



## 9. SAFETY

### Chapter 9.1-9.5

Electrical safety

RF exposure, safety & interference

Mechanical safety





# Electrical safety

Too much current and/or voltage may:

- Hurt/be dangerous to you
- Hurt/be dangerous to others
- Damage equipment
- Cause a fire
- Violate laws

Some possible causes:

- Human error
- Circuits touching
- Power transients
- Lightning
- RF feedback
- Bad design or implementation



# Electrical safety

Electrical CURRENT through the body can:

- Disrupt the function of cells
- Cause muscle contractions
- Heat up/burn tissue

**Table 9.1**

**Effects of Electric Current in the Human Body**

<i>Current</i>	<i>Reaction</i>
Below 1 milliamperere	Generally not perceptible
1 milliamperere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6-25 milliamperes (women) 9-30 milliamperes (men)	Painful shock, loss of muscular control*; the freezing current or "can't let-go" range.
50-150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1000-4300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

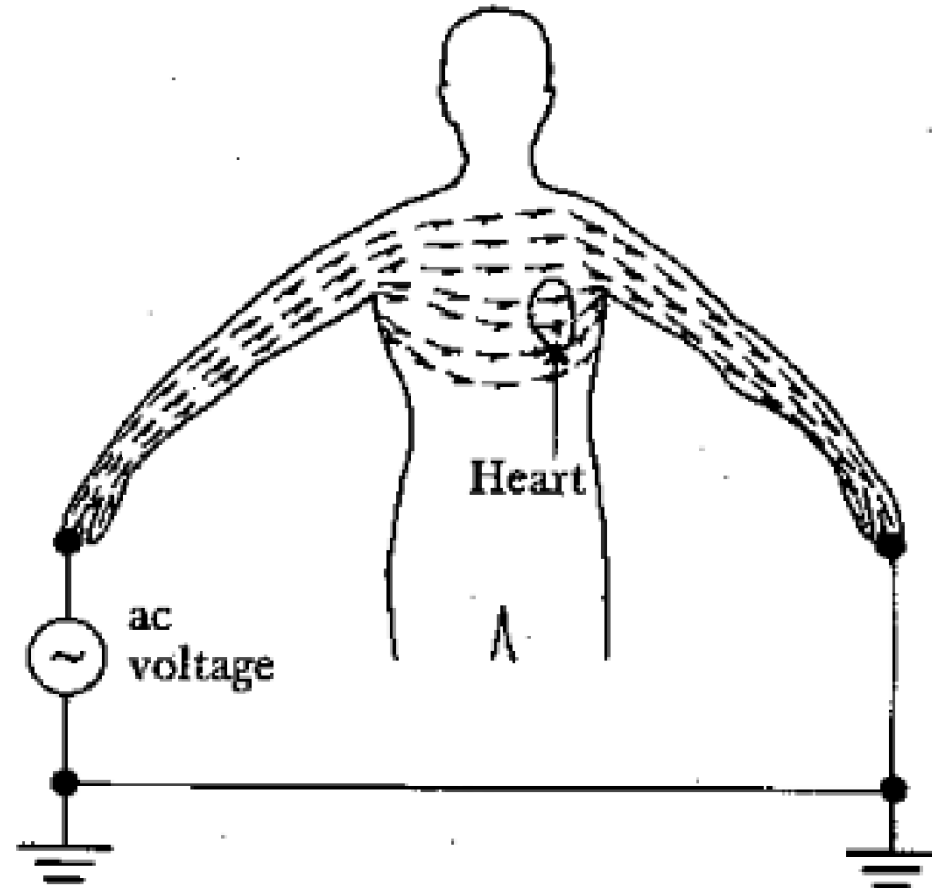
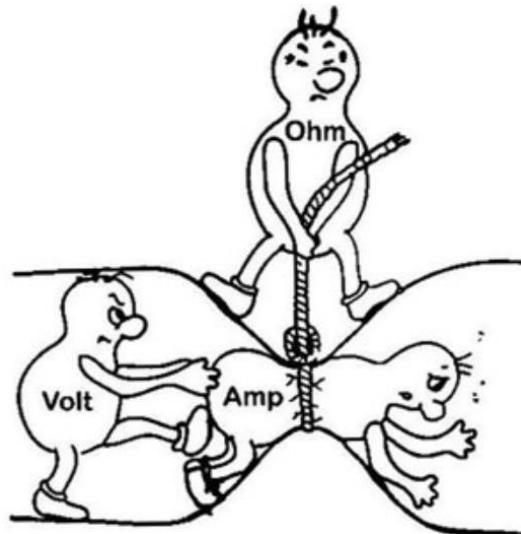


