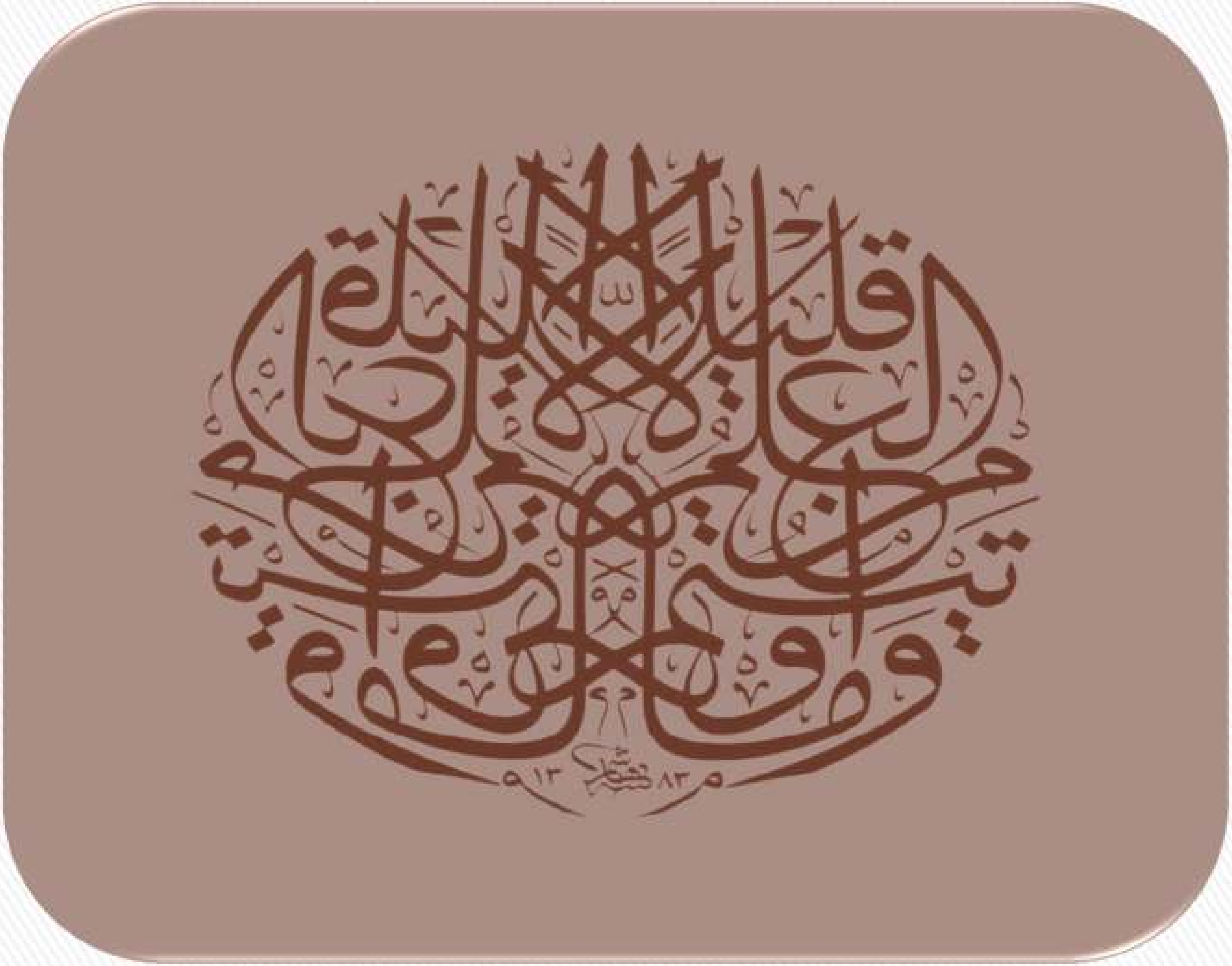

Benha University
Faculty Of Engineering at Shoubra

ECE 411
Antennas & Wave propagations
(2016/2017)

Lecture (1)
Introduction

Prepared By :
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Agenda

- Course Aim and Contents
- Teaching and Learning Methods
- Student Assessment , Schedule and Weighting
- References
- Introduction

Course Aim / Contents

- Antenna Fundamentals
- Point Sources
- Array of Point Sources
- Linear Wire Antennas
- Antenna Types
  - Dish antenna
  - Helix antenna
  - Micro-strip Patch antenna

Teaching and Learning Methods

- » **Modified Lectures**
- » **Class Activity**
- » **Lab.**
- » **Assignments (Quiz / Reports / project / Midterm Exam /Oral Exam)**

Student Assessment , Schedule and Weighting

Serial	Course Code	Course Name	Hours/week			Grades				Test Time
			Lecture	Practical/ practice	Total	Course Work	Oral or Practical	Written Exam	Total	
١	ECE411	Antenna and wave propagation	3	2	5	25	25	75	125	3

Assessment Schedule and Weighting

Quize	Midterm	Report	Project	Oral	Final Exam
W 6 , 12	W 7	W 13	W 14	W 14	W 15
40%					60%

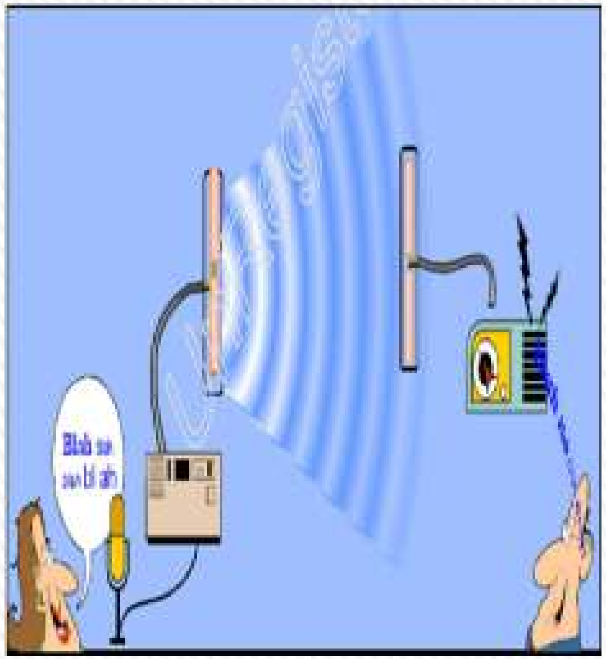
References

- Antennas , John D Kraus
- Antenna theory , Constantine A. Balanis

Introduction

What is Antenna ?

