Batteries

- Batteries have Positive and Negative terminals of connection and are a source of electromotive force (EMF). **See Questions B-003-016-002 and -004 .**

Primary Cells and Secondary Cells

- A Primary cell is a battery that is designed to be used once and discarded, and not recharged with electricity and reused.

- A Secondary is a battery that is designed to used and recharged by electricity and reused many times over. A secondary cell can also be called a Storage Cell. **See Question B-0016-003**

Common types of Primary Cells (non-rechargeable)

- Alkaline, Zinc-Carbon, Lithium, Mercury, Silver-Oxide
- **See Question B-003-016-007**

Common types of Secondary Cells (rechargeable)

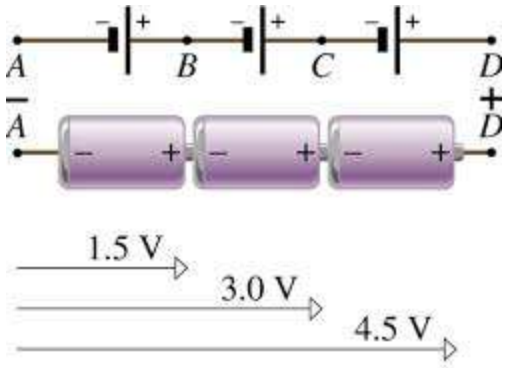
- Automotive Lead-Acid, Lithium-ion & Lithium polymer, Nickel-Cadmium, Nickel-metal hydride
- **See Question B-003-016-005**

Characteristic Voltage Potential of Batteries

Battery Type	Voltage	Rechargeable	Remarks
Alkaline	1.5	no	Moderate Energy
Zinc-Carbon	1.6	no	Cheap
Zinc-Chloride	1.5	no	Heavy duty - cheap
Lithium	3.0	no	Usually memory backup app'
Mercury	1.34	no	Banned/environmental hazard
Lead-Acid	2.1	yes	Automotive battery
Nickel-metal hydride	1.2	yes	Inexpensive rechargeable
Nickel Cadmium	1.2	yes	Capable of high discharge, current, environment hazard
Lithium Ion	3.7	yes	Expensive, very high energy density, light weight

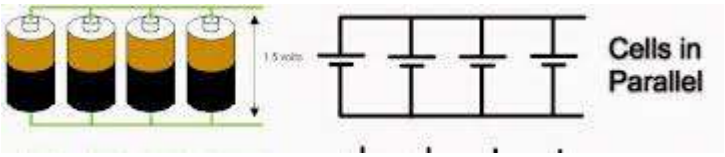
Battery with Cells in Series

- Add the individual cell voltages for total battery voltage. **See Question B-003-016-010**

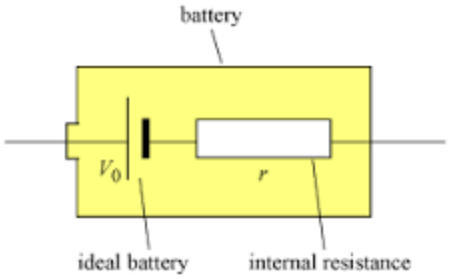


Battery will Cells in Parallel

- Total Battery voltage is that of an individual cell. Current capacity is the total of individual cell capacities added together. **See Question B-003-016-009**



- All real battery cells have some degree of internal resistance; this makes the battery terminal voltage to decrease when current is drawn. **See Question B-003-016-006**



Battery Capacity

- Battery Capacity is the amount of current it can deliver over a specified period of time. For instance, a Gel Cell rechargeable lead-acid battery may be specified at 12 amperes / hour capacity. That means, the fully charged battery should be able to deliver 12 amps into a load for an hour. To draw more current from a battery than its capacity rating means its discharge will happen sooner. **See Question B-003-016-008**

Battery Safety

- Batteries can have a great deal of stored energy. Too quick release of the energy by drawing too much current by short circuiting the battery may generate a great deal of heat (in the internal resistance of the cells) that may cause the battery to explode. Be careful and appropriately fuse all battery current delivery circuits. **See Question B-003-016-011 .**

- When charging lead-acid storage batteries, considerable hydrogen gas may be produced that vents out from the cells. Hydrogen gas is explosive; ensure the charging area is well ventilated and free of sparks or flame.