# Electrical safety

Ohms law applies :  $I = V / R$

Dry skin is a bad conductor, but moisture changes that dramatically

Example:  $50V / 10000 \text{ Ohm} = 0.005A$



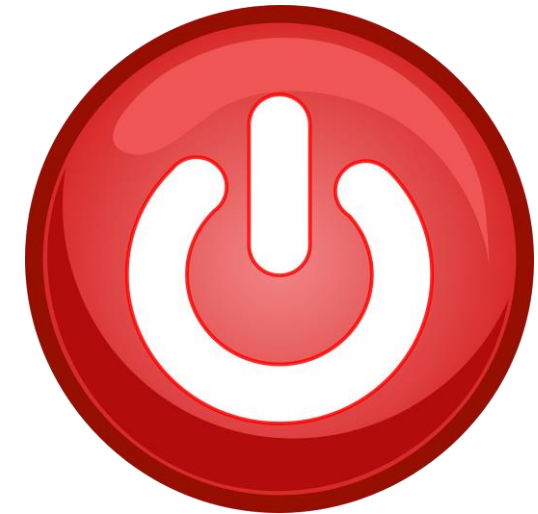


# Electrical safety

Turn power **OFF** when working on circuits

If you have to work on live circuits (don't) :

- Keep one hand in your pocket
- Wear insulating shoes
- Never bypass a safety interlock during testing
- Make sure capacitors are discharged
- Keep metal objects clear of storage battery terminals
- Avoid working on equipment with the battery connected
- Remove unnecessary jewelry from your hands
- Avoid working alone





# Fuses, Breakers and Ground Fault Circuit Interrupters

**Fuses** break the circuit if there is excessive current

**Breakers** can be reset and used again

**GFI/GFCI's** detect current imbalance



NOTE: Fuses and Breakers does **not** protect **you**



# Safety ground

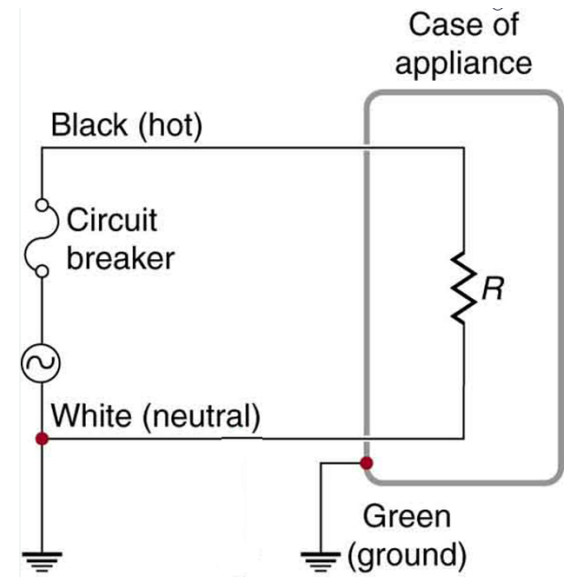
The **safety ground** is a direct connection to the power system's ground.

The purpose of safety ground is to ensure the fuse/breaker trips

Guidelines:

- Use three-wire power cords and plugs
- Make sure all equipment has a connection to the ground
- Verify AC wiring is done properly
- Never replace a fuse or circuit breaker with one of a larger size
- Don't overload single outlets

Use ground fault circuit interrupter (GFCI) circuit breakers/outlets



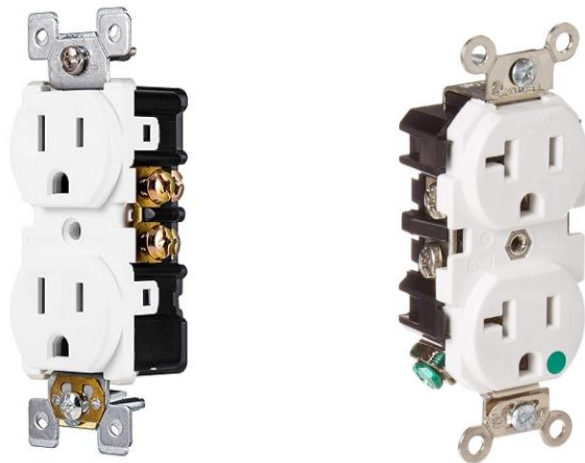


# Wiring standards

NEC standard :