- A usually metallic device (wire) for radiating or receiving radio waves.
- A transducer designed to transmit and receive electromagnetic waves, it converts signals on electric circuits (V&I) to EM waves (E&H) radiate in space and vise versa.
- An antenna is an electrical conductor or system of conductors



- In two-way communication, the same antenna can be used for transmission and reception
- In transmit systems the RF signal is generated, amplified, modulated and applied to the antenna.
- In receive systems the antenna collects electromagnetic waves that are through the antenna and induce alternating currents that are used by the receiver.

Frequency Bands

Frequency Band Name	Frequency Range	Wavelength (Meters)	Application
Extremely Low Frequency (ELF)	3-30 Hz	10,000-100,000 km	Underwater Communication
Super Low Frequency (SLF)	30-300 Hz	1,000-10,000 km	AC Power (though not a transmitted wave)
Ultra Low Frequency (ULF)	300-3000 Hz	100-1,000 km	
Very Low Frequency (VLF)	3-30 kHz	10-100 km	Navigational Beacons
Low Frequency (LF)	30-300 kHz	1-10 km	AM Radio
Medium Frequency (MF)	300-3000 kHz	100-1,000 m	Aviation and AM Radio
High Frequency (HF)	3-30 MHz	10-100 m	Shortwave Radio
Very High Frequency (VHF)	30-300 MHz	1-10 m	FM Radio
Ultra High Frequency (UHF)	300-3000 MHz	10-100 cm	Television, Mobile Phones, GPS
Super High Frequency (SHF)	3-30 GHz	1-10 cm	Satellite Links, Wireless Communication
Extremely High Frequency (EHF)	30-300 GHz	1-10 mm	Astronomy, Remote Sensing
Visible Spectrum	400-790 THz (4*10^14-7.9*10^14)	380-750 nm (nanometers)	Human Eye

Antennas selected according to the frequency range and the application

Types of Antennas

Dipole

Dish (Reflector)

Helix

Yagi Atenna

Pyramidal Horn

Conical Horn

Microstrip patch

Types of Antennas

A good antenna would radiate almost the power delivered to it from the transmitter in a desired direction or directions. A receiver antenna does the reciprocal process, and delivers power received from a desired direction or directions.

Antenna can be categorized by:

- Antenna Types according to Physical Structure
  - Wire antennas (dipole , Loop , Helix)
  - Aperture antennas
  - Micro-strip antennas
  - Antenna arrays
  - Reflector antennas

- Antenna Types according to Gain
  - High gain (Dish)
  - Medium Gain (Horn)
  - Low Gain (dipole)

Types of Antennas

- **Antenna Types Beam shape**
  - Omnidirectional (dipole)
  - Pencil beam (dish)
  - Fan beam (array)

  Pencil beam and Fan beam → Directional pattern

- **Antenna Types according to Bandwidth**
  - Wideband (Helix)
  - Narrowband (Patch)

- **Antenna Types according to Polarization**
  - Linear
  - Circular
  - Elliptical

- **Antenna Types according to size in comparison to the wavelength**
  - Short (infinitesimal) ($L < \lambda/50$)
  - Small ($\lambda/50 < L < \lambda/10$)
  - Long (finite length) ($L > \lambda/10$)

Fundamental Parameters of Antennas

To describe the performance of an antenna, definitions of various parameters are discussed.

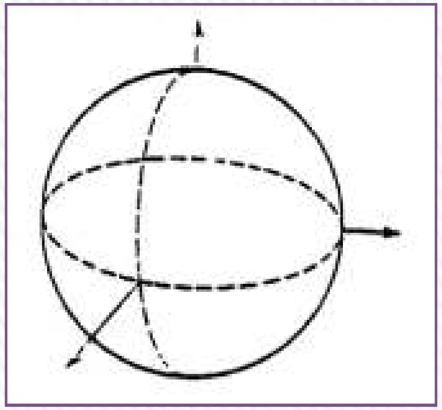
- The radiated power
- Radiation Pattern
- Beam solid angle & Beam area
- Directivity
- Gain
- Efficiency
- Effective and physical Aperture
- Radiation Resistance
- Antennas in Radio Communication Link (Ferris Eq.)

1 - RADIATED POWER

Suppose transmitting antenna located at the origin of spherical coordinate. From this coordinate system, there are three components of radiated field, in r, θ and φ.

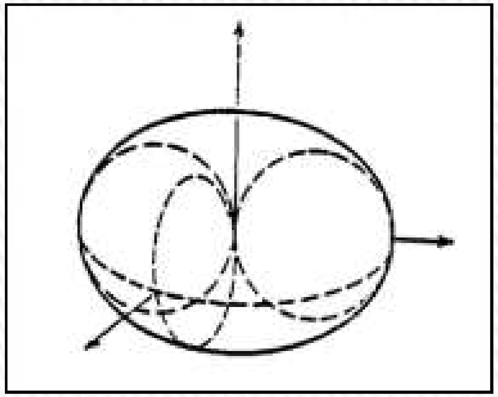
$$P_{rad} = \oint \mathrm{W}_{\mathrm{av}} . dS = \frac{1}{2} \oint \mathrm{Re}\left[\mathrm{E} \times \mathrm{H}\right] . dS$$

