Question 1(a) [3 marks]

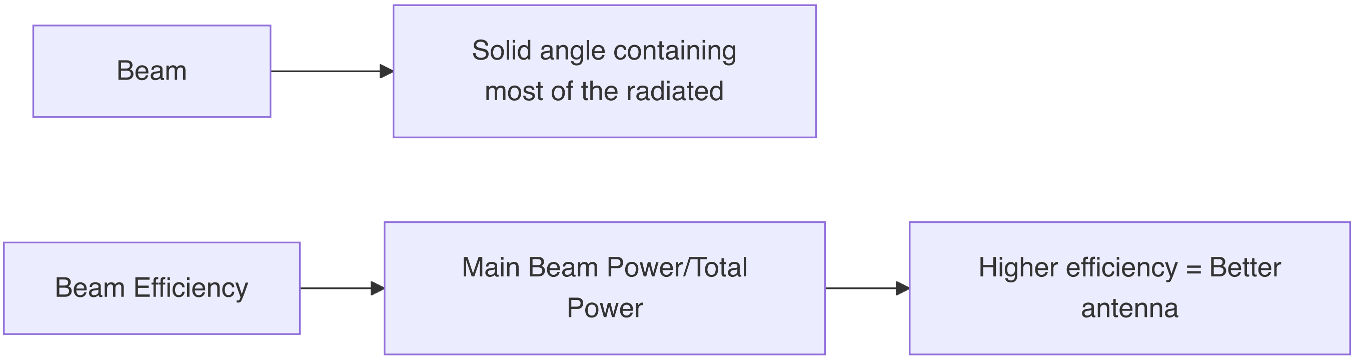
Define Beam Area and Beam Efficiency.

Answer:

Beam Area: The solid angle through which all of the power radiated by an antenna would flow if the radiation intensity was constant throughout this angle and equal to the maximum value.

Beam Efficiency: The ratio of the power contained in the main beam to the total power radiated by the antenna.

Diagram:



Mnemonic: "BEAM: Better Efficiency Achieves Maximum performance"

Question 1(b) [4 marks]

What is EM field? Explain its radiation from center fed dipole.

Answer:

EM field is a physical field produced by electrically charged objects that affects charged particles with a force.

Diagram:

```
                     |
                     |
  E-field            |            E-field
 (vertical)          |           (vertical)
                     |
        ↑            |           ↑
        |   current  |           |
        |      ↓     |           |
  ------+------------+---------- dipole antenna
        |      ↑     |           |
        |   current  |           |
        ↓            |           ↓
                     |
  H-field            |            H-field
```

```
    (circular)           |           (circular)
                         |
```

- **Electric field**: Perpendicular to antenna axis, maximum at antenna ends
- **Magnetic field**: Circular around antenna axis
- **Radiation mechanism**: Alternating current creates time-varying fields
- **Field behavior**: Near field (reactive) → intermediate → far field (radiating)

Mnemonic: "CERD: Current Excites Radiating Dipole"

Question 1(c) [7 marks]

Explain Power radiated by elementary dipole using Poynting Vector.

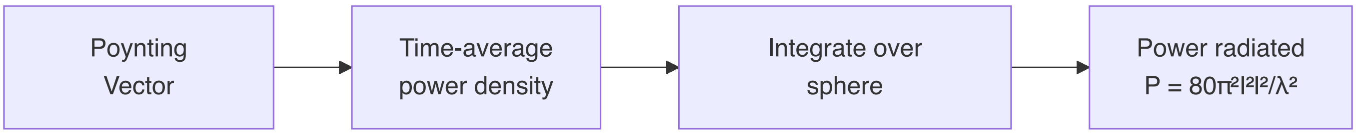
Answer:

Power radiated by an elementary dipole can be calculated using the Poynting vector, which represents power flow density.

Table: Key Steps in Poynting Vector Analysis

Step	Description
1	Calculate E-field components (Eθ, Eϕ)
2	Calculate H-field components (Hθ, Hϕ)
3	Determine Poynting vector: P = E × H
4	Integrate over a spherical surface

Diagram:



- **Electric field**: $E = (j\eta\ I_0 dl/2\lambda r)\sin\theta\ e^{-jkr}$
- **Magnetic field**: $H = (j\ I_0 dl/2\lambda r)\sin\theta\ e^{-jkr}$
- **Poynting vector**: $P = E \times H^* = (\eta|I_0|^2|dl|^2/8\pi^2 r^2)\sin^2\theta$
- **Total power**: $P = (\eta|I_0|^2|dl|^2/12\pi) = 80\pi^2 I^2 l^2/\lambda^2$

Mnemonic: "PEHP: Poynting Explains How Power propagates"

Question 1(c) OR [7 marks]

