# Subject Name Solutions

4341106 – Summer 2024

Semester 1 Study Material

*Detailed Solutions and Explanations*

## Question 1(a) [3 marks]

**Define Beam Area and Beam Efficiency.**

### Solution

**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**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Beam Area] {-{-}{} B[Solid angle containing{}br /{}most of the radiated power]}
    C[Beam Efficiency] {-{-}{} D[Main Beam Power/Total Power]}
    D {-{-}{} E[Higher efficiency = Better antenna]}
{Highlighting}
{Shaded}
```

### Mnemonic

"BEAM: Better Efficiency Achieves Maximum performance"

## Question 1(b) [4 marks]

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

### Solution

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 anter
      |      ↑       |          |
      |   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) $\rightarrow intermediate \rightarrow farfield(radiating)$

**Mnemonic**

"CERD: Current Excites Radiating Dipole"

## Question 1(c) [7 marks]

**Explain Power radiated by elementary dipole using Poynting Vector.**

**Solution**

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

Table 1: Key Steps in Poynting Vector Analysis

| Step | Description |
|---|---|
| 1 | Calculate E-field components (E , E ) |
| 2 | Calculate H-field components (H , H ) |
| 3 | Determine Poynting vector: P = E $\times H$ |
| 4 | Integrate over a spherical surface |

**Diagram**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Poynting Vector{br /{}P = E  H] {-}{-}{} B[Time{-}average{}br /{}power density]}
    B {-{-}{} C[Integrate over sphere{}br /{}P = ·ds]}
    C {-{-}{} D[Power radiated{}br /{}P = 80 ^{2}I^{2}l^{2}/ ^{2}]}
{Highlighting}
{Shaded}
```

- **Electric field**: E = (j  I$_0 dl/2r) sine^{-}$
- **Magnetic field**: H = (j I$_0 dl/2r) sine^{-}$
- **Poynting vector**: P = E $\times H* = (|I_0|^2|dl|^2/8^2r^2)sin^2$
- **Total power**: P = ( |I$_0|^2|dl|^2/12) = 80^2I^2l^2/^2$

**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.**

**Solution**

Table 2: 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**:

```
pie
    title "Antenna Performance Factors"
    "Directivity" : 25
    "Gain" : 25
    "Effective Aperture" : 20
    "Radiation Pattern" : 15
    "FBR" : 15
```

**Mnemonic**

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

## Question 2(a) [3 marks]

**Explain principle of pattern multiplication.**

**Solution**

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

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Array Pattern] {-{-}{} B["Element Pattern  Array Factor"]}
    B {-{-}{} C[Total Field Pattern]}
    C {-{-}{} D[Directivity Enhancement]}
{Highlighting}
{Shaded}
```

- **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.**

**Solution**

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

```
feed
```

- **Small loop**: Circumference <  /10, figure-8 pattern
- **Large loop**: Circumference ≈ , *maximumradiationperpendiculartoplane*
- **Applications**: Direction finding, AM radio reception
- **Radiation resistance**: Proportional to (circumference/ )$^4$ *forsmallloops*

**Mnemonic**

"LOOP: Low Output, Orientation Precise"

## Question 2(c) [7 marks]

**Design a Yagi-uda antenna and explain it.**

**Solution**

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

Table 3: Yagi-Uda Antenna Design Guidelines

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

**Diagram**:

```
Director 2     Director 1      Driven      Reflector
                              Element

   {{-}{-}0.15 {-}{-} {-}{-}0.15 {-}{-} {-}{-}0.25 {-}{-}      Radiation}
   {{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-} Boom Length {-}{-}{-}{-}{-}{-}{-}{-}{-}{-}      Direct
```

- **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.**

### Solution

Table 4: 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° | $180° \pm d$ |
| Beam Width | Narrower | Wider |
| Directivity | Higher | Lower |
| Applications | Broadcasting | Point-to-point links |

**Diagram**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Array Antennas] {-{-}{} B[Broad Side]}
    A {-{-}{} C[End Fire]}
    B {-{-}{} D[Max radiation perpendicular{}br /{}to array axis]}
    C {-{-}{} E[Max radiation along{}br /{}array axis]}
{Highlighting}
{Shaded}
```

### Mnemonic

"BEPS: Broadside Emits Perpendicularly, Sideways"

## Question 2(b) OR [4 marks]

**Draw & Explain Folded dipole antenna.**

### Solution

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

**Diagram**:

```
        /2



feed
```

- **Impedance**: 4 times higher than standard dipole (≈ 300)
- **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.**