Idealized
Point Radiator



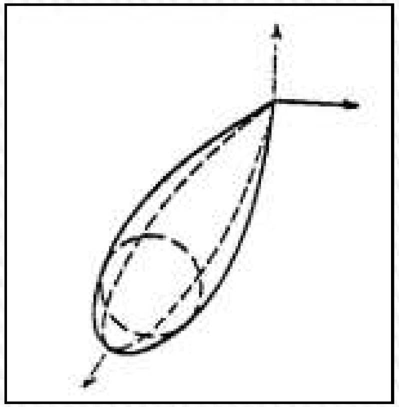
Isotropic

Vertical Dipole



Omnidirectional

Radar Dish



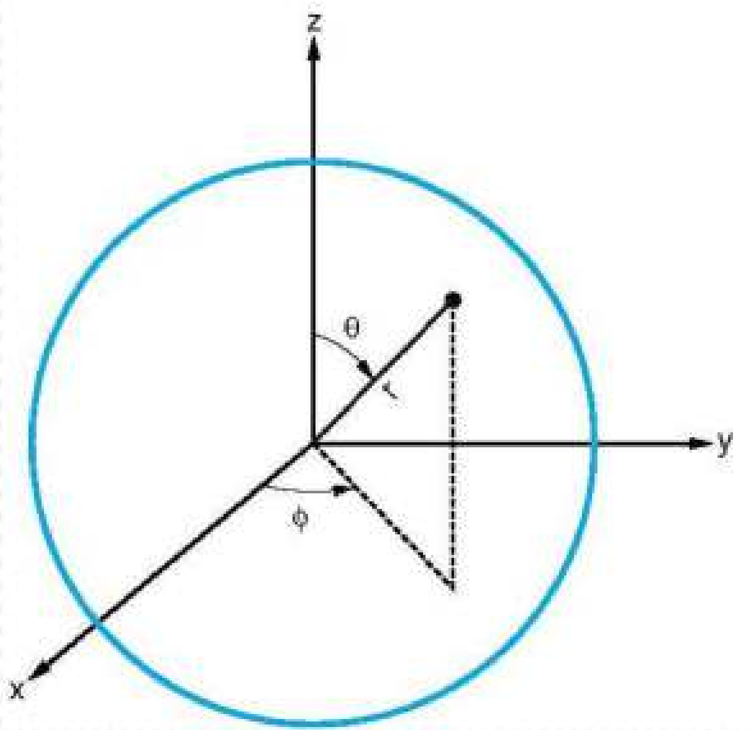
Directional

RADIATED POWER

For almost all practical applications, a receiving antenna located far enough away from the transmitter (as a point source of radiation) → far field region.

A distance *r* from the origin is generally accepted as being in the far field region if :

$$r \geq \frac{2L^2}{\lambda}$$



L is the length of the largest dimension on the antenna element, it is function of λ

2 - RADIATION PATTERNS

A mathematical and/or graphical representation of the radiation properties of an antenna, such as the:

- amplitude
- phase
- polarization, etc.

as a function of the angular space coordinates θ, ϕ.

RADIATION PATTERN

Radiation patterns usually indicate either electric field, **E** intensity or **power intensity**. Magnetic field intensity, **H** has the same radiation pattern as **E** related by η_0. (**E/ H=** η_0)

The polarization or orientation of the E field vector is an important consideration in an E field plot. A transmit receive antenna pair must share same polarization for the most efficient communication.

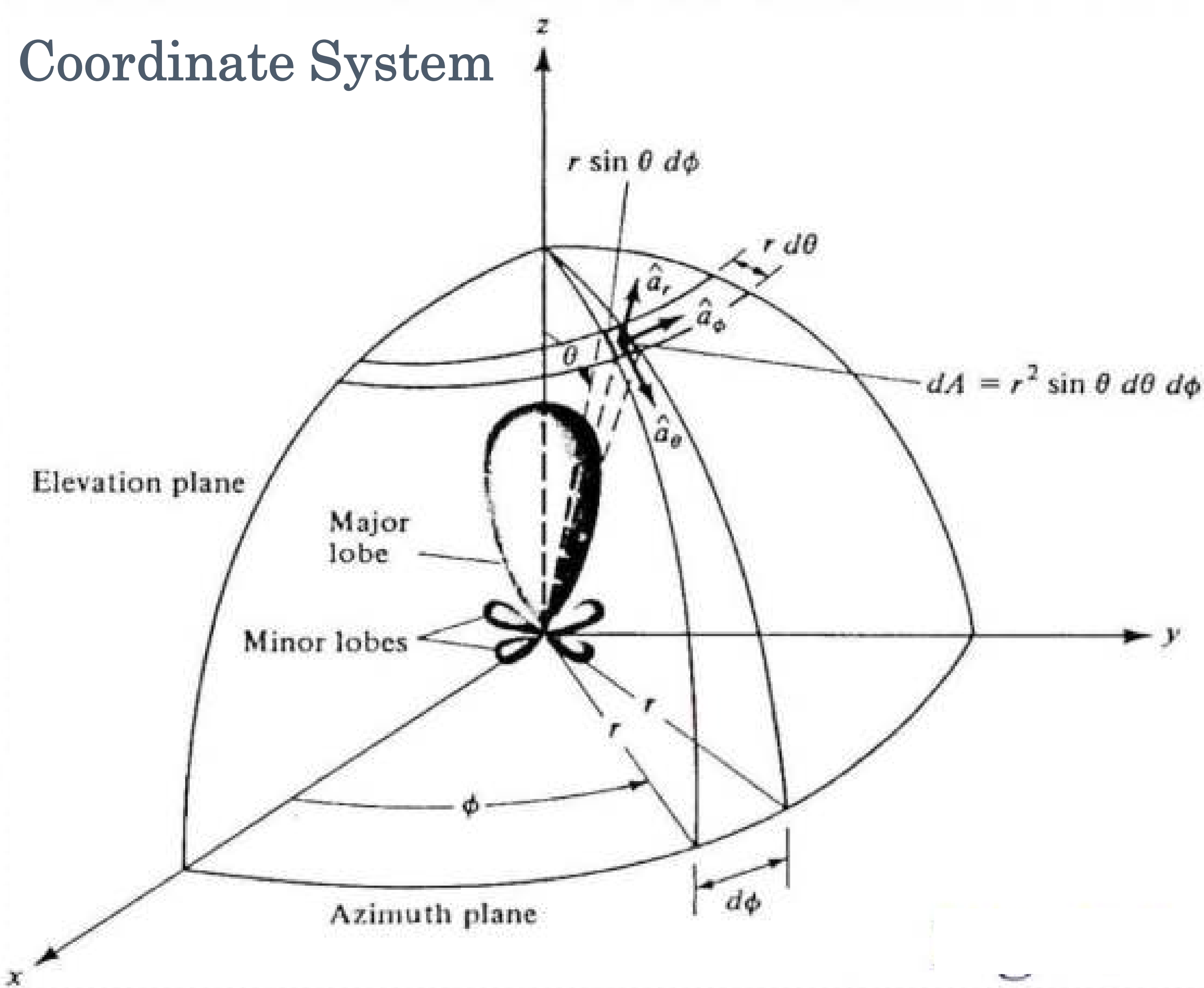
Field Pattern:

A plot of the field (either electric $|\underline{E}|$ magnetic $|\underline{H}|$) on a *linear* scale

Power Pattern:

A plot of the power (proportional to either the electric $|\underline{E}|^2$ or magnetic $|\underline{H}|^2$ fields) on a *linear* or *decibel (dB)* scale.

RADIATION PATTERN



RADIATION PATTERN

Since the actual field intensity is also depends on how much power delivered to antenna, we use and plot normalized function → divide the field or power component with its maximum value.

E.g. the normalized power function or normalized radiation intensity :

$$P_n(\theta,\phi) = \frac{P(r,\theta,\phi)}{P_{\max}}$$

RADIATION PATTERN

If the antenna radiates EM waves equally in all directions, it is termed as *isotropic antenna*, where the normalized power function is equal to 1.

So,

$$P_n(\theta,\phi)_{iso} = 1$$

In contrast with isotropic antenna, a *directional antenna* radiates and receives preferentially in some direction.