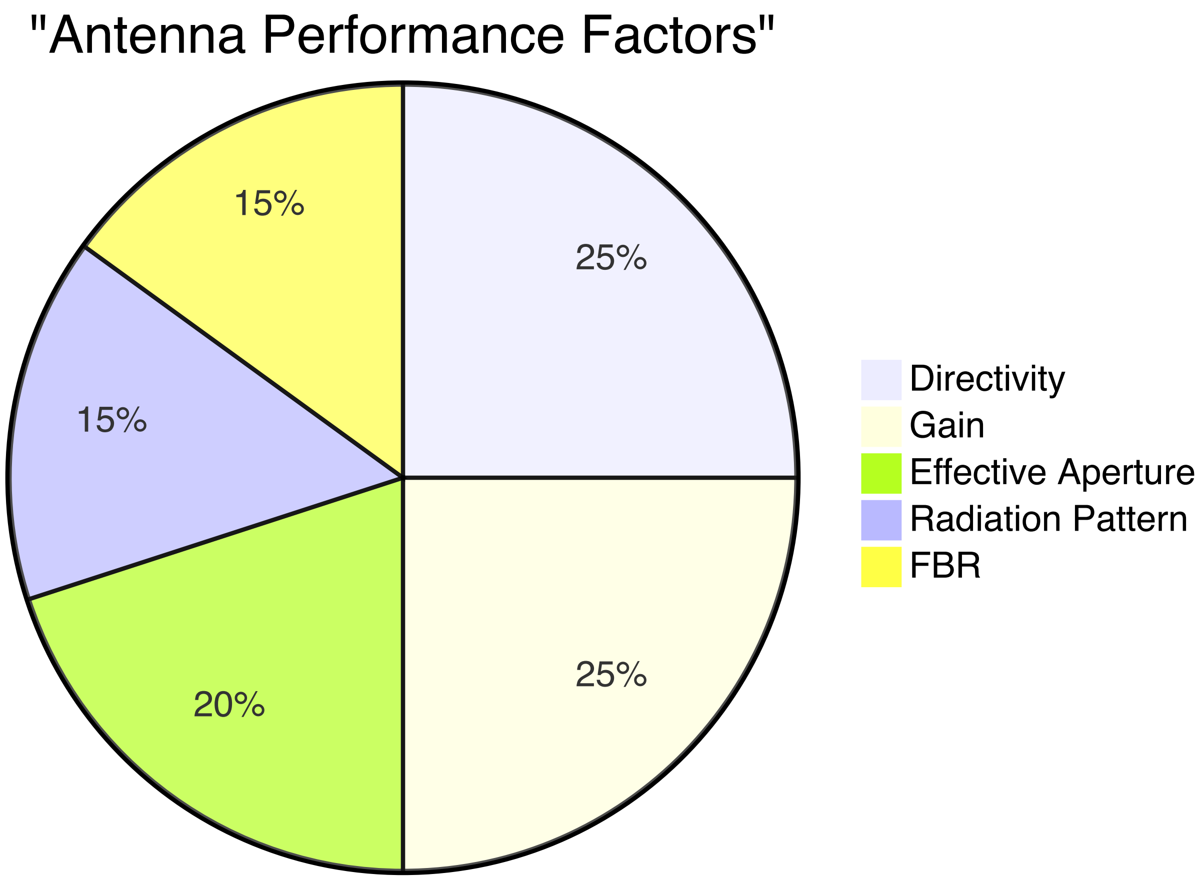
Define Antenna, Radiation Pattern, Directivity, Gain, FBR, Isotropic Radiator and Effective Aperture.

Answer:

Table: Key Antenna Parameters

Parameter	Definition
Antenna	A device that converts guided electromagnetic waves to free-space waves and vice versa
Radiation Pattern	Graphical representation of radiation properties as a function of space coordinates
Directivity	Ratio of radiation intensity in a given direction to average radiation intensity
Gain	Ratio of radiation intensity to that of an isotropic source with same input power
FBR (Front-to-Back Ratio)	Ratio of power radiated in forward direction to that in backward direction
Isotropic Radiator	Theoretical antenna that radiates equally in all directions
Effective Aperture	Ratio of power received by antenna to incident power density

Diagram:



Mnemonic: "DIAGRAM: Directivity Improves Antenna Gain, Radiation And More"

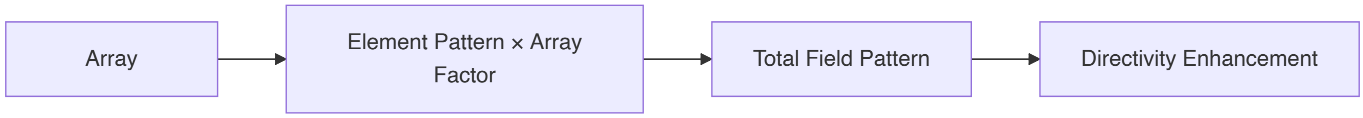
Question 2(a) [3 marks]

Explain principle of pattern multiplication.

Answer:

Pattern multiplication states that the radiation pattern of an array equals the product of the element pattern and the array factor.

Diagram:



- **Element pattern**: Radiation pattern of single element
- **Array factor**: Pattern due to arrangement of elements
- **Result**: Sharper beams, higher directivity

Mnemonic: "PEAM: Pattern Equals Array times Element Method"

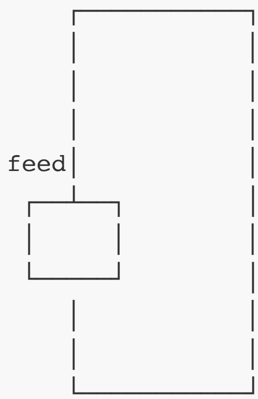
Question 2(b) [4 marks]

Draw & Explain Loop antenna.

Answer:

A loop antenna is a closed-circuit antenna consisting of one or more complete turns of wire.

Diagram:



- **Small loop**: Circumference < λ/10, figure-8 pattern
- **Large loop**: Circumference ≈ λ, maximum radiation perpendicular to plane
- **Applications**: Direction finding, AM radio reception
- **Radiation resistance**: Proportional to $(\text{circumference}/\lambda)^4$ for small loops

Mnemonic: "LOOP: Low Output, Orientation Precise"

Question 2(c) [7 marks]

Design a Yagi-uda antenna and explain it.

Answer:

Yagi-Uda is a directional antenna with driven element, reflector, and directors.