- Some batteries have an acid or caustic liquid electrolyte that may splash up into eyes while handling or installing. Ensure appropriate eye protection is worn.

- Never short circuit any battery and when charging, get the polarity right, positive on positive and negative on negative.

- Some batteries use very toxic chemistry and must be properly recycled or disposed of at a toxic waste facility.

Power Supplies and Powering your Equipment

- Most amateur radio equipment is designed to operate from a nominal 12 Volt DC power supply; this is the common automotive battery voltage available for mobile radio applications.

- When fusing the power lead connection directly from the vehicle battery, it is important to place the fuse as close to the battery as possible; in doing so, it provides protection against any possible short circuits from the insulation breaking down all along the power cable. Such a high current short circuit may cause a fire from overheated wiring. **See Question B-003-017-010.**

- Fuse protection is also important for all DC wiring you may do in assembling your amateur station. Here is a product that serves as a DC fused power distribution panel.

- For home operation, AC operated regulated power supplies are available to use with 12 Volt DC operated equipment. **See Question B-003-017-002**

- A typical moderate power transceivers used in the amateur radio service will be 50 to 100 watts RF power output and may draw in excess of 20 amperes at 12 volts on modulation peaks. **See Question B-003-017-003 .**

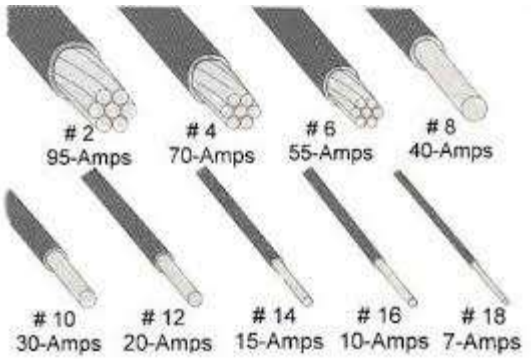
- Although amateur equipment may work at a nominal voltage of 12 volts, most power supplies provide approximately 13.8 volts DC; this is what a healthy automotive electrical system will deliver while under charge.

- Most amateur equipment will operate well and safely in a range of 11.5 to 15 volts.

- A low frequency hum on your radio transmission may indicate insufficient filtering in the AC power supply; a whine that changes pitch when operating mobile may indicate insufficient filtering of the alternator ripple voltage in an automotive installation. **See Questions B-003-017-004 and - 011 .**

- Ensure the wire conductors interconnecting the power supply to the transceiver, be they from an AC power supply or battery, be of adequate wire gauge to handle the current without significant voltage drop. **See Question B-003-017-009** *see following chart for explanation of wire gauge sizes*

An Explanation of Wire Size



- The thicker the wire, the less ohmic resistance per unit length.
- The thickness (diametre) of the non-ferrous wire is given as its American Wire Gauge (AWG) and determines it current-carrying capacity. Examples follow:
- Normal household wiring is # 14 AWG and limited to 15 amps; # 12 AWG is limited to 20 amps, # 10 AWG is limited to 30 amps and # 8 AWG is limited to 40 amps; the current is limited by the fusing or circuit breaker current rating on the circuit at the electrical circuit panel.
- Exceeding the limits of current through a conductor of a given size causes excessive voltage drop and power loss and excessive heating of the conductor due to its resistivity. The excessive heat generated in the conductor may be dangerous and start a fire.
- Wire conductors also have insulation that has a voltage rating. Do not use a voltage rating of the conductor insulation less than the voltage being carried by the circuit.

Key Operated Master Power Switch.

