

ECE 215 Spring 2025

Objective 3.3:
Antennas

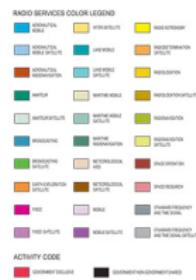


Objective 3.3

I can calculate the signal wavelength, antenna size, max antenna gain, and basic gain pattern for dipole, monopole, and parabolic dish antennas.

RF SPECTRUM BANDS

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM



CONFIDENTIAL

ASSOCIATION FOR ASIAN STUDIES

Brother F. W. D. Taylor Letters



RF SPECTRUM BANDS

3 kHz	30 kHz	300 kHz	3 MHz	30 MHz	300 MHz	3 GHz	30 GHz	300 GHz
VLF	LF	MF	HF	VHF	UHF	SHF	EHF	

Example: Ground Penetrating Radar (GPR)

Typical Applications:	Concrete Scanning	Voids	Utility Locating	Archaeology	Geotechnical Tunnels
	Bridge Deck				
Approximate Penetration*	2' (.6m)	5' (1.5m)	15' (4.5m)	30' (10m)	100' (30m)
Approximate Minimum Target Size**	1/64"(.4 mm)	1/16"(1.5 mm)	1/4"(6 mm)	4"(10 cm)	20"(.5 m)

Diagram illustrating the relationship between frequency and wavelength. A series of sine waves decreases in wavelength from left to right. Vertical tick marks below the waves are labeled with their corresponding frequencies: 2000 MHz, 1000 MHz, 500 MHz, 250 MHz, and 100 MHz.

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ANTENNAS IN THE WILD

- Monopole



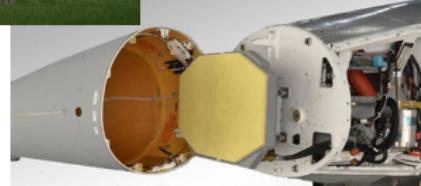
- Dipole



- Parabolic/Spherical

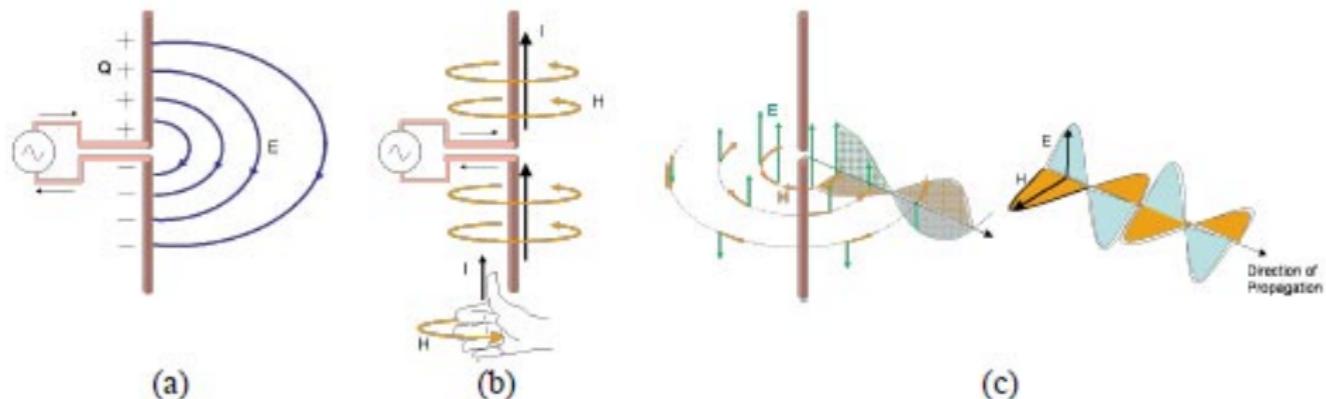


- AESA



HOW ANTENNAS WORK

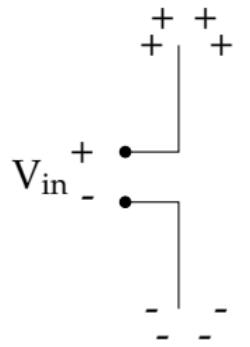
- Separation of charge (a) creates an electric field (E-field)
- Moving charge (b) creates a magnetic field (H-field)
- The Poynting Vector predicts the electromagnetic wave direction of propagation: $\vec{S} = \vec{E} \times \vec{H}$