Table: Yagi-Uda Antenna Design Guidelines

Element	Length	Spacing from Driven Element
Reflector	0.5λ × 1.05	0.15λ - 0.25λ
Driven Element	0.5λ	Reference point
Director 1	0.5λ × 0.95	0.1λ - 0.15λ
Director 2	0.5λ × 0.92	0.2λ - 0.3λ
Additional Directors	Decreasing	0.3λ - 0.4λ

Diagram:

```
        Director 2     Director 1     Driven      Reflector
                                      Element
            ┌┐             ┌┐                         ┌┐
            ||             ||            ┌┐           ||
            ||             ||            ||           ||
            ||             ||            ||           ||
   ─────────||─────────────||────────────||───────────||────────►
            |<--0.15λ-->|<--0.15λ-->|<--0.25λ-->|       Radiation
            |<----------- Boom Length ---------->|       Direction
```

- **Function**: Reflector reflects signal, directors guide it forward
- **Gain**: Increases with number of directors (diminishing returns)
- **Impedance**: 20-30 ohms (typically matched with balun)
- **Applications**: TV reception, point-to-point communication

Mnemonic: "YARD: Yagi Achieves Radical Directivity"

Question 2(a) OR [3 marks]

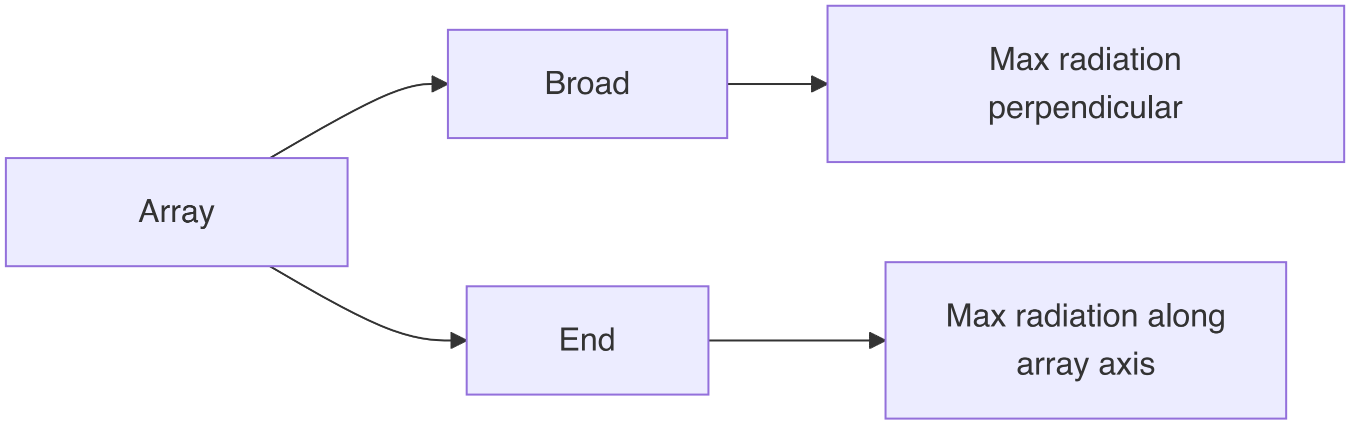
Compare broad fire and end fire array antenna.

Answer:

Table: Broad Side vs End Fire Array

Parameter	Broad Side Array	End Fire Array
Direction of Maximum Radiation	Perpendicular to array axis	Along array axis
Phase Difference	0°	180° ± βd
Beam Width	Narrower	Wider
Directivity	Higher	Lower
Applications	Broadcasting	Point-to-point links

Diagram:



Mnemonic: "BEPS: Broadside Emits Perpendicularly, Sideways"

Question 2(b) OR [4 marks]

Draw & Explain Folded dipole antenna.

Answer:

A folded dipole consists of a half-wavelength dipole with its ends folded back and connected, forming a narrow loop.

Diagram:

```
      λ/2
   ┌─────────┐
   │         │
   │         │
   │         │
feed│         │
 ┌─┴─┐       │
 │   │       │
 └───┘       │
   │         │
   │         │
   └─────────┘
```

- **Impedance**: 4 times higher than standard dipole (≈300Ω)
- **Bandwidth**: Wider than simple dipole
- **Applications**: TV antennas, FM receiving antennas
- **Advantage**: Less susceptible to noise

Mnemonic: "FIBER: Folded Impedance Booster Enhances Reception"

Question 2(c) OR [7 marks]

Give names of Non-resonant antennas and explain any one in detail with its radiation pattern.

Answer:

Non-resonant antennas include Rhombic, V antenna, Terminated folded dipole, Beverage, and Long-wire antennas.

Rhombic Antenna in Detail:

Diagram:

```
                  ┌───────┐
                 /         \
                /           \
               /             \
              /               \
             /                 \
            /                   \
           /                     \
          /                       \
         /                         \
   ┌─────┘                          └─────┐
   │                                      │
 ──┴──                                  ──┴──
 Feeder                              Terminating
                                      Resistor
```

Table: Rhombic Antenna Characteristics

Parameter	Description
Structure	Four long wires arranged in rhombus shape
Termination	Resistive load at far end (non-resonant)
Directivity	High (8-15 dB)
Frequency Range	Wide bandwidth (multi-octave)
Radiation Pattern	Unidirectional, cone-shaped
Applications	HF point-to-point communications

- **Advantages**: High gain, broad bandwidth, simple construction
- **Disadvantages**: Large physical size, power loss in terminating resistor
- **Pattern**: Main lobe along major axis of rhombus

Mnemonic: "RHOMBIC: Reliable High-Output Multi-Band Impressive Communications"

Question 3(a) [3 marks]