- Hot = Black (Red)
- Neutral = White
- Ground = Green

#14 AWG wire, max 15A breaker  
 #12 AWG wire, max 20A breaker



US "AC" WIRING COLOR CODES "NEC"			
PHASE SUPPLY	WIRE & CABLE	US "NEC" ( 120, 208 & 240V )	US "NEC" ( 277 & 480V )
3-PHASE	LINE 1 "L1"		
	LINE 2 "L2"		
	LINE 3 "L3"		
COMMON	NEUTRAL "N"		
GROUND / EARTH "PG" <small>www.electricaltechnology.org</small>			
1-PHASE	LINE "L"		*

\* Use this in case of a Second Hot Wire i.e. in Single Phase, Two Lines 240V AC System.



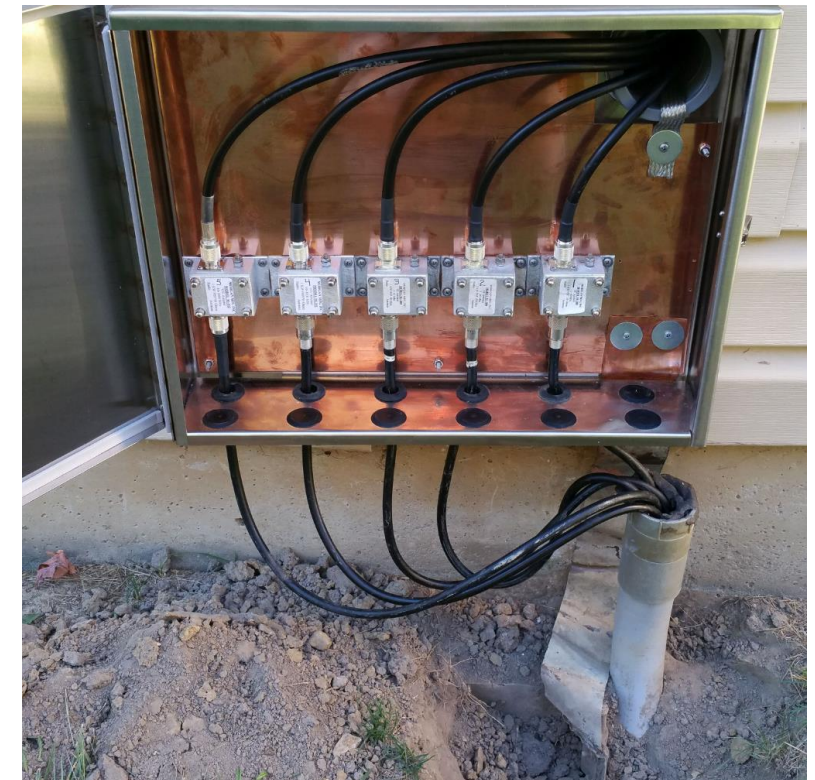
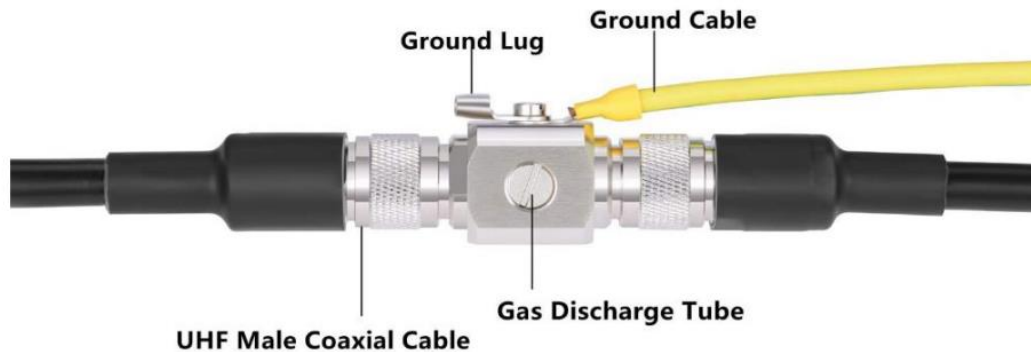