RADIATION PATTERN

The polar plot also can be in terms of dB. Where normalized E field pattern,

$$E_n(\theta,\phi) = \frac{E(r,\theta,\phi)}{E_{\max}}$$

This will be identical to the power pattern in decibels if:

$$E_n(\theta,\phi)(dB) = 20\log[E_n(\theta,\phi)]$$

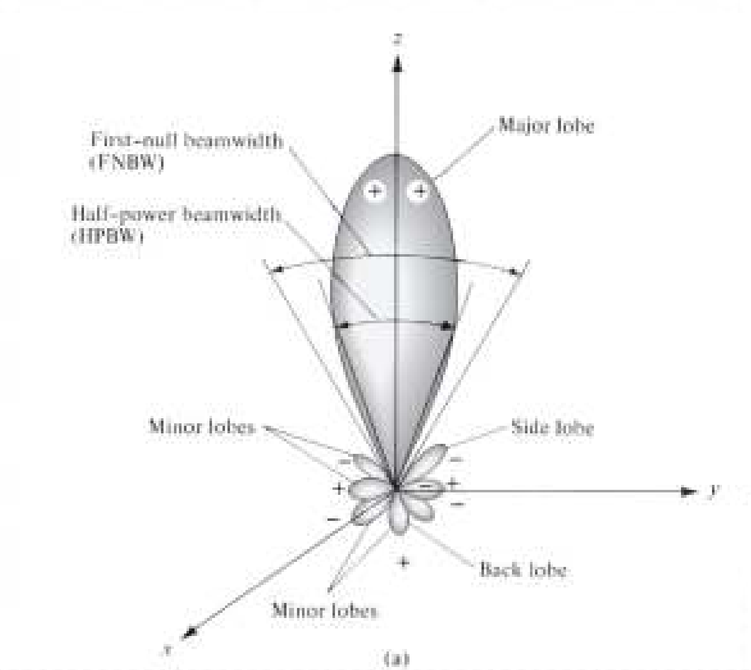
whereas

$$P_n(\theta,\phi)(dB) = 10\log[P_n(\theta,\phi)]$$

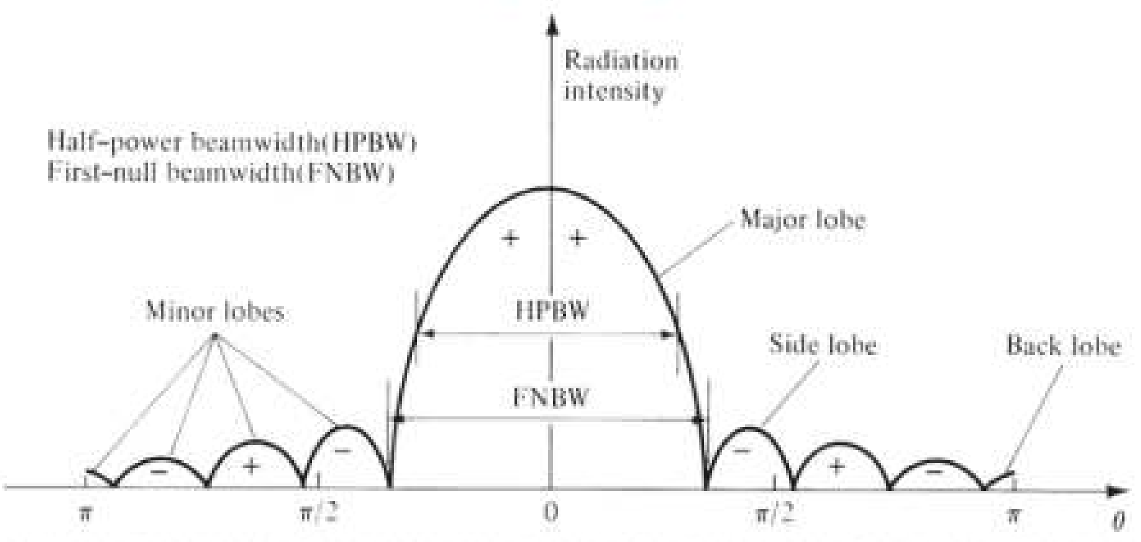
RADIATION PATTERN

The normalized radiation patterns for a generic antenna, called polar plot. A 3D plot of radiation pattern can be difficult to generate and work with, so take slices of the pattern and generate 2D plots (rectangular plots) for all θ at φ=π/2 and φ=3π/2 (- π/2)

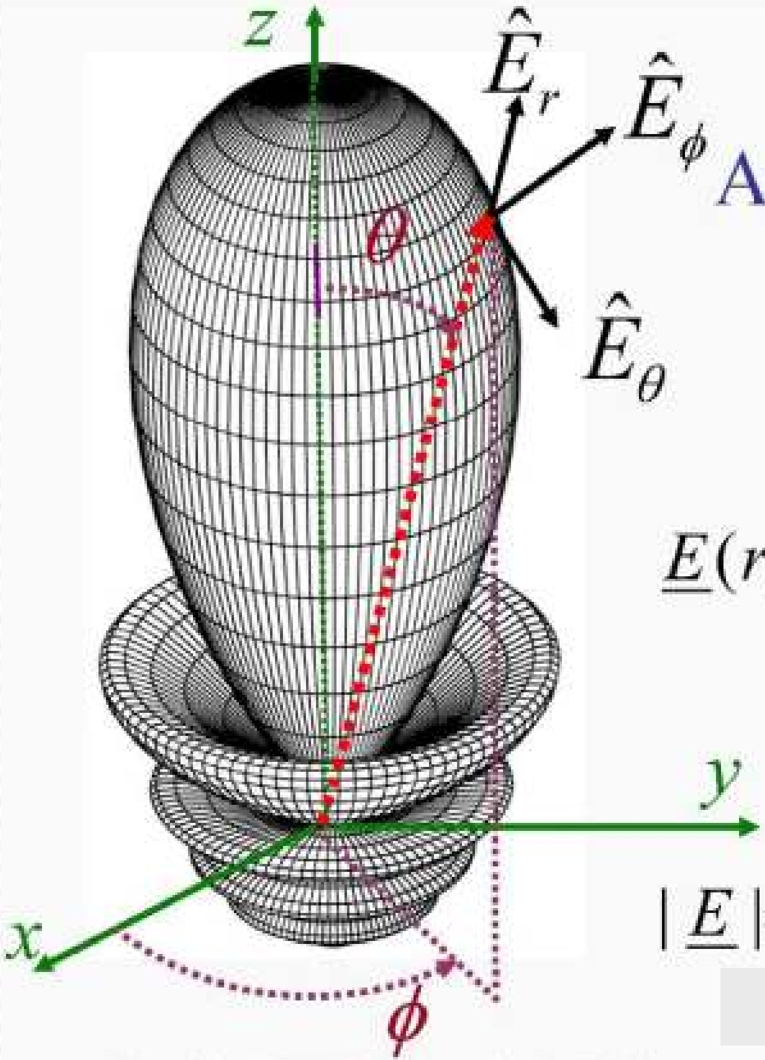
Polar plot



Rectangular plot (in dB)