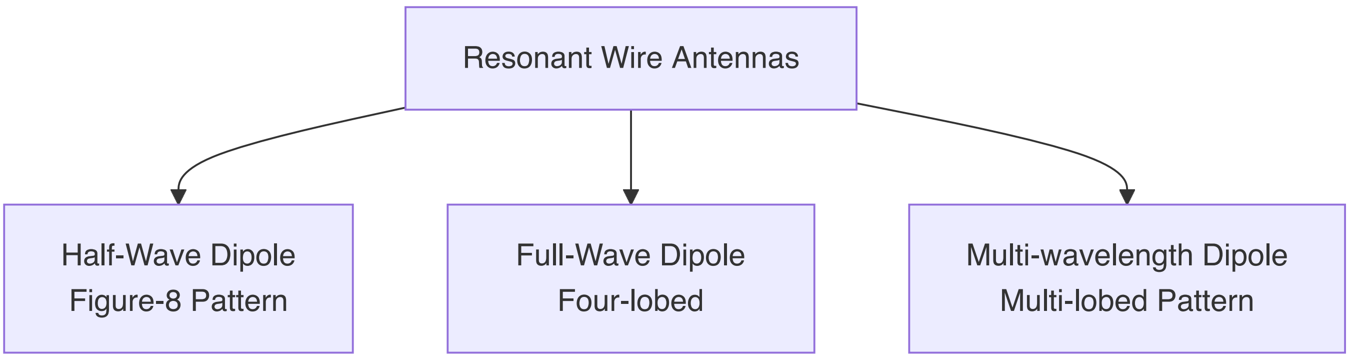
Compare radiation pattern of different resonant wire antennas.

Answer:

Table: Radiation Patterns of Resonant Wire Antennas

Antenna Type	Pattern Shape	Directivity	Polarization
Half-Wave Dipole	Figure-8 (donut)	2.15 dBi	Linear
Full-Wave Dipole	Four-lobed	3.8 dBi	Linear
3λ/2 Dipole	Six-lobed	4.2 dBi	Linear
2λ Dipole	Eight-lobed	4.5 dBi	Linear

Diagram:



Mnemonic: "MOLD: More wavelengths create Lots of Directivity lobes"

Question 3(b) [4 marks]

Draw V and Inverted V antenna with radiation Pattern.

Answer:

Diagram: V-Antenna

```
      /\
     /  \
    /    \
   /      \
  /        \
 /          \
Feed        Feed
Point       Point

Radiation Pattern: Bidirectional along axis
```

Diagram: Inverted V-Antenna

```
         Feed
         Point
           |
           V
          / \
         /   \
        /     \
       /       \
      /         \
     Ground     Ground

Radiation Pattern: Omnidirectional with slight elevation
```

- **V-Antenna**: Two wires forming V-shape, bidirectional pattern
- **Inverted V**: Half-wave dipole with arms drooping down, omnidirectional
- **Applications**: Amateur radio, FM reception
- **Advantages**: Simple, flexible installation options

Mnemonic: "VIPS: V-shapes Improve Pattern Selectivity"

Question 3(c) [7 marks]

Explain Morse Code and Practice Oscillator.

Answer:

Morse code is a method of transmitting text using standardized sequences of dots and dashes.

Table: Basic Morse Code Elements

Element	Timing	Sound
Dot (.)	1 unit	Short beep
Dash (-)	3 units	Long beep
Space between elements	1 unit	Short silence
Space between letters	3 units	Medium silence
Space between words	7 units	Long silence

Diagram: Simple Morse Code Practice Oscillator

```
         +9V
          |
          R1
          |
         ┌┴┐
  C1     │ │                       Speaker
┌──┬────┤8├───┬────┬──────────────┬──┐
│  │    │5│   │    │              │  │
│  │    │5│   │    R2             C2 │
│  │    │5│   │    │              │  │
│  │    └┬┘   │    │              │  │
│  │     │    │    │              │  │
└──┴─────┴────┴────┴──────────────┴──┘
  Key        Ground
```

- **Components**: 555 timer, resistors, capacitors, key, speaker
- **Operation**: Key closing completes circuit, creating oscillation
- **Frequency**: Typically 600-800 Hz (adjustable with R2)
- **Applications**: Ham radio training, emergency communications

Mnemonic: "TEMPO: Timing Elements Make Perfect Oscillation"

Question 3(a) OR [3 marks]

Draw and Explain Microstrip Patch antenna.

Answer:

A microstrip patch antenna consists of a metal patch on a grounded substrate.

Diagram:

```
    ┌───────────────┐   ←-- Patch (metal)
    │               │
    │               │   Thickness
    │               │   ↕
════════════════════════ ←-- Substrate
    │               │
    │               │   ←-- Ground plane
    └───────────────┘


    ↑               ↑
    Feed            Radiation
    point
```

- **Structure**: Metal patch on dielectric substrate with ground plane
- **Advantages**: Low profile, lightweight, easy fabrication, conformable
- **Disadvantages**: Narrow bandwidth, low efficiency, low power handling
- **Applications**: Mobile devices, RFID, satellite communications

Mnemonic: "MAPS: Microstrip Antenna Patches are Simple"

Question 3(b) OR [4 marks]

Draw and Explain Horn antenna.

Answer:

A horn antenna is a waveguide with flared open end that directs radio waves in a beam.

Diagram:

```
             ┌───────────┐
             │           │
             │           │
        ┌────┤           │
        │    │           │
        │    │           │
Feed    │    │           │
point   │    │           │
        │    │           │
        └────┤           │
             │           │
             │           │
             └───────────┘

          Waveguide      Horn
```

- **Types**: E-plane, H-plane, Pyramidal, Conical
- **Frequency range**: Microwave (1-20 GHz)
- **Advantages**: High gain, wide bandwidth, low VSWR

- **Applications**: Satellite communications, radar, radio astronomy

Mnemonic: "HEWB: Horns Enhance Waveguide Beamwidth"

Question 3(c) OR [7 marks]

List different feed system for Parabolic reflector antenna and explain any one.