**Solution**

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

**Rhombic Antenna in Detail:**

**Diagram**:

```
                   /         {}
                  /           {}
                 /             {}
                /               {}
               /                 {}
              /                   {}
             /                     {}
            /                       {}
           /                         {}



Feeder                               Terminating
                                      Resistor
```

Table 5: 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.**

**Solution**

Table 6: 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 |
| 3 /2 Dipole | Six-lobed | 4.2 dBi | Linear |

| | | | | |
|---|---|---|---|---|
| 2 | Dipole | Eight-lobed | 4.5 dBi | Linear |

**Diagram**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph TD
    A[Resonant Wire Antennas] {-{-}{} B[Half{-}Wave Dipole{}br /{}Figure{-}8 Pattern]}
    A {-{-}{} C[Full{-}Wave Dipole{}br /{}Four{-}lobed Pattern]}
    A {-{-}{} D[Multi{-}wavelength Dipole{}br /{}Multi{-}lobed Pattern]}
{Highlighting}
{Shaded}
```

**Mnemonic**

"MOLD: More wavelengths create Lots of Directivity lobes"

## Question 3(b) [4 marks]

**Draw V and Inverted V antenna with radiation Pattern.**

**Solution**

**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.**

**Solution**

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

Table 7: 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.**

**Solution**

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.**

**Solution**

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.**

**Solution**

Table 8: 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**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Parabolic Reflector] {-{-}{-} B[Focal Point]}
    B {-{-}{-} C[Feed Horn]}
    C {-{-}{-} D[Waveguide/Coax]}
    D {-{-}{-} E[Receiver/Transmitter]}
{Highlighting}
{Shaded}
```

- **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.**

**Solution**

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

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Transmitter] {-{-}{} B[Antenna]}
    B {-{-}{} C[Propagation Medium]}
    C {-{-}{} D[Receiver Antenna]}
    D {-{-}{} E[Receiver]}
{Highlighting}
{Shaded}
```

- **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.**

**Solution**

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.**

**Solution**

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

Table 9: 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**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Transmitter] {-{-}{} B[High Gain Antenna]}
    B {-{-}{} C[Scattering Volume{}br /{}in Troposphere]}
    C {-{-}{} D[Receiving Antenna]}
    D {-{-}{} E[Receiver]}
    F[Factors] {-{-}{} G[Weather]}
    F {-{-}{} H[Frequency]}
    F {-{-}{} I[Antenna Size]}
{Highlighting}
{Shaded}
```

- **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.**

**Solution**

**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.**

**Solution**

Table 10: 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**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph TD
    A[Ionospheric Frequencies] {-{-}{} B[MUF]}
    A {-{-}{} C[LUF]}
    A {-{-}{} D[OUF]}
    B {-{-}{} E[Highest frequency{}br /{}that returns to Earth]}
    C {-{-}{} F[Lowest frequency{}br /{}with adequate SNR]}
    D {-{-}{} G[Best working frequency{}br /{}85\% of MUF]}
{Highlighting}
{Shaded}
```

**Mnemonic**

"MLO: Maximum and Lowest determine Optimum"

## Question 4(c) OR [7 marks]

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

**Solution**

Table 11: 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  , where h is virtual height and   is incidence angle

**Mnemonic**

"VCS: Virtual height Controls Skip distance"

## Question 5(a) [3 marks]

**With neat figure show different Ionosphere layers.**

**Solution**

**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.**

**Solution**

Table 12: 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**:

```
pie
    title "Satellite Communication Systems"
    "Telecommunication" : 30
    "Broadcasting" : 25
    "Data Communication" : 20
    "Military" : 15
    "Navigation" : 10
```

**Mnemonic**

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

## Question 5(c) [7 marks]

**Draw and explain DTH receiver system.**

**Solution**

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 13: 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.**

**Solution**

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**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph TD
    A[Smart Antenna] {-{-}{} B[Adaptive{}br /{}Beamforming]}
    A {-{-}{} C[Spatial{}br /{}Multiplexing]}
    A {-{-}{} D[Interference{}br /{}Suppression]}
{Highlighting}
{Shaded}
```

**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.**

**Solution**

Kepler's 3rd law relates the orbital period of a satellite to its semi-major axis.
**Formula**: $\mathrm{T}^2 = (4^2/GM) \times a^3$
Where:

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

**Diagram**:

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    A[Kepler{s 3rd Law] {-}{-}{} B["T^{2}  a^{3}"]}
    B {-{-}{} C[T = orbital period]}
    B {-{-}{} D[a = semi{-}major axis]}
    E[Applications] {-{-}{} F[Satellite orbit determination]}
    E {-{-}{} G[Spacecraft mission planning]}
{Highlighting}
{Shaded}
```

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

**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.**

**Solution**

Table 14: 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"