📘 1. Lecture Content Outline & Notes

Title: Frequency Response of LTI Systems

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1. Introduction

- The frequency response describes how an LTI system responds to sinusoidal inputs of different frequencies.
- Especially useful for analyzing **filters**, **control systems**, and **communication systems**.

2. Definition

- If an LTI system is subjected to a complex exponential input:

$$x(t) = e^{j\omega t}$$

- The output is:

$$y(t) = H(j\omega)e^{j\omega t}$$

- Where:
  - $H(j\omega)$ is the **frequency response** of the system.
  - It is the Fourier Transform of the **impulse response** $h(t)$.

3. Computation of Frequency Response

- For **continuous-time** systems:

$$H(j\omega) = \int_{-\infty}^{\infty} h(t)e^{-j\omega t}dt$$

- For **discrete-time** systems:

$$H(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h[n]e^{-j\omega n}$$

4. Interpretation

- $|H(j\omega)|$: **Gain** (Amplitude response) at frequency ω
- $\angle H(j\omega)$: **Phase shift** introduced at frequency ω

5. Bode Plot

- Bode plot = Logarithmic plot of:
  - Magnitude $20 \log_{10} |H(j\omega)|$
  - Phase $\angle H(j\omega)$
- Useful for understanding:
  - Stability
  - Resonance
  - Filter behavior

6. Example Applications

- **Low-pass filter**: Passes low frequencies, attenuates high
- **High-pass filter**: Opposite
- **Band-pass filter**: Passes a specific range