

Radio Frequency Interference Unit Objectives

I. *Brief Introduction to Radio Astronomy*

II. *Electromagnetic Radiation Basics*

- Understand the nature of electromagnetic radiation
 - Speed of light $c = 3 \times 10^8$ m/s
 - Light can travel in vacuum unlike sound waves
 - Not all light is visible e.g. infrared, radio, x-rays
 - Emphasis on the fact that visible light and radio waves are both forms of electromagnetic radiation.
- Understand and correctly label parts of a transverse wave and longitudinal wave
- Produce transverse and longitudinal waves using a slinky. Observe constructive and destructive interference.
- Understand relationship between wavelength, frequency, and wave velocity.
 - $v = f \lambda$
- Perform calculations of wavelength given frequency and calculate frequency given wavelength for light.
 - Qualitatively understand parts of the electromagnetic spectrum from longest wavelength to shortest wavelength
 - *Radio waves*
 - *Microwaves*
 - *Infrared*
 - *Visible*
 - *Ultraviolet*
 - *X-rays*
 - *Gamma rays*
 - Opportunity to apply knowledge of scientific notation
 - Practice calculations using $v = f \lambda$
- Demonstrate a qualitative understanding of photons
- Understand Planck's energy relation $E = h f$ ($h = 6.026 \times 10^{-34}$ J s). Explain how higher energy processes correspond to higher frequencies of light and lower energy processes correspond to lower frequencies of light.
- Compare and contrast light waves and sound waves.

III. *Bandwidth Basics*

- Investigate where AM, FM, UHF and VHF frequencies are located in the radio spectrum using the AR-3000A by matching frequencies.
- Create a bandwidth allocation chart of AM, FM, UHF, VHF from data obtained from investigation.
- Students will compare their charts obtained by experimentation to the official United States Frequency Allocations of the Radio Spectrum. (have poster)

IV. *Antenna Basics*

- Students will identify some basic antennas including...
 - Yagi antenna
 - Discone antenna
 - Long wire antenna
 - Parabolic reflector antenna
 - VLF Loop Antenna
- Investigate radio waves from the Sun using the Yagi antenna, Discone antenna and long wire antenna connected to the AR-3000A Communications Receiver.
 - Determine which antennas are directional and which are non-directional by pointing them to the Sun and then away.
 - Identify the frequency where each antenna measures the highest power flux from the sun.
 - Compare power flux vs. frequency for different antennas of the same kind.
- Understand resonance and how antenna length is related to the optimal wavelengths (frequencies) for reception.
 - Compare an optimal AM antenna to an FM antenna.
 - Explain how AM signals are detectable by short antennas.
 - Explain how optimal antenna length is often unnecessary to receive a good signal and under what circumstances.
- Students will make a crude antenna map using the whip, Yagi and Discone antennas. (power vs. azimuth) These crude maps will then be compared to actual antenna pattern from Kraus' Radio Astronomy or other antenna manual/reference.
 - Students are encouraged to try to detect these smaller lobe patterns.

- Pringle Can Wireless Antenna
 - Detect microwaves using Pringle Can Antenna
- Use VLF Loop Antenna to detect radiation emissions from power lines.
- Using the SRT, perform an *npoint* scan of the Sun. Explain the results of the npoint scan to the class. Discuss sky temperature, solid angle, frequency, power flux. Calibrate the SRT and explain the importance of calibration for observations in astronomy.
 - Compare the performance of the Discone antenna to the SRT at the same frequencies.

V. *Receiver/ Transmitter Basics*

- Construct a simple radio receiver and hear transmissions using this device.
 - Simple radio receiver: antenna, head phones, diode, ground wire and spike.
 - Construction of other simple radios (optional)
- Attempt identification of transmission source.
 - Determine frequency/wavelength of transmission source if possible and investigate relationship between receiver length and wavelength of source.
 - Discuss the phenomena of **resonance** and how it is related to receiver design.
- Demonstrate the simplest possible transmitter. Static can be transmitted a distance of a few inches and can be detected by an AM receiver tuned to an empty channel. Explain the physics behind how this transmitter works (changing current → accelerating charges). Explain why the static is strongest the instant the nickel taps and disappears or reduces afterwards.
- Construct a simple transmitter and transmit signals to be detected with the detector receiver mentioned earlier.

VI. *Signal Propagation Effects*

- In the evening, students will find the most remote AM radio station they can receive and record the station's name (frequency) and its location.
- Next day in class, students will share their findings and be asked to tune to those stations using an AM radio. Upon failure to receive these stations students will be introduced to the **scattering** of radio waves off of the **ionosphere**.

- Discuss the radio window (1 cm – 10 m) and optical window (0.4 – 0.8 microns) and its relationship to the ionosphere.
- Students will use the AR-3000A to monitor a narrow bandwidth (0.5 – 1 kHz) encompassing the remote AM stations for 24 hours and interpret the results.
- Students will be able to explain how it is possible to detect a thunderstorm occurring on the opposite end of the Earth with an essay including a diagram.
- Students will investigate space weather and how it can affect transmissions.
Recommended resource: www.spaceweather.com