



**TRAIL
LIFE
USA**

Electrical Engineering

Name _____

Do requirement 1

- _____1. Explain the conventional and electron flow theories for current. Explain how Ohm's law is used to solve for each V, I, and R. Ohm's law is $V = IR$, where V is voltage in volts (V); I is current in amps (A); and R is resistance in ohms (Ω)

Do eight requirements (2-31) with at least two each from the first three topics

(Electricity and Magnetism, Energy Storage and Power Conversion, and Projects)

Electricity and Magnetism (Do at least two)

- _____2. Explain the differences in series and parallel circuits and do the following:
- _____a. Draw circuit diagrams showing the difference between series and parallel circuits.
 - _____b. Build the circuits using low voltage direct current (DC).
 - _____c. Measure DC voltage, current and resistance of the two DC circuits using a multimeter.
 - _____d. Under appropriate adult supervision, safely measure wall outlet voltage (rms VAC).
- _____3. Construct an electromagnet and do the following:
- _____a. Test how many paper clips or washers you can pick up with different configurations constructed by varying:
 - Number of turns or length of coil
 - Battery voltage or batteries in series to increase DC voltage across the coil
 - Battery size, type, or batteries in parallel to increase the DC current in the coil
 - _____b. Explain the results of your tests.



- _____c. List ways you could improve your device.
- _____4. Speakers are electromagnetic devices. Under appropriate adult supervision, hook up speakers to a home stereo system and explain the following:
- _____a. Why there are two wires for each speaker and why is one marked or shaped differently.
- _____b. Changes to the speaker operation when the wires are reversed.
- _____5. Lead a younger patrol in the following static electricity experiment:
- _____a. Inflate several balloons.
- _____b. Rub one of the balloons on your hair and then slowly pull it away from your head.
- _____c. Have someone else observe what happens. Explain what is happening.

Energy Storage and Power Conversion (Do at least two)

- _____6. Learn the basic electro-chemical technologies behind the following batteries, their energy densities (Wh/kg) and other advantages and disadvantages they have when compared.
- Nickel-cadmium (NiCd)
 - Nickel-metal hydride (NiMH)
 - Lithium-ion (Li-ion)
 - Lithium polymer (LiPo)
- _____7. Under appropriate adult supervision, locate the battery under the hood of a vehicle and do the following:
- _____a. Identify the positive (+) and negative (-) terminals.
- _____b. Explain how the battery gets recharged while the engine is running.
- _____c. Explain how the vehicle continues to run if the battery is disconnected.
- _____8. A typical mobile device comes with a power brick for charging that is powered by household alternating current (AC). The simplest power brick is a transformer-based AC/DC converter made up of at least a transformer, a rectifier, and an output filter. Do the following:
- _____a. Describe the difference between AC and DC.

- _____b. Explain the three basic functions: transformer, rectifier, and output filter.
- _____c. Explain why the power brick gets warm during use.
- _____d. Copy the input and output specifications from the back or side of the power brick and compute the power loss of the brick.
- _____e. Using a multimeter under appropriate adult supervision, safely measure the DC output voltage (open circuit) of an inexpensive power brick. Explain why it is higher than the listed output voltage.
- _____9. Learn and explain to your unit how electric motors and generators work. Explain how car alternator produces AC current and how it's converted to DC. Explain this by drawing an AC current wave and an AC rectified DC waveform.
- _____10. List the most common methods we use to generate electricity. Describe what natural resources and mechanisms are used and the advantages and disadvantages of each. List several new technologies that are being used compared to 100 years ago.
- _____11. Lead a younger patrol in the following activities:
 - _____a. Replace batteries in a device using the "+" and "-" symbols to position the battery.
 - _____b. Discuss the common battery sizes (AA, AAA, 9V, C, D) shapes and names. Give examples of where you might use each type and how to safely store them.