- It is good practice to have a key operated master power switch controlling the delivery of AC power to your amateur radio station; such an installation will ensure there is no unauthorized use of the station equipment. **See Question B-003-018-001 and -003 .**

- A simple way of preventing unauthorized use of mobile radio installation is to control the power delivery to the radio switched through the ignition switch. An alternative to this is to unplug the microphone when not in use. **See Question B-003-018-002**

- Some electrical equipment with particularly high and lethal voltages in the internal workings have **a safety interlock switch** to ensure the power is cut off when the cabinetry is opened. This is often part of vacuum tube amateur radio linear amplifiers. Ensure these safety features are maintained and not defeated. **See Question B-003-018-004 .**

- Other equipment operating off the AC mains power may not have interlocking switches when accessing inside; ensure the equipment is un-plugged when servicing unless you are well experienced and ever cautious of the shock hazard. **See Question B-003-018-011**

Electric Shock and Electrocution.

- Electric Shock is the physiological reaction or injury caused by electric current passing through the human body.

- Electrocution is death caused by an electric shock.

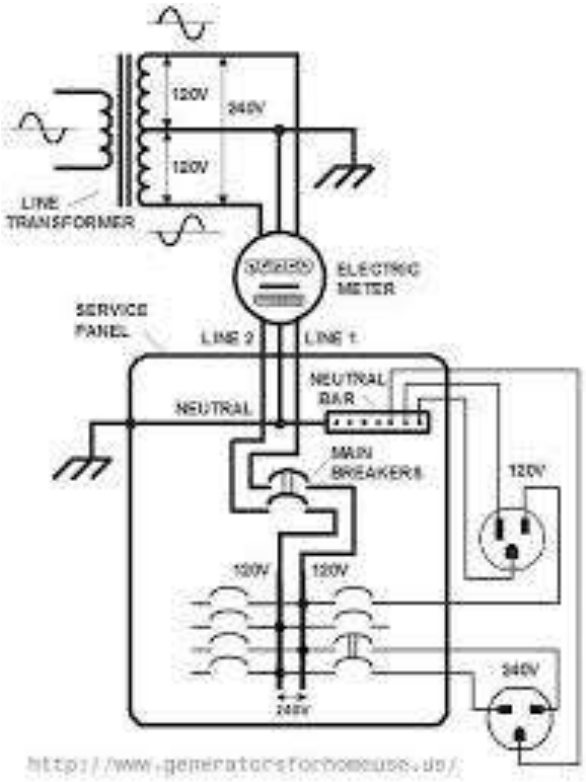
- A sustained electric shock from 60 Hz AC at as little as 20 milliamperes flowing through the torso of the body is enough cause to ventricular fibrillation of the heart and potential death. **See Questions B-003-018-005 and -006**

- Because of moderately high body and skin resistance to current flow, low voltages are considered safe. The threshold of voltage to be considered potentially dangerous of humans is 30 volts. **See Question B-003-018-007 .** However, even voltages as low as 12 or 9 volts exposed to moist skin can create a tinkling sensation.

- Body exposure to high voltage (and therefore high current) can cause significant burning and tissue damage.

- If providing aid to someone suffering electrical shock, ensure first electrifying conductors are de-energized. Failure to do this, the person providing aid may also become a victim. **See Questions B-003-018-008 and -009**

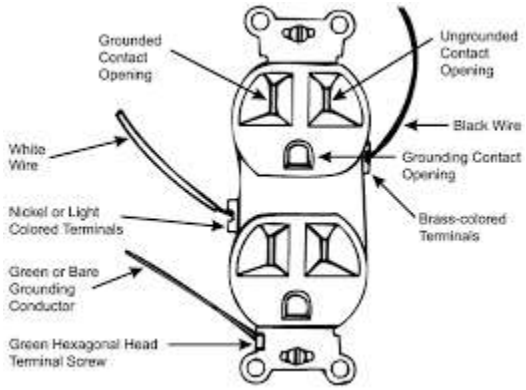
<u>Residential house current distribution wiring</u>



- Grounding of the electrical panel is by way of city water underground delivery pipes. **See Question B-003-019-002**

- Grounding, if no city water delivery pipe is available. is typically via two 10 foot ground rods made of Copper-clad steel. **See Questions B-003-019-004 and -005**

Standard Duplex Outlet



- In residential wiring, the bare copper wire is ground; this connects to the grounding bar in the electrical panel which is connected with # 8 wire to the grounding water pipe or grounding rods. The bare ground wire connects to the green coloured lug on the receptacle and the rounded socket hole for the plug.