RADIATION PATTERN



Normalized 3-D Amplitude *Field* Pattern of Linear Array

Linear Scale

$N = 10,\ d = \lambda/4$

$$\underline{E}(r,\theta,\phi)\,|_{r=r_c} = \hat{a}_r E_r(r_c,\theta,\phi) + \hat{a}_\theta E_\theta(r_c,\theta,\phi) + \hat{a}_\phi E_\phi(r_c,\theta,\phi)$$

$$|\,\underline{E}\,| = \sqrt{|\,E_r\,|^2 + |\,E_\theta\,|^2 + |\,E_\phi\,|^2}$$

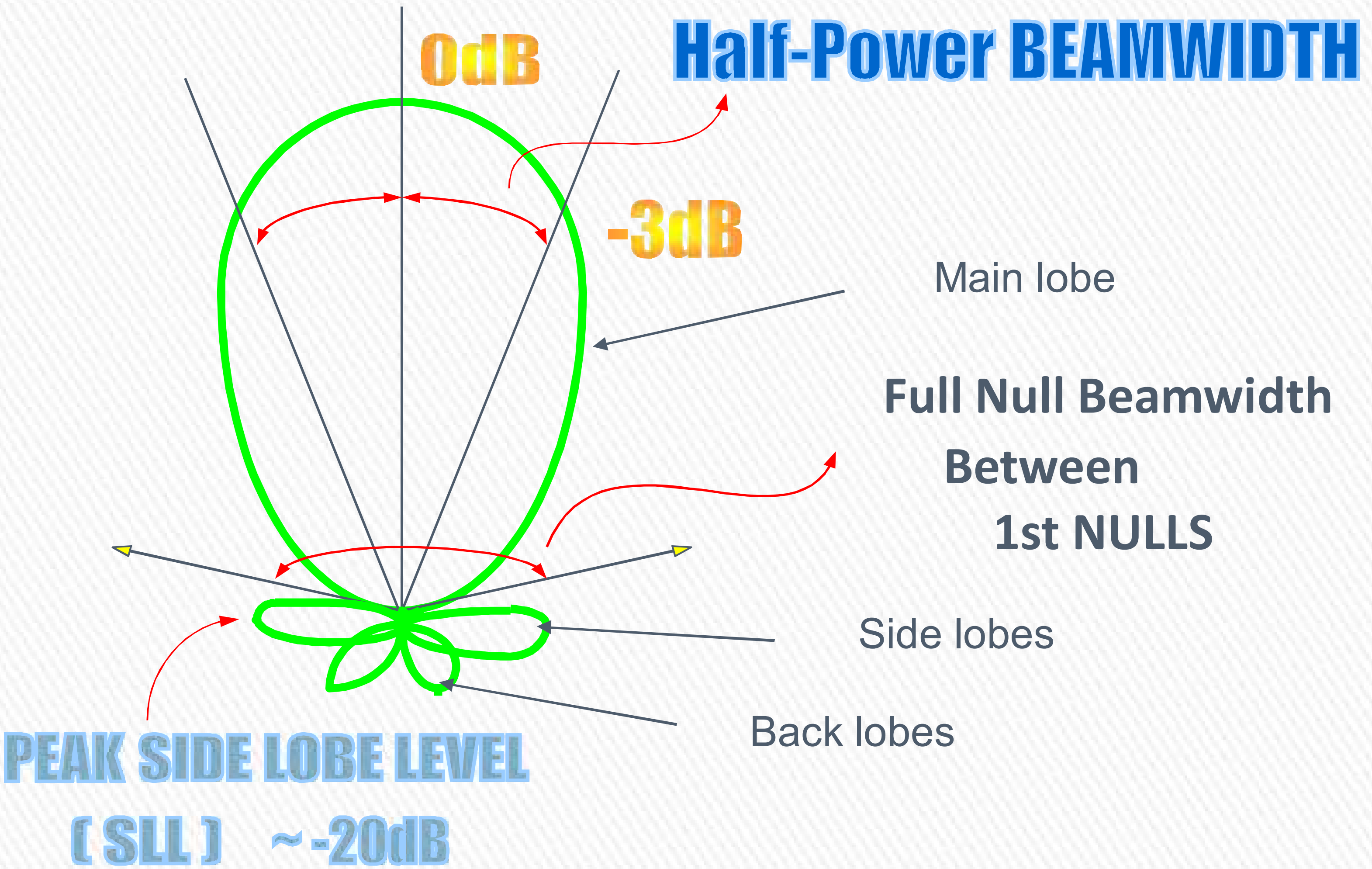
RADIATION PATTERN

The are some zeros and nulls in radiation pattern, indicating no radiations.

These lobes shows the direction of radiation, where main or major lobe lies in the direction of maximum radiation. The other lobes divert power away from the main beam, so that good antenna design will seek to minimize the side and back lobes.

Beam's directional nature is **beamwidth**, or half power beamwidth or 3 dB beamwidth. It will shows the angular width of the beam measured at the half power or -3 dB points.

