LECTURE:2

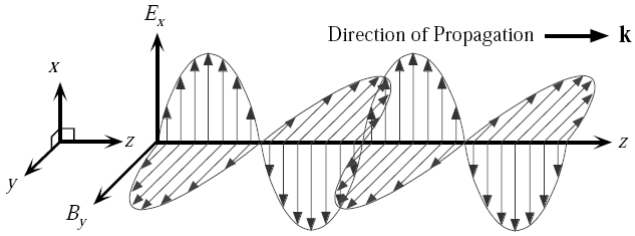
ELECTROMAGNETIC SPECTRUM

ELECTROMAGNETIC SPECTRUM

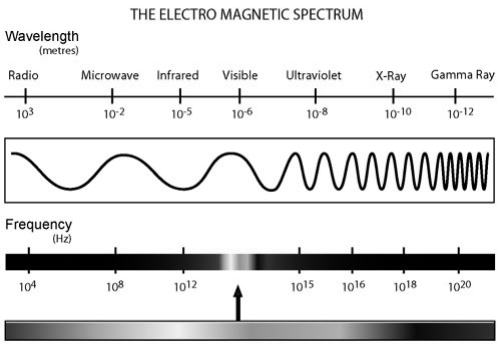
- **Electromagnetic waves:** In an electromagnetic wave the electric and magnetic fields are mutually perpendicular. They are also both perpendicular to the direction in which the wave propagates or travels.
- The electric and magnetic fields oscillate together between maximum positive and maximum negative values.
- The frequency of these oscillations and the wavelength of the waves determines whether the electromagnetic wave is visible light (and its color), ultraviolet light, infrared light, radio waves, X-rays, or gamma rays

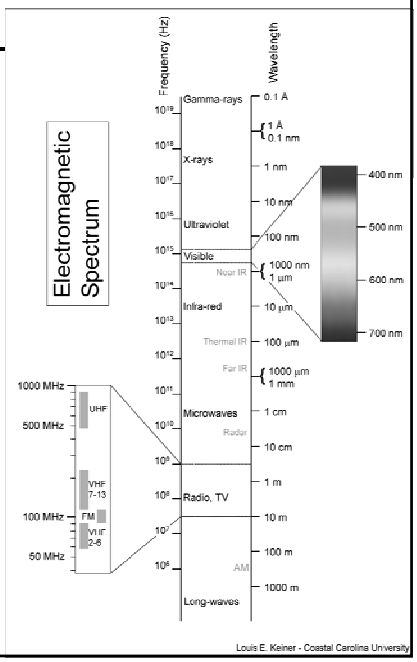
CONT'D

- Electromagnetic radiation exists in a range of frequencies called the electromagnetic spectrum.
- Each frequency has a specific wavelength and as the frequency decreases, the actual length of the wave gets longer.

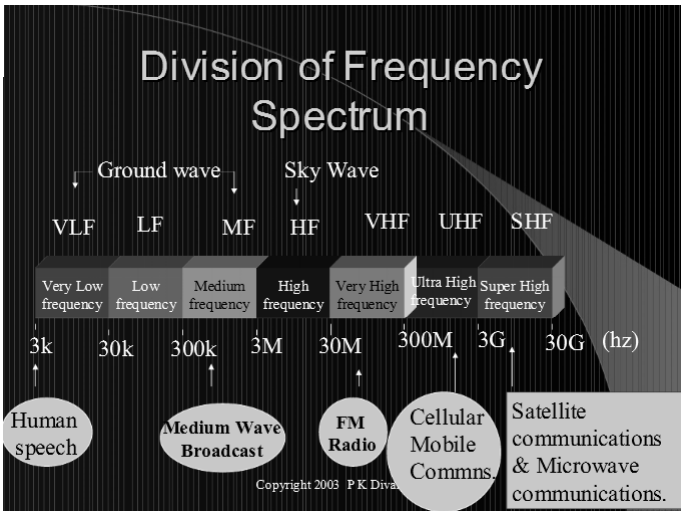


ELECTROMAGNETIC SPECTRUM





CONT'D



FREQUENCY/WAVELENGTH RELATION

- Each frequency can be specified in terms of its equivalent wavelength.
- Frequency and wavelength are directly related to the speed of light .
  - **$c=f \times \lambda$**

    c= speed of light , 3x10^8 m/s

    f= frequency (Hz)