Answer:

Table: Parabolic Reflector Feed Systems

Feed System	Position	Characteristics
Front Feed	At focus, in front of dish	Simple, some blockage
Cassegrain	Secondary reflector with feed at center of dish	Reduced noise, compact
Gregorian	Secondary concave reflector	Better gain, larger size
Offset Feed	Feed offset from main axis	No blockage, asymmetric
Waveguide Feed	Direct waveguide at focus	Simple, limited flexibility

Front Feed System (Detailed):

Diagram:

- **Operation**: Feed placed at focal point, illuminates reflector
- **Advantages**: Simple design, easy alignment, maximum efficiency
- **Disadvantages**: Feed and support structure block part of aperture
- **Applications**: Satellite dishes, radio telescopes, radar

Mnemonic: "FACTS: Focused Aperture Captures Transmitted Signals"

Question 4(a) [3 marks]

Explain working principle of HAM radio.

Answer:

HAM radio (Amateur Radio) operates on designated frequency bands for non-commercial communications.

Diagram:

- **Operation**: Transmitter generates RF signal, antenna radiates signal
- **Frequency bands**: HF (3-30 MHz), VHF (30-300 MHz), UHF (300-3000 MHz)
- **Modes**: AM, FM, SSB, CW (Morse), digital modes
- **License**: Required for legal operation (levels based on skills)

Mnemonic: "TEAM: Transmission Enables Amateur Messages"

Question 4(b) [4 marks]

Explain Duct Propagation.

Answer:

Duct propagation occurs when radio waves are trapped within atmospheric layers with varying refractive indices.

Diagram:

```
        ------------------  ←-- Upper atmosphere

         ===============  ←-- Duct layer (temperature inversion)
        /     Trapped    \
       /       waves      \
      /                    \
     /                      \
    /                        \
   /                          \
 Transmitter                Receiver

     ==================== Ground/Sea
```

- **Formation**: Temperature inversion creates refractive index gradient
- **Frequency range**: VHF, UHF, microwave frequencies
- **Advantages**: Extended communication range (beyond horizon)
- **Occurrence**: Common over oceans, varies with weather conditions

Mnemonic: "TRIP: Trapped Rays In atmospheric Paths"

Question 4(c) [7 marks]

Explain Tropospheric Scattered Propagation in detail.

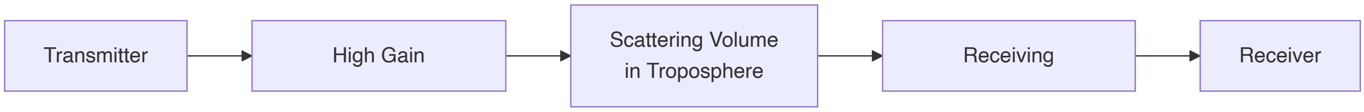
Answer:

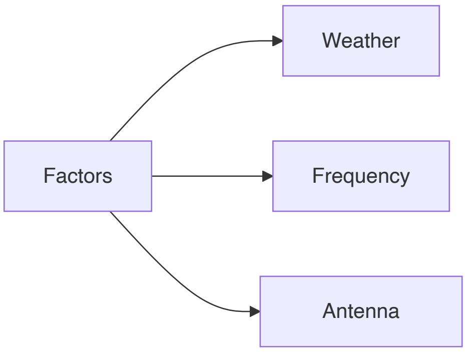
Tropospheric scatter uses the scattering properties of the troposphere to enable beyond-horizon communications.

Table: Tropospheric Scatter Characteristics

Parameter	Description
Mechanism	Forward scattering of radio waves by tropospheric irregularities
Frequency Range	300 MHz to 10 GHz (UHF/SHF)
Range	100-800 km
Path Loss	High (requires high-power transmitters)
Reliability	Affected by weather conditions

Diagram:





- **Mechanism**: Signal scattered by refractive index irregularities
- **Equipment**: High-power transmitters, large antennas, sensitive receivers
- **Applications**: Military, backup communications, remote areas
- **Advantages**: Beyond line-of-sight, relatively stable

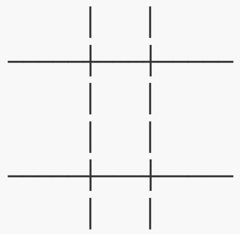
Mnemonic: "STARS: Scatter Tropospheric Allows Range beyond Sight"

Question 4(a) OR [3 marks]

Draw turnstile and super turnstile antenna.

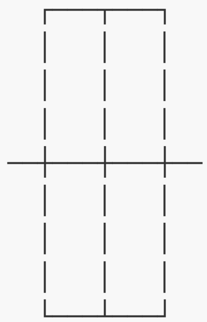
Answer:

Diagram: Turnstile Antenna



```
Two dipoles at 90° fed with 90° phase difference
```

Diagram: Super Turnstile (Batwing) Antenna



```
Multiple elements for broadband operation
```

- **Turnstile**: Two dipoles at right angles, circular polarization
- **Super turnstile**: Multiple elements for increased bandwidth
- **Applications**: TV broadcasting, FM broadcasting, satellite communications
- **Advantage**: Omnidirectional horizontal pattern

Mnemonic: "TACO: Turnstile Antennas Create Omnidirectional patterns"

Question 4(b) OR [4 marks]