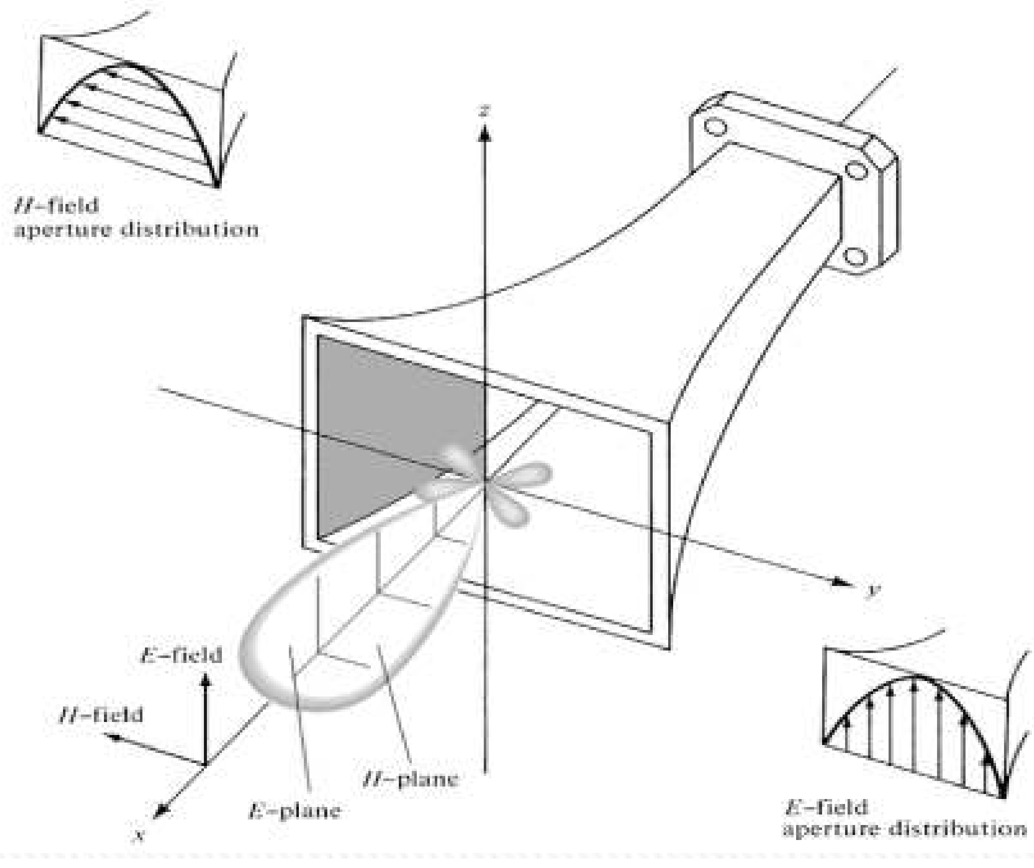
RADIATION PATTERN



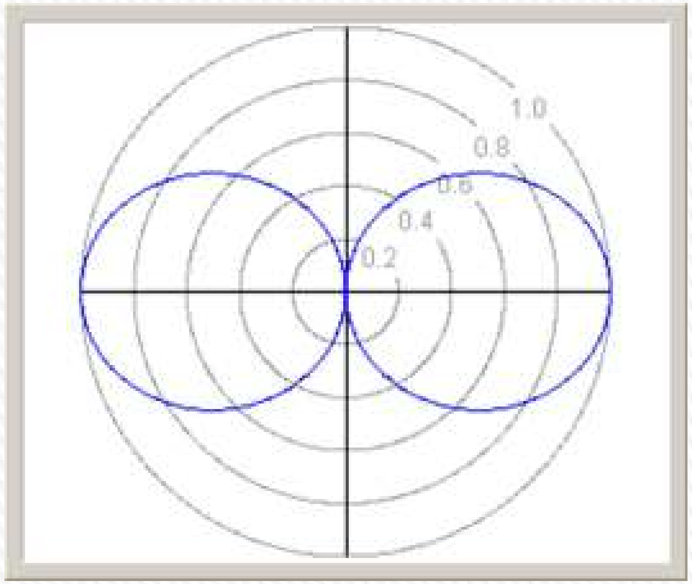
RADIATION PATTERN

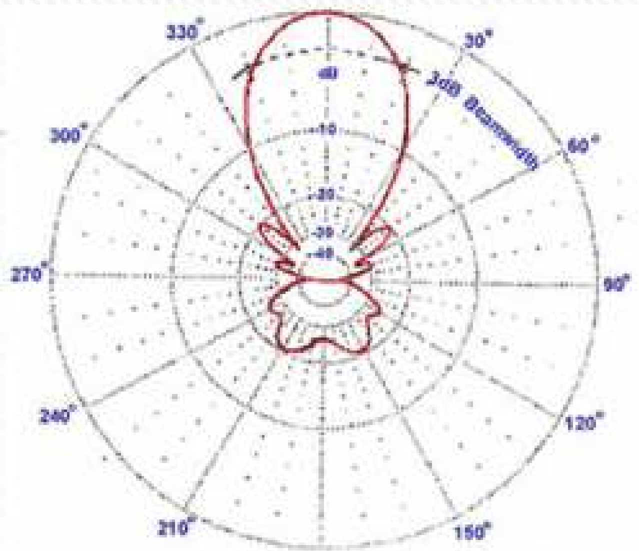
For Shown figure,

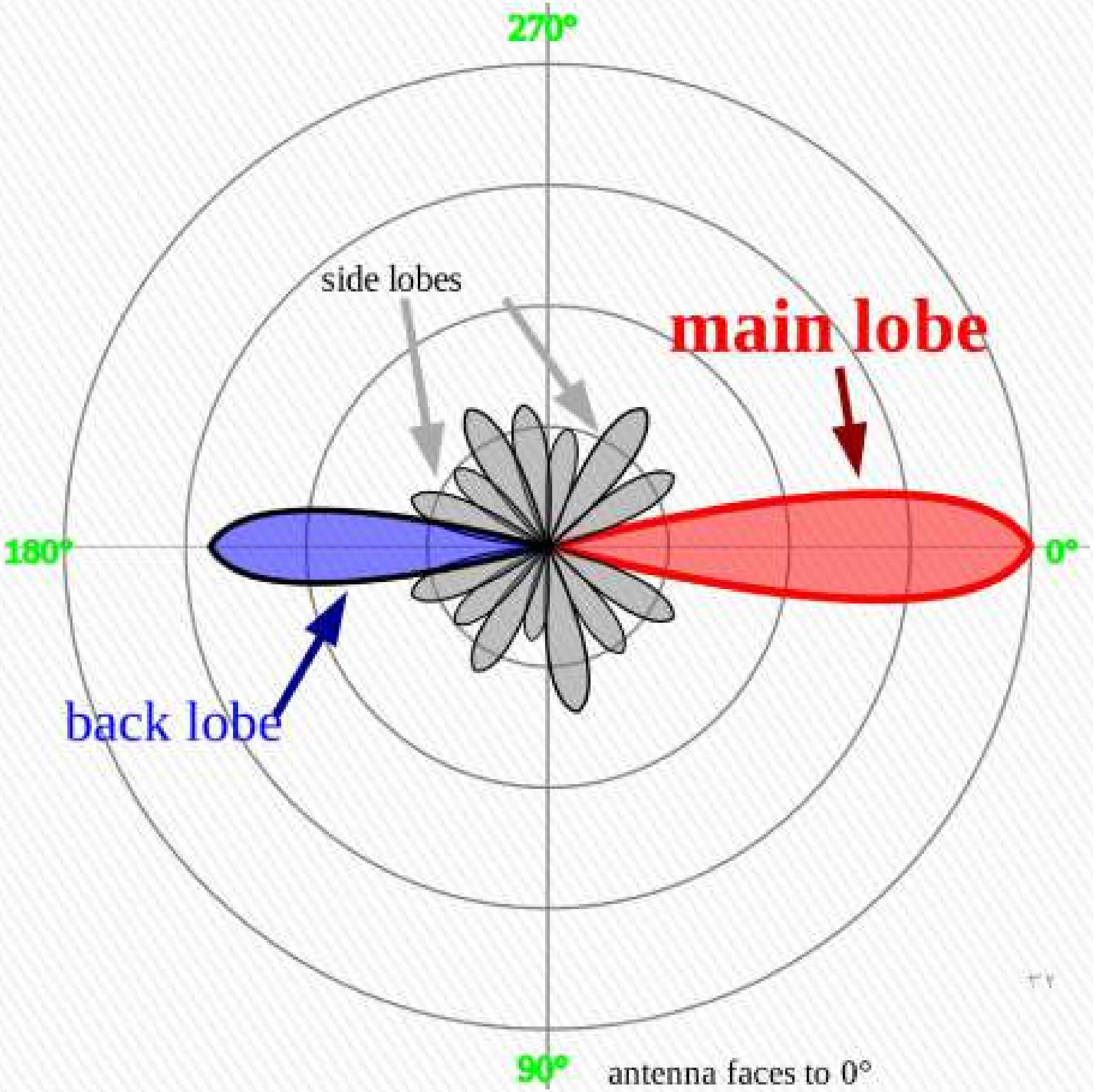
- the x-z plane (elevation plane, φ=0) is the principal E-plane
- the x-y plane (azimuthal plane; θ=π/2) is the principal H-plane.