    λ= wavelength (m)

- Visible Region:

Color	Wavelength interval	Frequency interval
red	~ 625 to 740 nm	~ 480 to 405 THz
orange	~ 590 to 625 nm	~ 510 to 480 THz
yellow	~ 565 to 590 nm	~ 530 to 510 THz
green	~ 520 to 565 nm	~ 580 to 530 THz
cyan	~ 500 to 520 nm	~ 600 to 580 THz
blue	~ 430 to 500 nm	~ 700 to 600 THz
violet	~ 380 to 430 nm	~ 790 to 700 THz

RADIO WAVES

- **Radio waves:** Radio waves generally are utilized by antennas of reasonable size.
- Their wavelengths range from hundreds of meters to about one millimeter.
- They are used for transmission of data, via modulation. Television, mobile phones, wireless networking and amateur radio all use Radio Waves.

CONT'D

- **Common Radio Bands**:
  - Extremely low frequency
  - Very low frequency (VLF) -3 kHz to 30 kHz
  - Long wave
  - Medium wave (AM)
  - Shortwave (HF or high frequency) -(3–30 MHz)
  - Very high frequency (VHF) - 30 MHz to 300 MHz
  - Ultra high frequency (UHF)- 300 MHz and 3 GHz
  - FM broadcast band, used for broadcasting FM radio stations, goes from 87.5 to 108.0 MHz

BANDS

Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3-30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30-300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz-3 MHz	Sky	AM radio
HF (high frequency)	3-30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30-300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz-3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3-30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30-300 GHz	Line-of-sight	Radar, satellite

UV (ULTRA VIOLET)

- Ultraviolet (UV) radiation is defined as that portion of the electromagnetic spectrum between x rays and visible light, i.e., between 40 and 400 nm
- Germicidal lamps are designed to emit UVC radiation because of its ability to kill bacteria

INFRARED RAYS

- Electromagnetic radiation with a wavelength between 0.7 and 300 micrometres, which equates to a frequency range between approximately 1 and 430 THz
- Its wavelength is longer (and the frequency lower) than that of visible light, but the wavelength is shorter (and the frequency higher) than that of terahertz radiation microwaves
- Military applications include target acquisition, surveillance, night vision, homing and tracking
- IR data transmission is also employed in short-range communication among computer peripherals/mobiles
- Infrared radiation can be used as a deliberate heating source-to heat the occupants, and also to remove ice from the wings of aircraft.

MICROWAVES

- Microwaves are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently.
- Frequencies between 300 MHz (0.3 GHz) and 300 GHz
- Microwaves are used in television news to transmit a signal from a remote location to a television station from a specially equipped van
- Radar uses microwave radiation to detect the range, speed, and other characteristics of remote objects
- A microwave oven passes (non-ionizing) microwave radiation (at a frequency near 2.45 GHz) through food, causing heating by absorption of energy in the water, fats and sugar contained in the food

X-RAYS

- **X-RAYS**
  - + Wavelengths: 10 to 0.01 nm
  - + They are shorter in wavelength than UV rays and longer than gamma rays
  - + X-rays have smaller wavelengths and therefore higher energy
  - + Frequency Range (10^{16} Hz to 10^{19} Hz)
  - + X-rays can penetrate solid objects
  - + **Use:** *X-rays* are high energy waves which penetrate through skin and muscle to produce an image of the skeleton on a photographic film

GAMMA RAYS

- Gamma rays typically have frequencies above 10^{19} Hz (10^{-10} to 10^{-15}) m
- Gamma-rays have the smallest wavelengths and the most energy of any other wave in the electromagnetic spectrum.
- Gamma-rays can kill living cells, a fact which medicine uses to its advantage, using gamma-rays to kill cancerous cells.
- Due to their tissue penetrating property, gamma rays/X-rays have a wide variety of medical uses such as in CT Scans and radiation therapy

VOICE BAND

- Voice frequency 300Hz-3400Hz
- Human ear receiving frequency 20Hz-20Khz.