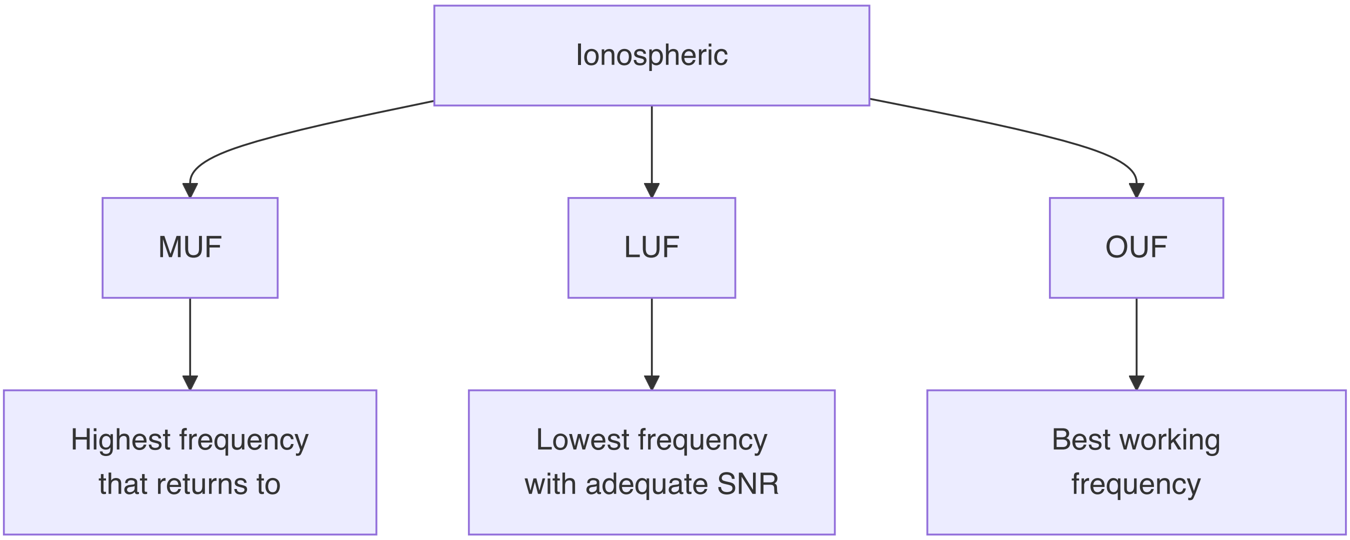
Give full form of MUF, LUF and OUF.

Answer:

Table: Ionospheric Propagation Parameters

Abbreviation	Full Form	Description
MUF	Maximum Usable Frequency	Highest frequency that can be reflected by ionosphere
LUF	Lowest Usable Frequency	Lowest frequency providing adequate signal-to-noise ratio
OUF	Optimum Usable Frequency	Best working frequency (85% of MUF)

Diagram:



Mnemonic: "MLO: Maximum and Lowest determine Optimum"

Question 4(c) OR [7 marks]

Explain virtual height, critical frequency and skip distance in detail.

Answer:

Table: Key Ionospheric Propagation Parameters

Parameter	Definition	Significance
Virtual Height	Apparent reflection height assuming straight-line propagation	Determines maximum communication range
Critical Frequency	Maximum frequency reflected at vertical incidence	Indicates ionization density
Skip Distance	Minimum distance where ionospheric signals can be received	Creates "skip zones" with no reception

Diagram:

```
                  /|\
                 / | \
                /  |  \       Critical freq: Maximum
               /   |   \      frequency at 90° incidence
              /    |    \
             /     |     \
            /      |      \
Transmitter/       |       \Receiver
          /        |        \
         /         |         \
```

```
         /         |          \
        /          |           \
       /           |            \
      /            |             \
     /             |              \
    /              |               \
   /               |                \
  /                |                 \
 /                 |                  \
Earth              |                 Earth
       |<------ Skip Distance -------->|

Virtual height: Apparent reflection height
```

- **Virtual height**: Typically 300-400 km for F layer, varies with time/season
- **Critical frequency**: Usually 5-10 MHz for F2 layer, depends on solar activity
- **Skip distance**: Given by D = 2h tan θ, where h is virtual height and θ is incidence angle

Mnemonic: "VCS: Virtual height Controls Skip distance"

Question 5(a) [3 marks]

With neat figure show different Ionosphere layers.

Answer:

Diagram: Ionospheric Layers

```
Height (km)
   ^
   |
400|                   F2 Layer
   |           ----------------------
   |
300|                   F1 Layer (daytime)
   |           ----------------------
   |
200|                   E Layer
   |           ----------------------
   |
100|                   D Layer
   |           ----------------------
   |
   +--------------------------------------->
                 Electron Density
```

- **D Layer**: 60-90 km, absorbs HF waves, disappears at night
- **E Layer**: 90-150 km, reflects MF/lower HF, weakens at night
- **F1 Layer**: 150-220 km, present in daytime only

- **F2 Layer**: 220-400 km, main reflection layer, present day/night

Mnemonic: "DEAF: Down to up - D, E, And F layers"

Question 5(b) [4 marks]

