
  1. Voltage in a open circuit
  2. Current in a open circuit
  3. Resistance in a open circuit
  4. Power in a open circuit
  5. Sample circuit
- C. Short Circuit
  1. Voltage in a short circuit
  2. Current in a short circuit
  3. Resistance in a short circuit
  4. Power in a short circuit
  5. Sample circuit
- D. Series Circuits
  1. Voltage in a series circuit
  2. Current in a series circuit
  3. Resistance in a series circuit
  4. Power in a series circuit
  5. Sample circuits

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E. Parallel Circuits
    1. Voltage in a parallel circuit
    2. Current in a parallel circuit
    3. Resistance in a parallel circuit
    4. Power in a parallel circuit
    5. Sample circuits

F. Combination Circuits
    1. Voltage in a combination circuit
    2. Current in a combination circuit
    3. Resistance in a combination circuit
    4. Power in a combination circuit
    5. Sample circuits

III. Measurement Devices
    A. Ohm meter
    B. Volt meter
    C. Current meter

IV. Using Meters Lab

VII. Circuit set up from schematic diagrams
    A. Breadboard

VIII. Troubleshooting circuits
    A. Symptoms and circuit analysis
        1. Plan of trouble shooting
            a. working knowledge of the circuit
            b. review the circuit diagram
        2. Measure

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TOPIC UNIT 6: Other Basic Circuit Fundamentals. Voltage Dividers, Current Dividers, Potentiometers, Wheatstone Bridge Circuit, Variable Resistance Sensors

I. Voltage Dividers
- A. Voltage Divider Formula
  - 1. Sample circuit
- B. Current Divider Formula
  - 1. Current Divider Formula
    - a. Sample circuit

II. Wheatstone Bridge Circuit
- A. Wheatstone Bridge Circuit Function
- B. Circuit Calculations
- C. Sample Circuit

III. Variable Resistance Sensors
- A. Thermistor
  - 1. negative temperature coefficient resistance changes inversely with temperature
  - 2. positive temperature coefficient resistance changes directly with temperature
- B. Strain Gages
- C. Photo conductive cell
- D. Potentiometer
  - 1. voltage divider
  - 2. rheostat

IV. Labs related to Other Basic Circuit Fundamentals
- A. Potentiometer Lab
- B. Current Divider Lab
- C. Wheatstone Bridge Lab
- D. Thermistor Lab

Lab/Project/Test ____

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TOPIC UNIT 7: Magnetism, Coils, Relays, and Solenoids

I. Magnetism Fundamentals
   A. Natural magnet
   B. Electromagnet
      1. Theory
      2. Coil
      3. Rrelay
      4. Solenoid

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TOPIC UNIT 8: AC Characteristics, Sine Wave, Peak, Peak-To-Peak, RMS, Average, Frequency, and Time

I. Alternating Voltage and Current Fundamentals
   A. The x-y Axis
   B. The Sine Wave
   C. Peak-to-Peak Voltage
   D. Peak Voltage
   E. RMS Voltage
   F. Time
   G. Frequency
   H. Comparing AC voltage to DC voltage
   I. Average Voltage
   J. Sample Calculations
   K. Measuring AC Voltage and Current
   L. Instantaneous Voltage

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TOPIC UNIT 9: Oscilloscope, Function Generator, Voltage Measurement, Time Measurement, Resistors and AC Voltage

I. Oscilloscope
   A. Oscilloscope over view
      1. Grid
      2. Volts/division
      3. Time/division
      4. Ground setting
      5. Probes
         a. 1x
         b. 10x
      6. Isolation transformer
      7. Focus
      8. Intensity
      9. Triggering
      10. Other functions

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TOPIC UNIT 10: Capacitance, Construction, Physical Characteristics, Unit of Measure, Electric Field, Dielectric, Charge, Discharge, RC Time Constant, Capacitors in Series, and Capacitors in Parallel

I. Capacitance
   A. Construction and physical characteristics
   B. Electrostatic charge
   C. Discharge
   D. Capacitors and DC voltage
   E. Capacity = Coulombs per volt = C/V
   F. Unit of measure
      1. Farad = 1C/V
   G. Series capacitors
   H. Parallel capacitors
   I. RC time constant
   J. Lab
   K. Capacitor voltage rating
   L. Schematic symbol

