### Q7)Structure of an 802.11 PHY Layer Frame

The **PHY (Physical) layer frame** in 802.11 Wi-Fi is responsible for transmitting raw data bits over the air. Its structure varies slightly depending on the standard (e.g., DSSS, OFDM), but the general components are consistent. Below is a breakdown of the **OFDM-based PHY frame** (used in 802.11a/g/n/ac/ax/be):

**1. Key Components of an 802.11 PHY Frame**

An 802.11 PHY frame consists of three main parts:

1. **Preamble**
2. **PHY Header (PLCP Header)**
3. **Data Field (PSDU – PLCP Service Data Unit)**

**A. Preamble**

The preamble synchronizes the transmitter and receiver and prepares for decoding.

**Legacy Preamble (802.11a/g)**

* **Short Training Field (STF)**
  + Helps with **signal detection, synchronization, and frequency correction**.
  + Duration: **8 μs** (10 short symbols).
* **Long Training Field (LTF)**
  + Used for **channel estimation and fine-tuning**.
  + Duration: **8 μs** (2 long symbols).

**High-Efficiency (HE) Preamble (802.11ax)**

* **Repeated STF/LTF** for multi-user (MU) transmissions.
* **Additional fields** for **BSS coloring** (to reduce interference in dense networks).

**B. PHY Header (PLCP Header)**

Carries metadata about the transmission.

* **Signal (SIG) Field** (Legacy) / **HE-SIG (802.11ax)**
  + **Modulation scheme** (e.g., BPSK, QAM).
  + **Data rate** (e.g., 6 Mbps, 54 Mbps).
  + **Frame length** (in bytes).
  + **Channel bandwidth** (20/40/80/160 MHz).
* **Service Field**
  + Contains **scrambler seed** to avoid long sequences of 0s/1s.

**C. Data Field (PSDU – PLCP Service Data Unit)**

The actual payload from the MAC layer, including:

1. **MAC Protocol Data Unit (MPDU)**
   * Contains **source/destination addresses, control info, and user data**.
2. **Tail Bits (6 bits)**
   * Resets the convolutional encoder (used in error correction).
3. **Pad Bits**
   * Ensures the frame fits the OFDM symbol structure.

**2. Differences Across Wi-Fi Standards**

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| Standard | Preamble Type | Modulation | Key PHY Features |
| 802.11a/g | Legacy (STF/LTF) | OFDM | Fixed 20 MHz channels. |
| 802.11n | Mixed (Legacy + HT) | OFDM + MIMO | 40 MHz channels, Greenfield mode. |
| 802.11ac | VHT Preamble | OFDM + MU-MIMO | 160 MHz, 256-QAM. |
| 802.11ax | HE Preamble | OFDMA | BSS coloring, TWT. |
| 802.11be (Wi-Fi 7) | EHT Preamble | Multi-Link OFDMA | 320 MHz, 4096-QAM. |