- The white insulated copper conductor is the Neutral and connected to the neutral bar in the electrical panel; this in turn is connected to the grounding in the panel. The white Neutral wire is connected to the wide blade side of the electrical plug. There should be no electrical shock hazard touching the white neutral wire because it is at ground potential.

- The black (or red) insulted copper wire is Hot relative ground potential and is connected to the circuit breaker in the electrical panel and connects to the narrow blade of the receptacle. There is definite shock (or electrocution) hazard coming in contact with the black conductor.

- Equipment power electrical cords also usually have BLACK and WHITE wires that polarize with the HOT narrow and NEUTRAL wide blades of the plug respectively.

- The GREEN insulation always denotes the "ground" conductor in a power cord and is connected to the third "U" shaped prong of the power plug.

- The green wire of the power cord at the equipment end is always connected to the metallic chassis and cabinet; this prevents any chance of the cabinet becoming "hot" with electricity relative to ground. Any short circuit of "hot" AC potential will be conducted to ground and trip the circuit breaker at the electrical panel. **See Questions B-003-019-006, -010 and -011**

- **<u>Ground Fault Interrupter (GFI) receptacle</u>**. This type of AC power receptacle (or circuit breaker) is mandated for washrooms, outside receptacles and now kitchens (within 30 inches of the sink). Their purpose is to prevent shock injury in wet areas. They use a sensitive electronic circuit that monitors the current on both blade sockets of the receptacle when something is plugged in. All is normal when the current in the Hot and Neutral sides of the circuit is the same. However, if the Hot side indicates more current flow than the return Neutral side, there may be current leakage from the appliance into and through the person using it. If leakage exceeding 5 milliamp differential occurs, the internal switch to the GFI opens cutting the circuit within 300 milliseconds saving the person from shock and electrocution. It may be a good idea to have an amateur radio station powered through a GFI protected circuit. However, some GFI receptacles have been known to cause RFI (radio frequency interference), or be sensitive to invalid tripping from the same.

Charged Capacitors can Shock You!

- Large electrolytic capacitors are designed to store electrical energy and are typically used in power supplies to filter the pulsating DC following the rectifier. After the power supply is turned off, and even unplugged, the filter capacitors may still retain a charge of electricity. **Be careful**, if it is a high voltage power supply, **the charge on the capacitors may be lethal.** In a good power supply design, there will be a **bleeder resistor** that gradually drains the charge from the capacitors and all should be safe in a short period of time; but if in doubt, check the voltage across the capacitors carefully to see if all is safe before servicing.

Inductive Reactance of Long Station Grounding Conductors.

- It is a good practice to ground all amateur equipment to a common grounding bar which in turn is grounded to water pipes of the house or more ideally, to grounding rods in very close proximity to the station location within the premises.

- If the conductor connecting the equipment to the point of grounding is a significant length, although providing a good electrical ground (to power line AC), **it may not be a good Radio Frequency (RF) ground due to the relatively high inductive reactance of the long grounding wire.** Thus with some antenna system configurations (such as end fed long-wire antenna operation), the station equipment may have significant RF potential while transmitting and potentially this may cause problems with RFI and/or an RF tickling sensation to the operator

when transmitting. This is usually not a problem when using well matched antennas fed with balanced line or coaxial cable**. See Questions B-003-019-007 and -009**

Static discharge and Lightning Protection

- A radio tower that is well grounded directly at the base on the ground with several ground rod is probably the best way to protect your house from damage; however, even so, a direct hit has such high current flow, some damage is still very likely.