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TOPIC UNIT 11: Phase Angles, Trigonometric Functions

I. Basic Trig functions
   A. Sine
   B. Cosine
   C. Tangent
   D. Phase angle Φ = theta
   E. Sample problems
   F. Pythagorean theorem

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TOPIC UNIT 12: Capacitors and AC Voltage, Capacitive Reactance, and Phase Angle

I. Capacitors and AC Voltage
- A. Phase relationship
  - 1. Current leads voltage
- B. Capacitive reactance
  - 1. $X_C = 1/ 2\pi fC$
- C. RC circuits in series
- D. Measuring phase angle
- E. Lab

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TOPIC UNIT 13: Inductors, Construction, Physical Characteristics, Unit of Measure, Magnetic Field, Turns, Charge, Discharge, RL Time Constant, Inductors in Series, Inductors in Parallel, and Troubleshooting Inductors

I. Inductance
- A. Construction and physical characteristics
- B. Magnetic field
- C. Buildup of magnetic field
- D. Inductors and DC voltage
- E. Faraday's Law
- F. Lenz's Law
- G. Induced voltage
- H. Inductor rating
- F. Unit of measure
    1. Henry = H = 1Amp/s / Volt = 1 amp per second per volt
- G. Series inductors
- H. Parallel inductors
- I. RL time constant
- J. Schematic symbol
- K. Lab

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TOPIC UNIT 14: Inductors and AC Voltage, Inductive Reactance, Phase Angle

I. Inductors and AC Voltage
- A. Phase relationship
  1. Voltage leads current
- B. Inductive reactance
  1. $X_L = 2\pi fL$
- C. RL circuits in series
- D. Measuring phase angle
- E. Lab

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TOPIC UNIT 15: Transformers, Magnetic Coupling, Primary Winding, Secondary Winding, Phase Relationship, Step Up, Step Down, Isolation, Turns Ratio, Core Material, Center Tap, Voltage, Current and Power Ratio

I. Transformers
   - A. Mutual inductance
   - B. Construction
   - C. Schematic symbol
   - D. Voltage input and output
   - E. Types
   - F. Operation of transformers
   - G. Turns ratio
   - H. Transformer voltage, current and power ratings
   - I. Phase relationship between input and output
   - J. Losses
     1. Laminated core
   - K. Step up, Step down, Isolation
   - L. Multiple outputs
   - M. Troubleshooting

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TOPIC UNIT 16: Resistors, Capacitors, Inductors and AC Voltage

I. RLC circuits
   A. Voltage
   B. Current
   C. Impedance
   D. Power

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TOPIC UNIT 17: Parallel AC Circuits

I. Parallel RC circuits
   A. Voltage
   B. Current
   C. Impedance
   D. Power

II. Parallel RL circuits
   A. Voltage
   B. Current
   C. Impedance
   D. Power

Basic Electricity – Course Structure

TOPIC UNIT 18: Thevenin's Circuit Analysis

I. Thevenin's Theorem
- A. Calculating Vth = Thevenin voltage
  1. Find Vth by removing the load resistance from the original circuit and calculating voltage across the open circuit where the load resistor was located
- B. Calculating Rth = Thevenin resistance
  1. Find Rth by shorting all voltage sources and opening all current sources in the original circuit. Calculate the total resistance between the now open connection points
- C. Thevenin equivalent circuit
  1. Draw the Thevenin equivalent circuit. The Thevenin voltage source (Vth) in series with the Thevenin resistance (Rth). Place the load resistance into the Thevenin equivalent circuit.
- D. Solution
  1. Find the solution for voltage and current using original load resistor. Use the rules for series circuits.

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TOPIC UNIT 19: Troubleshooting

I. Troubleshooting
   A. Final project
      1. Schematic diagram of project from a word description
      2. Set up the project
      3. Working circuit demonstration
      4. Show measurement skills
         b. Ohm meter
         c. Volt meter
         d. Amp meter
         e. Oscilloscope
         f. Function generator
         g. Power supply

II. Collect data
   A. Microsoft Office products
   B. Report

III. Bugs placed in circuit
   A. Switches open/closed

IV. Troubleshoot
   A. Correct procedure
   B. Document procedure

V. Replace components

VI. Retest circuit

VII. Report

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