# Lightning protection

Intended to avoid fire, and attempt to protect equipment

## Guidelines:

- Use short, large diameter conductors
- Provide a direct path to ground – avoid sharps bends
- Bond earth connections together
- Local building & electrical codes apply
- Lightning arresters should be at the entrance to the building





# RF safety

Antennas and feedlines work as transformers.  
High voltages may be present at multiple places in the system

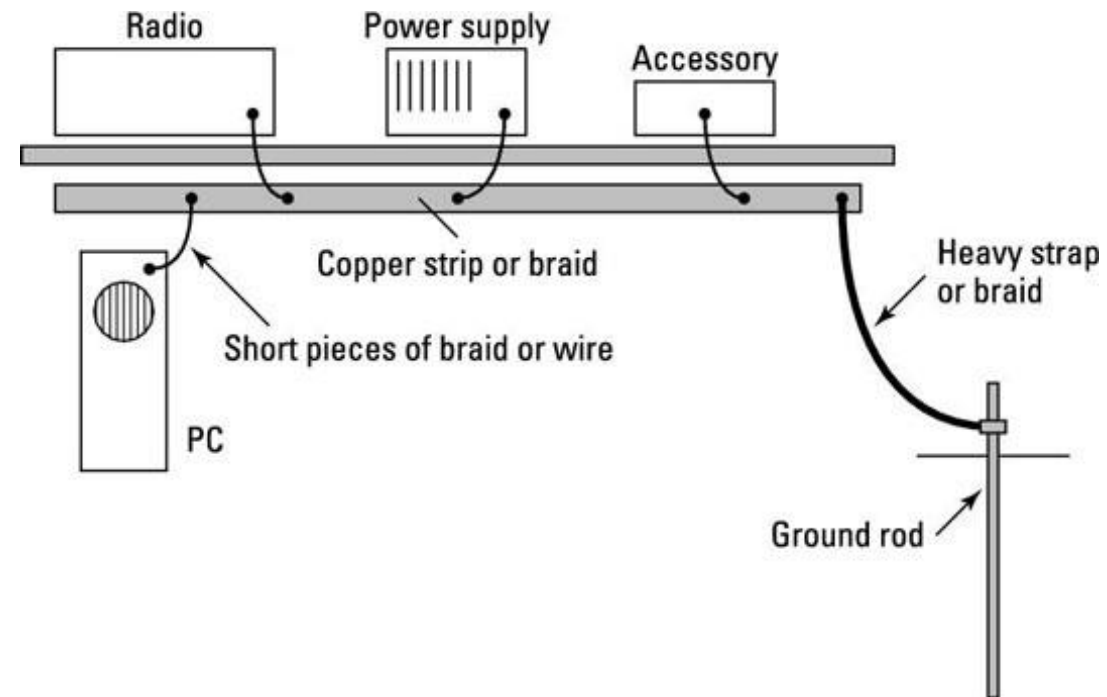
RF energy may be reflected back into the equipment

RF current may cause burns

All wires will pick up some RF energy and may cause interference on audio and data

## RF grounding

- Bond equipment together with short, wide straps
- Keep connections short
- Avoid loops
- Single, short connection to real ground





# RF exposure

RF energy is non-ionizing, but may be absorbed by objects & the body

Some frequencies are more absorbed by the body than others

## **MPE** depending on **AVERAGE**

- Proximity
- Radiation pattern
- Power
- Frequency
- Duty cycle (mode)
- Time

FCC OET Bulletin 65, Model or Measure

<https://www.arrl.org/rf-exposure-calculator>

### **CONTROLLED ENVIRONMENT**

Where all are aware of, and can take steps to, minimize exposure.

### **UNCONTROLLED ENVIRONMENT**

Areas open to general public, neighbors etc.