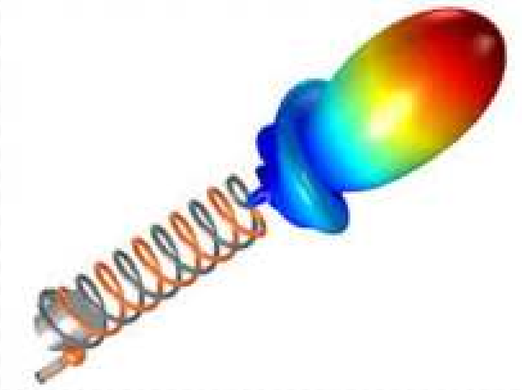
RADIATION PATTERN

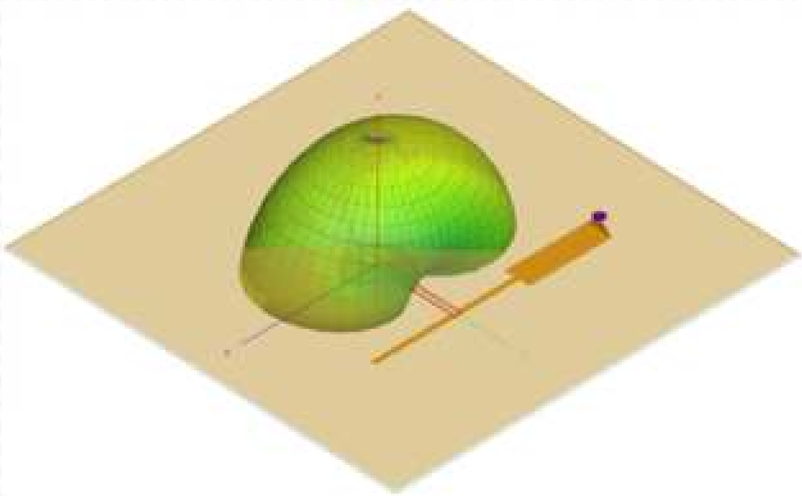




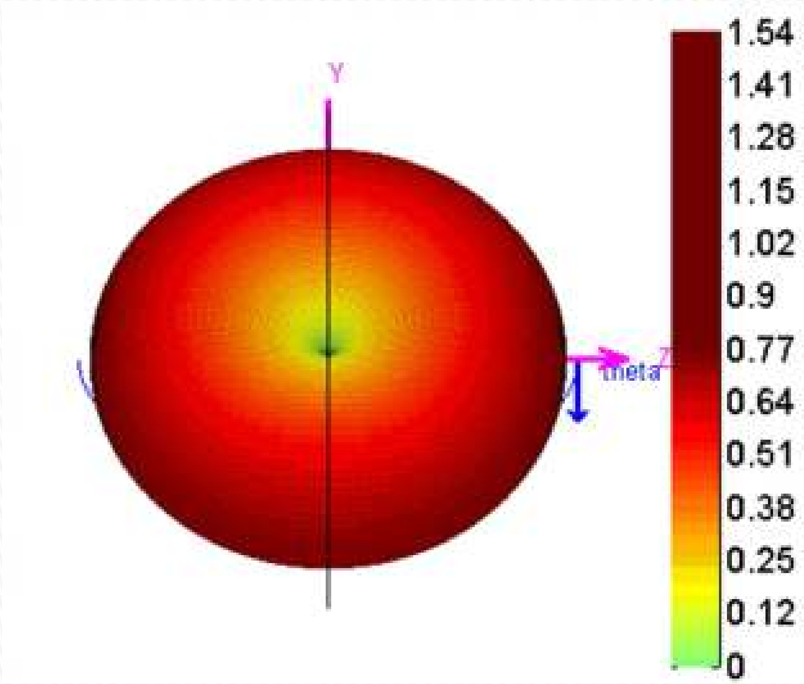


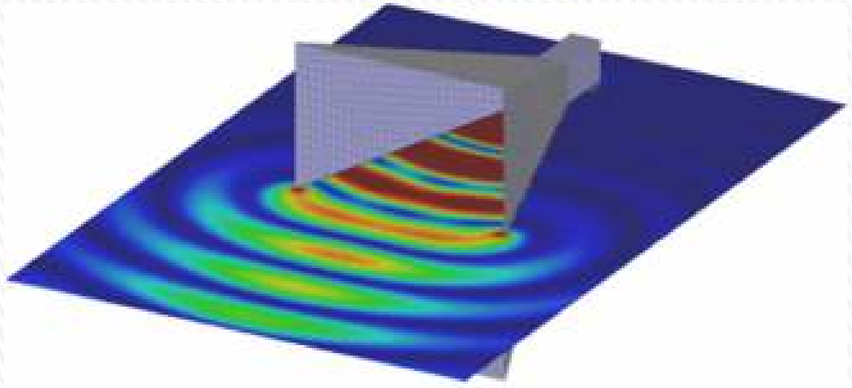
RADIATION PATTERN

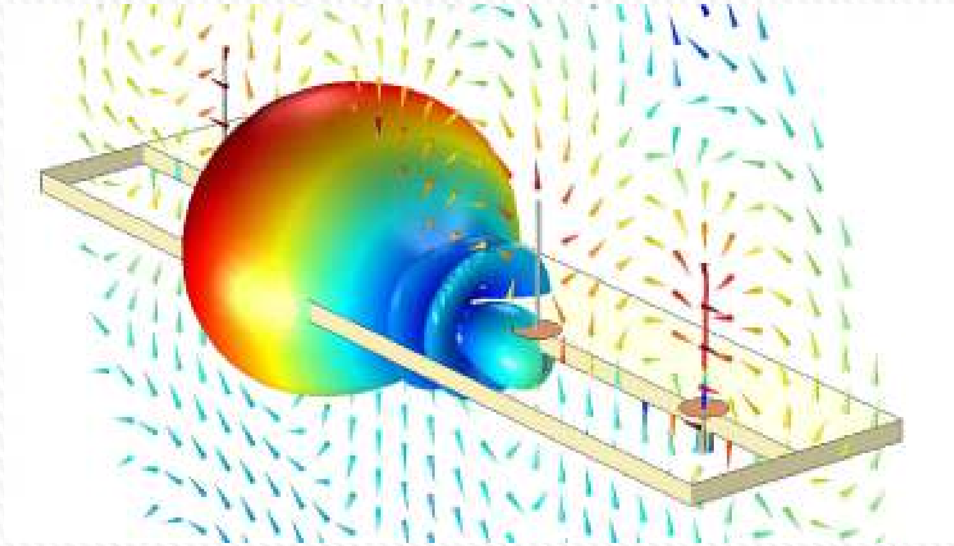