Projects (Do at least two)

- _____12. Build a circuit containing a battery made from a lemon or potato. List ways you could improve your device.
- _____13. Build a solar powered circuit from scratch or a kit from a hobby store. Experiment with different light sources and document your experimental results.
- _____14. Build a wind-powered circuit from scratch or a kit from a hobby store. Experiment with different wind speeds and document your experimental results.
- _____15. Describe a breadboard and a printed circuit board (PCB). Then do the following:
 - _____a. Explain the uses of each and which requires soldering.

- _____b. Explain the different types of soldering tools, solder, the use of solder flux, and proper temperature control.
- _____c. Demonstrate how to correctly solder an electrical solder joint and solder a circuit element onto a PCB.
- _____16. Identify the electronic symbols for battery, switch, ground, resistor, capacitor, inductor, diode, light-emitting diode (LED), transistor, and integrated circuit. Then do the following:
 - _____a. Use the resistor color code to determine the resistance of three resistors.
 - _____b. Using a multimeter, measure the resistance value of those three resistors and compare your measured results to the coded value.
 - _____c. Draw a schematic of a simple electronic circuit that includes a battery, switch, LED, dynamic element (capacitor or inductor), and a nonlinear element (diode or transistor).
 - _____d. Describe the flow of electricity with the switch on and off.
 - _____e. Build your circuit and explain the results.
- _____17. With a breadboard and logic chips, design and build a half-adder or digital counter.
- _____18. Using a kit from a hobby store or equivalent, build a working control or timer circuit.
- _____19. Using a kit from a hobby store or equivalent, build a working audio amplifier.
- _____20. Using an Arduino microcontroller, make an electronics project of your choice that is approved by your Mentor.
- _____21. Make an electronics project of your choice that is approved by your Mentor.

History

- _____22. Create and give a small presentation to your patrol discussing Benjamin Franklin and Thomas Edison and their contributions to electricity.
- _____23. Learn about the “war of currents” between George Westinghouse, Nikola Tesla and Thomas Edison and explain the following:
 - _____a. The different powers systems and the pros and cons of each
 - _____b. The purpose and use of rectifiers during this time

- _____ 24. Read about Michael Faraday and his contributions to electromagnetism and do the following:
- _____ a. Build a simple homopolar motor and explain how it works and draw a diagram showing the magnetic fields to your patrol or unit.
 - _____ b. Explain how a Faraday cage works and how a microwave uses this technology.
- _____ 25. Research two famous engineers in electrical or electronics engineering and report what engineering degrees these engineers earned, their major accomplishments, and what organizations they led or for which they performed significant engineering.
- _____ 26. Create and present a video or presentation to your troop, unit, or other group about the first light bulb including the history, technical challenges, and impact to life.
- _____ 27. Create and present a video or presentation to your troop, unit, or other group about the first telephone including the history, technical challenges, and impact to life.

Professional Activities

- _____ 28. With a parent, attend a meeting of a local professional engineering society related to electrical or electronics engineering. List any scholarships or special opportunities for youth and young engineers that the Society may sponsor.
- _____ 29. Modern electrical or electronics engineering specialties include agricultural, aerospace, biomedical, computer, control systems, electrical, electronics, industrial, materials, nuclear, power systems, software, and systems engineering. Choose two specialties you have not used for another Science and Technology Trail Badge and do the following:
- _____ a. Describe what type of work is done in those two engineering specialties and how the work of those two specialties is related.
 - _____ b. Choose one specialty, and explain the education, training, and experience required to serve successfully in that profession.
- _____ 30. Note: This requirement is listed in multiple Trail Badges, but may only be used for one Trail Badge. Explain what it means to be an Engineer Intern and a Licensed Professional Engineer. List the requirements to become a Licensed Professional Engineer in your state.

_____ 31. Note: This requirement is listed in multiple Trail Badges, but may only be used for one Trail Badge. Read the Code of Ethics or Professional Conduct for Professional Engineers for your state (or NSPE Code of Ethics for Engineers if your state does not have one). One role of the engineer is providing society with accurate facts in order to make the best possible decisions.

_____ a. Explain how the code you read relates to the Trailman Oath and good stewardship.

_____ b. List possible consequences to the public if an engineer does not follow this Code.

Trail Badge Mentor Signature

Date

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