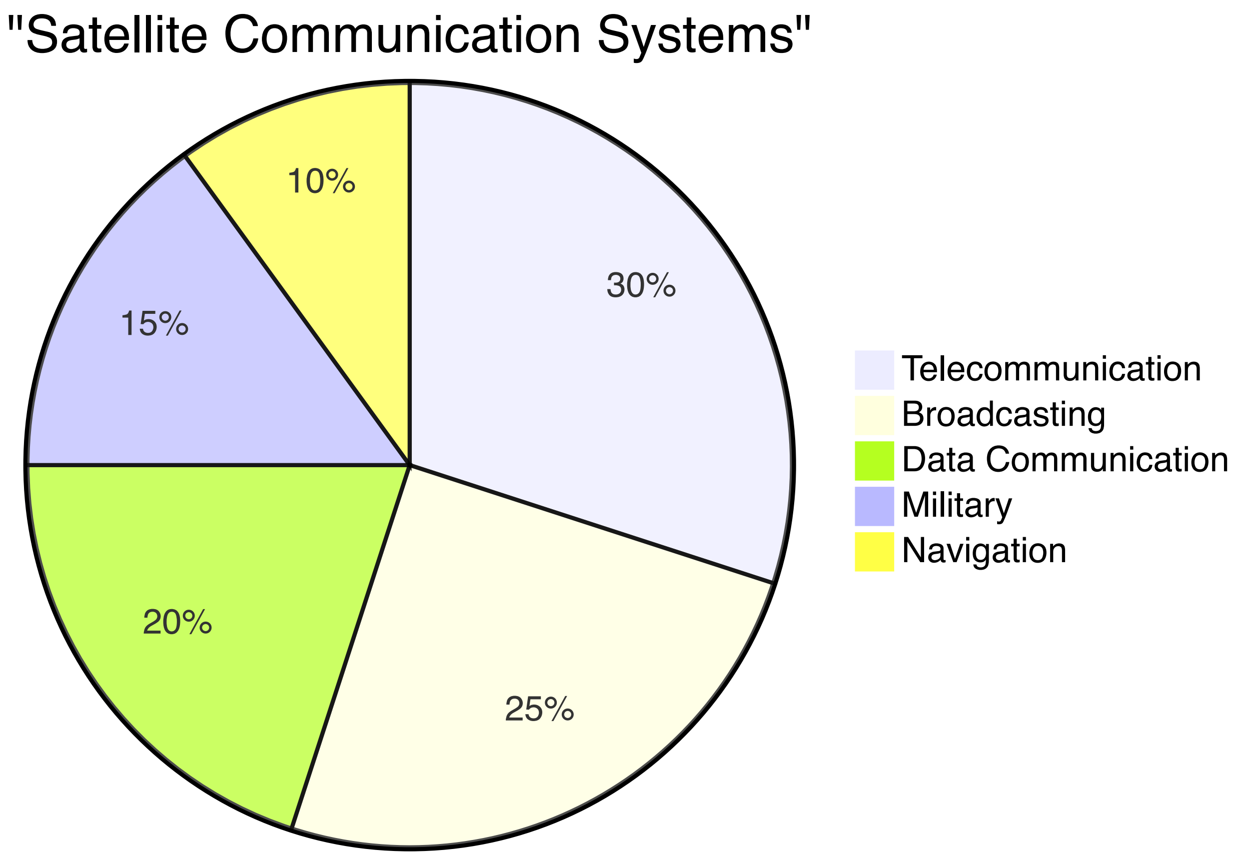
Give names of different types of satellite communication systems and compare it.

Answer:

Table: Satellite Communication Systems

System Type	Frequency Bands	Applications	Characteristics
Telecommunication	C, Ku, Ka bands	Phone, data, internet	Global coverage, high capacity
Broadcasting	Ku, C bands	TV, radio transmission	High power, wide coverage
Data Communication	L, S, Ka bands	IoT, VSAT, M2M	Low to medium data rates
Military	X, EHF bands	Secure communications	Encrypted, jam-resistant
Navigation	L band	GPS, GLONASS, Galileo	Precise timing, positioning

Diagram:



Mnemonic: "TBDMN: Telecom, Broadcasting, Data, Military, Navigation"

Question 5(c) [7 marks]

Draw and explain DTH receiver system.

Answer:

DTH (Direct-to-Home) system delivers television programming directly to viewers via satellite.

Diagram:

```
                TV
                |
                v
            Set-top Box
                |
                v
             LNB/LNBF <---- Satellite signals
                |
                v
            Dish Antenna
             (0.6-1.2m)
```

Table: DTH System Components

Component	Function	Specifications
Dish Antenna	Collects satellite signals	45-120 cm diameter
LNB (Low Noise Block)	Converts high frequency to lower IF	Noise figure: 0.3-1.0 dB
Coaxial Cable	Carries IF signal to receiver	RG-6 type, 75 ohm
Set-top Box	Demodulates/decodes signals	MPEG-2/4 decoder
TV Set	Displays programming	HDMI/Component input

- **Frequency**: Ku-band (10.7-12.75 GHz) or C-band (3.7-4.2 GHz)
- **Modulation**: QPSK or 8PSK digital modulation
- **Signal processing**: Digital compression (MPEG-2/4)
- **Features**: EPG (Electronic Program Guide), PVR (recording)

Mnemonic: "DOCS: Dish Obtains, Converts and Shows signals"

Question 5(a) OR [3 marks]

What is the Need of Smart Antennas? Write its applications.

Answer:

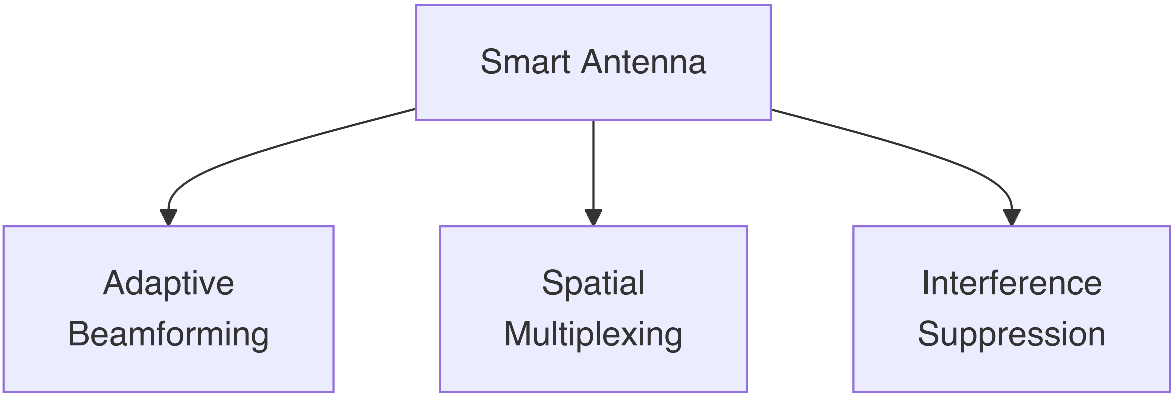
Smart antennas use adaptive signal processing to dynamically optimize radiation patterns.