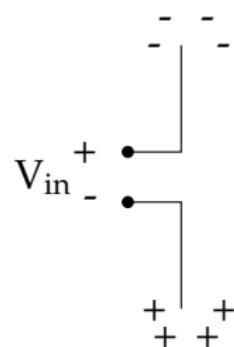
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$$V_{IN} > 0$$



$$V_{IN} < 0$$



1/2-Wave Dipole Antenna

IMPORTANT QUANTITIES

Wavelength and frequency

$$\lambda = \frac{c}{f}$$



Radiation Pattern

Antenna Gain

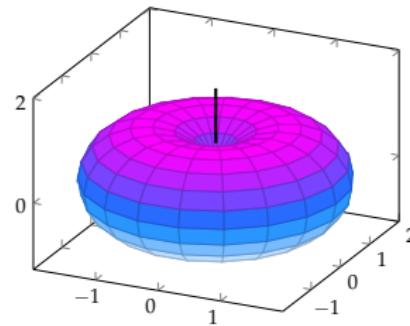
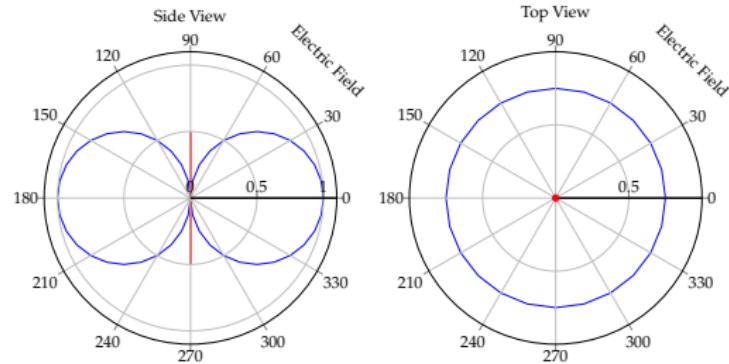


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Wavelength and frequency

Radiation Pattern

Antenna Gain

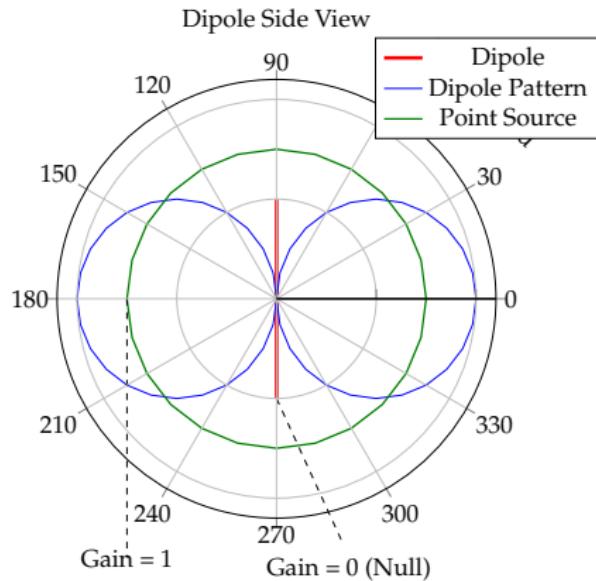


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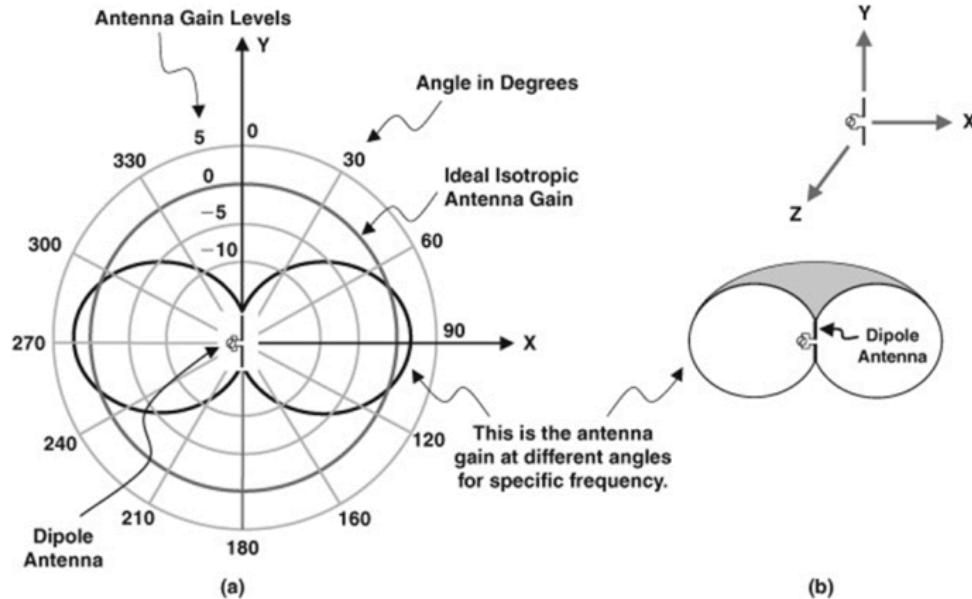
Wavelength and frequency