# RF exposure limits

## Controlled Exposure (6-Minute Average)

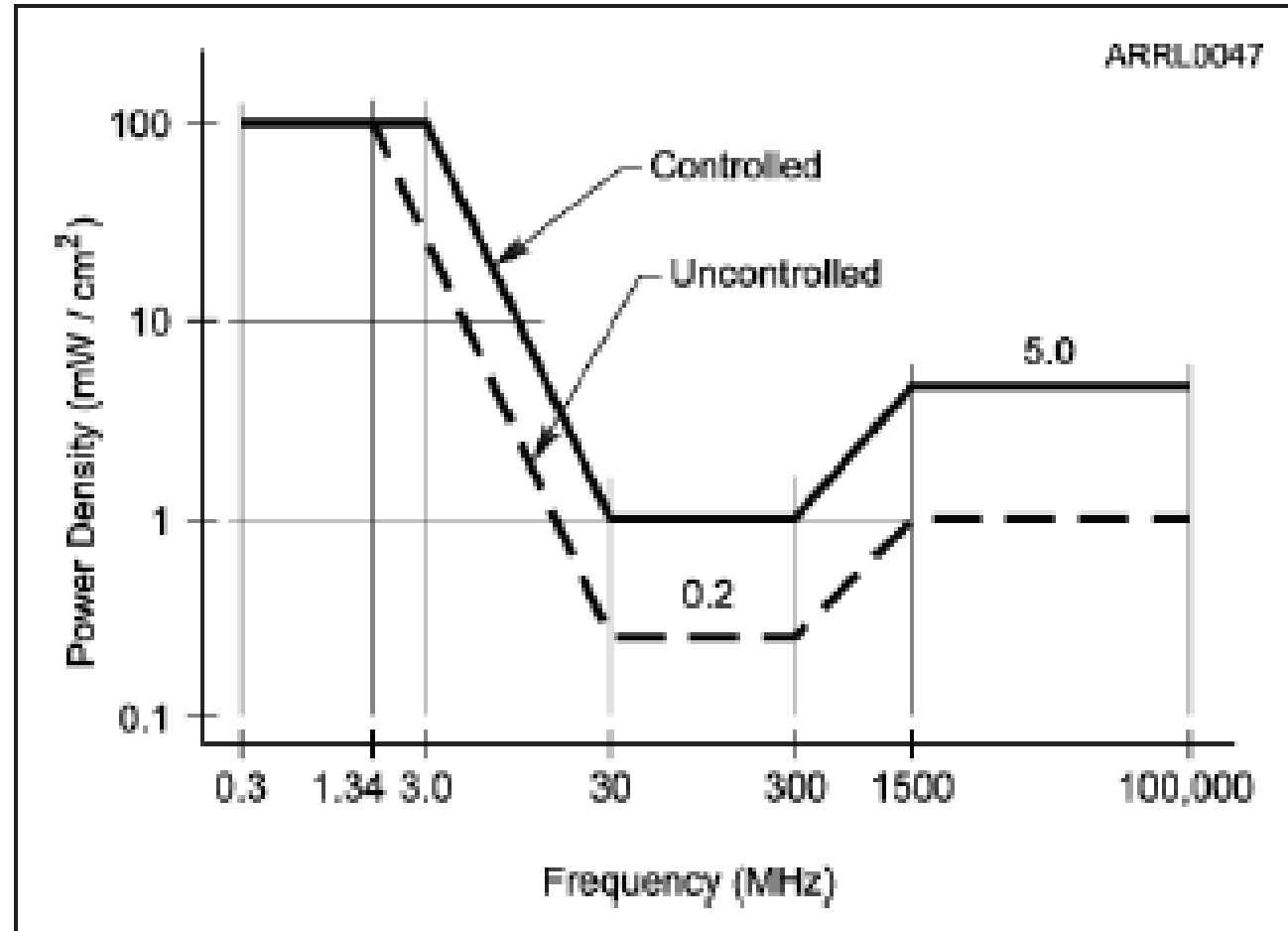
Frequency Range (MHz)	Power Density (mW/cm <sup>2</sup> )
0.3-3.0	(100)*
3.0-30	(900/f <sup>2</sup> )*
30-300	1.0
300-1500	f/300
1500-100,000	5