- **Protection** from incidental damage from nearby lightning strikes and activity; however, is much more practical to undertake and should be part of any amateur's practice when lightning storms threaten.

- It is good practice to disconnect valuable amateur radio equipment from antennas and power lines when there is lightning activity. Under such conditions, high voltages can be inducted in the antenna system and feed line thereby damaging sensitive front end receiver components. And even nearby strikes can induce damaging voltages in the AC power lines. It has even been experienced that high static voltages can be induced in antennas when dark clouds go by (with no lightning) damaging the front end solid state devices on poorly designed equipment. Antennas such as dipoles are especially vulnerable to static voltage build-up since there is inherently no DC path across the transmission line conductors and conduction to ground. A one-to-one voltage BALUN will solve this potential problem.

- For added protection, there are **lightning arrestor** products available for coaxial cables made by **PolyPhaser**. For maximum protection, these should be installed outside at the cable entrance to the premises where direct grounding can take place. **See Question B-003-020-002**

- Even with all the protective installation practices to lessen the effects of potential lightning and static damage, it is still wise, when storm and lightning activity is forecast, to disconnect equipment and ground all antenna and rotor cable cables and wiring. **See Questions B-003-020-001 and -003**

Tower and Climbing Safety

- The typical amateur radio tower is at least 15 metres high. Falls from towers far less high can result in crippling injuries. A fall arrest climbing belt and harness is therefore essential safety equipment when erecting and doing tower work. Such equipment must meet certain CSA standards. **See Questions B-003-020-004 and -005** *VE3LC up the tower in picture below.*

- Ensure everybody helping as part of the tower ground crew are wearing construction "hard hats" and keep attentive of work happening up the tower. Nuts, bolts or tools dropping from above hitting a person on the head can be lethal. **See Question B-003-020-007** .

- When installing any towers or masts or antennas, ensure if they topple, they will be well clear of power lines. Commercial antennas are mandated to have the following label on their product:

RF Safety, Installation and Operating Practices

- In the Regulations and Policy part of course instruction, we told about **Safety Code 6 entitled "Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz**". This is a Guideline document from **Health Canada** but is mandated by Industry Canada to be followed by all manufactures and operators of radio equipment including Amateur Radio. The Industry Canada document that mandates this for Amateur Radio operations in this respect is contained in CPC-2-0-03. You should have a copy as part of your student study material.

- In practical terms, there are a number of exam questions that must be addressed on the topic of RF exposure.

- Ensure your wire antennas have all elements and open wire feed lines well out of reach of anybody touching or coming near. When transmitting, there are high RF voltages on RF conducting wires that can cause RF burns. **See Questions B-003-020-008, -009 and B-003-021-011**

- Before making repairs on antennas and feed lines, ensure the transmitting equipment is disconnected from AC power and feedline. **See Question B-003-020-010 .**

- Ground level mounted antennas should be installed with fencing around to ensure no one can come in contact with it**. See Question B-003-020-011 .**
- UHF Yagi and Microwave dish antennas can concentrate a high intensity RF field at close proximity. Ensure the general public has no access to where these antennas are installed. And, when working in the area of a transmitting antenna, keep clear of the front side of antennas; your eyes are particularly sensitive to the heating effects of RF energy. **See Questions B-003-021-001, -002, -006 -007 and -008 .**

- When working on VHF and UHF transmitting equipment, it is important not to operate with the cabinet shield removed, especially enclosing the RF power amplifier section. Besides the danger of electrical shock, there can be considerable RF energy that can radiate out posing a RF exposure risk. **See Question B-003-021-003 .**

- All antennas installed in a premises should be located as far away as possible from living spaces. **See Question B-003-021-010** .

- When operating a portable hand held radio, in order to minimize RF radiation exposure, it is good practice to keep the transmitting antenna away from your head by several inches and minimize the transmit duty cycle to ensure you are never transmitting any more that 50 % of the time and preferably a lot less in any 6 minute period. **See Questions B-003-021-004 and -005**