Radiation Pattern

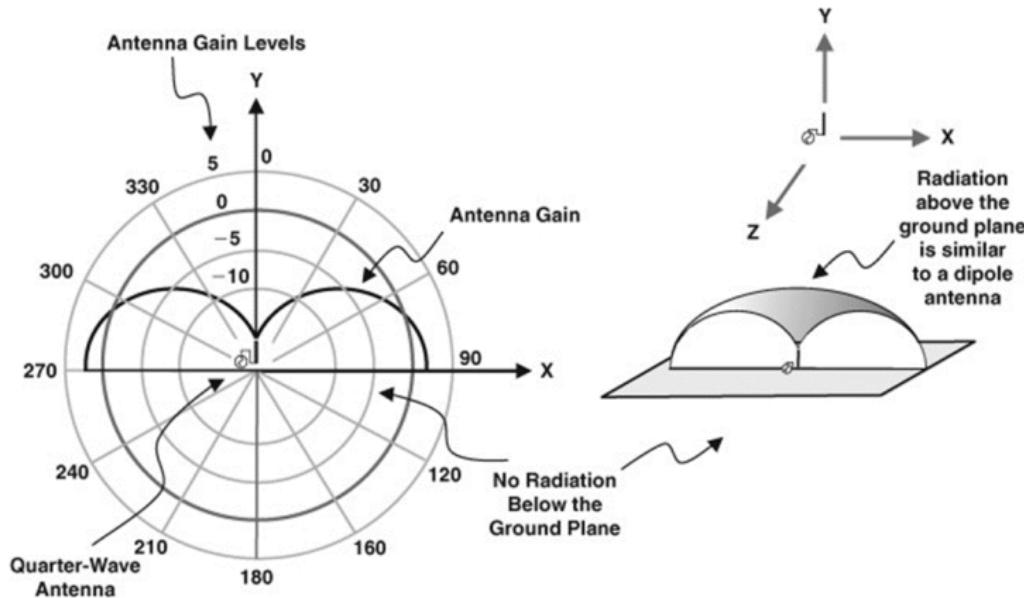
Antenna Gain



$\frac{\lambda}{2}$ -DIPOLE ANTENNA

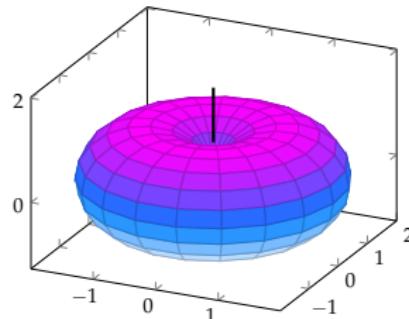
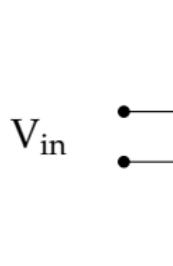


$\frac{\lambda}{4}$ -MONOPOLE ANTENNA

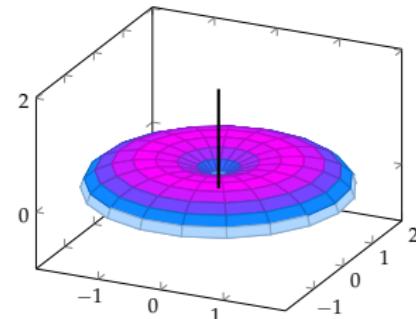


DIPOLE/MONOPOLE ANTENNAS

$\frac{\lambda}{2}$ Dipole (Gain = 1.64)



$\frac{\lambda}{4}$ Monopole (Gain = 3.28)



DIPOLE/MONOPOLE EXAMPLES

- Calculate the required length of a $\frac{\lambda}{2}$ dipole designed for a 144MHz radio
- Calculate the required length of a $\frac{\lambda}{4}$ monopole designed for a 800 kHz AM radio

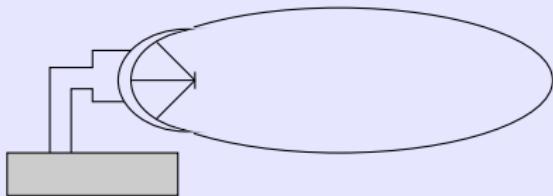
ANTENNA SIZE

	3 kHz	30 kHz	300 kHz	3 MHz	30 MHz	300 MHz	3 GHz	30 GHz	300 GHz
	VLF	LF	MF	HF	VHF	UHF	SHF	EHF	
Wavelength (m)	100k	10k	1k	100	10	1	0.1	0.01	0.001
$\lambda/2$ dipole	50k	5k	500	50	5	0.5	0.05	0.005	0.0005
$\lambda/4$ monopole	25k	2.5k	250	25	2.5	0.25	0.025	0.0025	0.00025



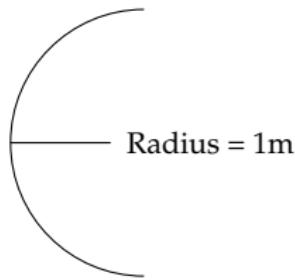
DISH ANTENNAS

- Focuses beam in a particular direction
- Gain given by: $G = \frac{(2\pi r)^2}{\lambda^2} * \eta$
- Where have you seen these?



PARABOLIC EXAMPLE

What frequency is the following antenna designed for? Assume $\eta = 91\%$ and $G = 300$.



PHASED ARRAYS

- Array of antenna elements
- Each element is delayed in phase (time) from the one before it
- "Wave front" is the sum of the peaks
- Beam propagates at an angle, determined by phase delay