## Uncontrolled Exposure (30-Minute Average)

Frequency Range (MHz)	Magnetic Field Power Density (mW/cm <sup>2</sup> )
0.3-1.34	(100)*
1.34-30	(180/f <sup>2</sup> )*
30-300	0.2
300-1500	f/1500
1500-100,000	1.0

f = frequency in MHz

\* = Plane-wave equivalent power density





# RF exposure mitigation

- Locate antennas away from where people can get close to them
- Raise the antenna
- Avoid pointing beam antennas where people are likely to be
- Use a lower gain antenna to reduce radiated power density or reduce transmitter power
- Limit the average power of your transmissions
- Place mobile antennas on the roof or trunk of the car (maximizes shielding)
- Use a remote microphone to hold a handheld transceiver away from your head



# RF interference

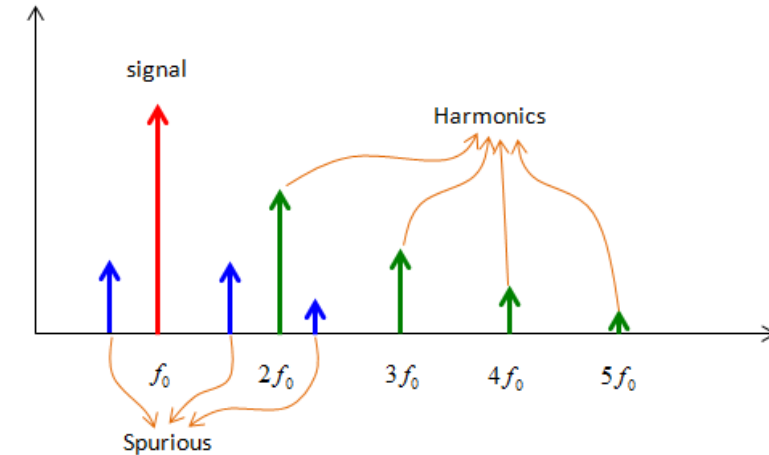
RFI is caused by

- Fundamental overload
- Harmonics
- Spurious emissions

Strong signals may overwhelm a receiver even if they are out of band.

A high pass filter on the antenna input of the receiver may help attenuating the amateur HF signals.

Broadcast reject filters attenuate signals from AM/FM/TV stations.





# RF interference

## Shielding / Shielded wire

- Keep small signals from being affected (microphone cables)

## Filters

- Prevent unwanted signals from being radiated
- Keep unwanted signals from being received

## AC power line filters

## Specialized band pass/reject or high/low pass

## Ferrite chokes

## Getting complaints?

- I. Make sure you don't have an issue
- II. Help your neighbor







# Mechanical safety

Check local zoning codes or restrictions in your deed/lease

Stay clear of power lines

- Minimum **10 ft clearance** is something falls

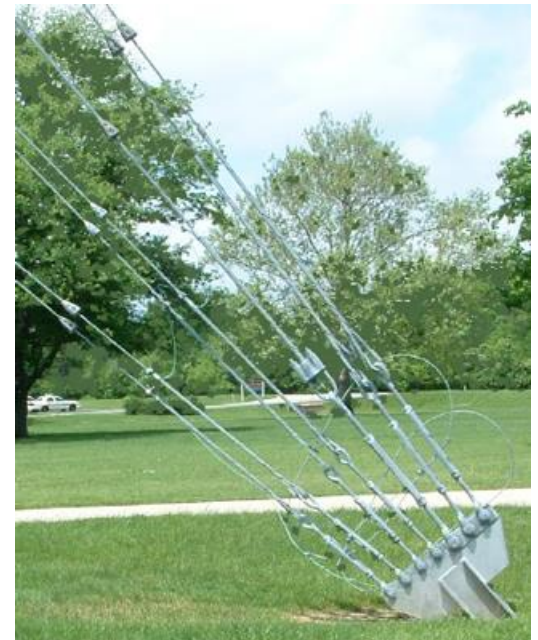
Never attach antennas or guy wires to **utility poles**

- Risk of contact with power lines

Follow **local electrical code** for grounding

Ground each leg of **tower with separate 8ft rod** & bond to each other

Run **safety wire through turnbuckles** to avoid loosening







# Tower work & Climbing safety

Get training!

Use appropriate gear & use tie-off at all times

Never climb a crank-up tower (unless retracted/locked)

Do not climb alone

Stay clear of power lines





**DONE! TEST TIME!**

**Monday, June 3, Auburn**  
register @ [hamstudy.org](https://hamstudy.org)