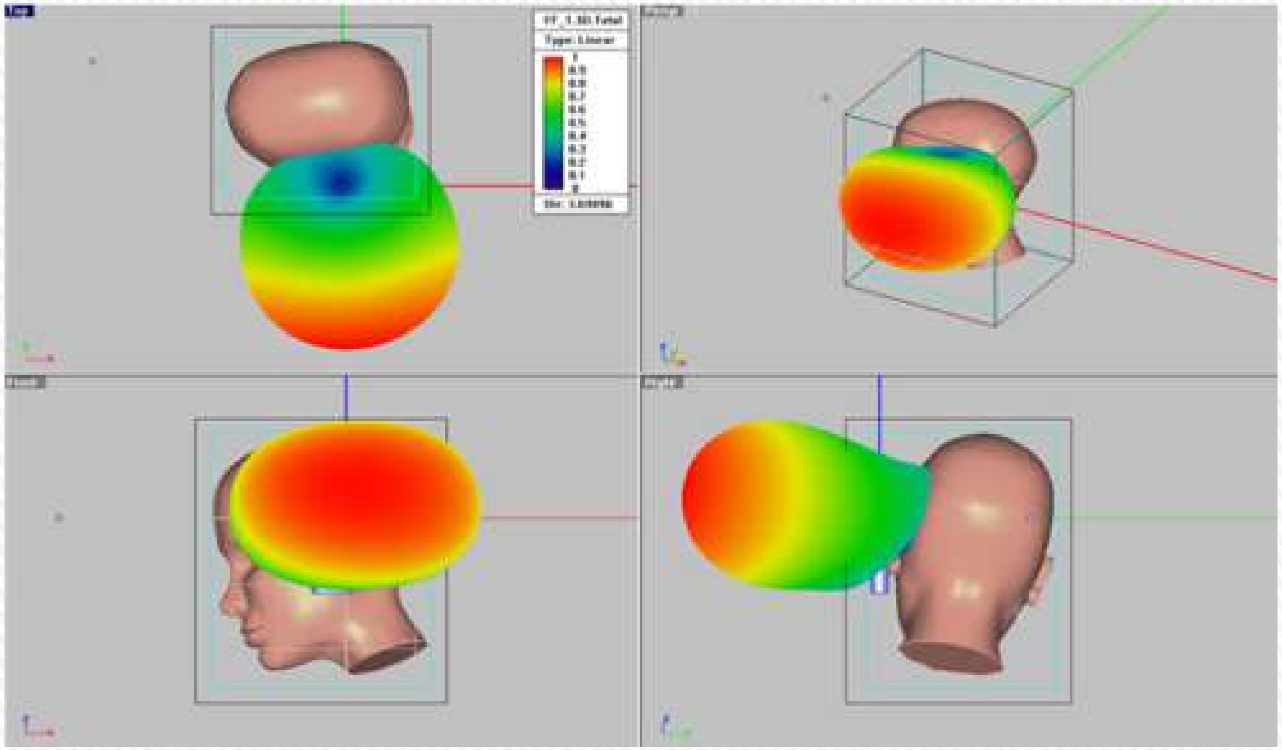
RADIATION PATTERN

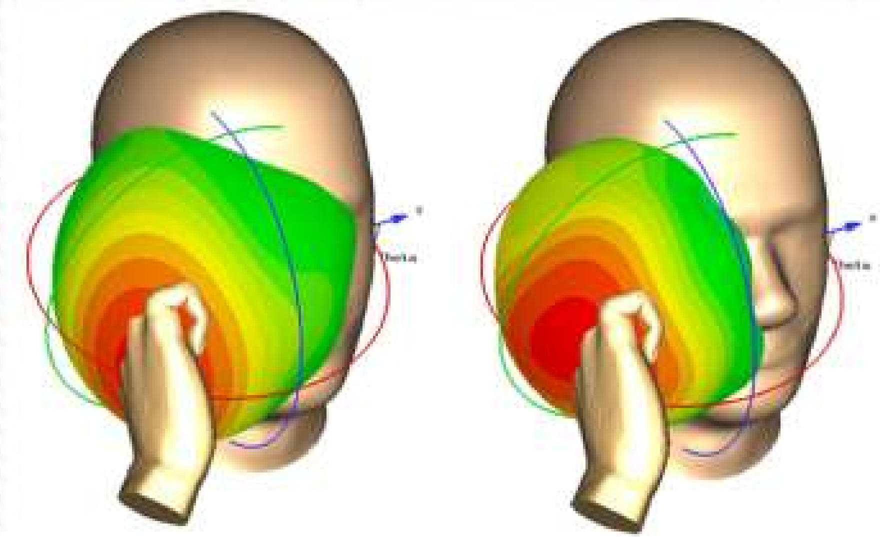






MOBILE RADIATION PATTERN





Next Lecture

Antenna parameters (Cont.)

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Thank You