Needs:

- Increased capacity in congested networks

- Improved signal quality and coverage
- Reduced interference and multipath fading
- Enhanced spectral efficiency

Diagram:



Applications:

- Mobile communication networks (4G/5G)
- MIMO systems for high data rates
- Radar systems with enhanced target detection
- Wireless LANs with improved coverage

Mnemonic: "SAFE: Smart Antennas For Efficiency"

Question 5(b) OR [4 marks]

Explain Kepler's 3rd law.

Answer:

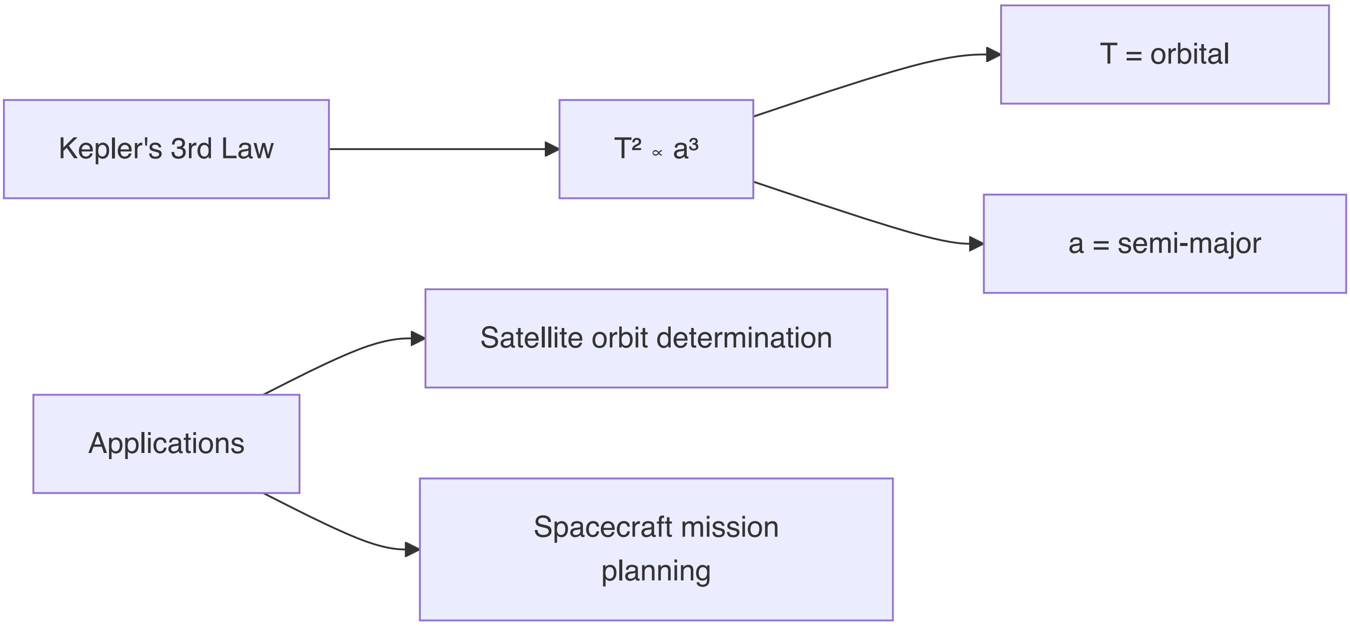
Kepler's 3rd law relates the orbital period of a satellite to its semi-major axis.

Formula: $T^2 = (4\pi^2/GM) \times a^3$

Where:

- T = orbital period
- a = semi-major axis
- G = gravitational constant
- M = mass of central body

Diagram:



- **Meaning**: Larger orbits have longer periods
- **Application**: Determines satellite orbit characteristics
- **Geostationary orbit**: Period = 24 hours, altitude ≈ 35,786 km

Mnemonic: "CAP: Cube of Axis equals Period squared"

Question 5(c) OR [7 marks]

Identify the different types of Antennas for Terrestrial Mobile communication and explain in detail.

Answer:

Table: Terrestrial Mobile Communication Antennas

Antenna Type	Typical Gain	Polarization	Applications
Base Station Antennas	10-18 dBi	Vertical/Dual	Cell towers, fixed infrastructure
Mobile Station Antennas	0-3 dBi	Vertical	Smartphones, vehicles, portable devices
Repeater Antennas	5-10 dBi	Circular/Dual	Signal boosting, coverage extension
Diversity Antennas	Variable	Multiple	Multipath mitigation, MIMO systems

Base Station Antennas (Detailed):

Diagram:

```
     ┌────┐
     │    │
     │    │
     │    │      Array of
     │    │     radiating
     │    │     elements
     │    │
     │    │
     │    │
     │    │
     └────┘
       |
    Sector coverage
```

- **Types**: Panel arrays, collinear arrays, sector antennas
- **Characteristics**:
  - High gain (10-18 dBi)
  - Directional radiation pattern (60°-120° sectors)
  - Downtilt capability (electrical/mechanical)
  - Multiple-band operation
- **Advanced features**:
  - Multiple-input multiple-output (MIMO)
  - Remote electrical tilt (RET)
  - Integrated diplexers/triplexers

Mobile Station Antennas:

- Compact size (internal/external)
- Omnidirectional pattern
- Multiple band support (700-2600 MHz)
- Implementations: PIFA, helical, monopole designs

Mnemonic: "BEST: Base-stations Employ Sector Technology"