**Practical 5**

Spectral Density Plot

using the "AirPassengers" dataset to perform spectral analysis. We will plot the spectral density to identify the dominant frequencies in the data. The "AirPassengers" dataset contains monthly totals of international airline passengers from 1949 to 1960, making it an excellent example for this analysis.

### **Explanation of the Code**

1. **Loading Libraries:**
   * We load the necessary libraries: ggplot2, forecast, and tseries. If the packages are not already installed, the code will install them first.
2. **Loading "AirPassengers" Dataset:**
   * We load the "AirPassengers" dataset, which comes pre-installed with R. This dataset contains the monthly totals of international airline passengers from 1949 to 1960.
3. **Plotting Original Data:**
   * We plot the original "AirPassengers" data using ggplot2 to visualize the monthly passenger counts over time.
4. **Performing Spectral Analysis:**
   * We use the spectrum function from the tseries package to perform spectral analysis on the "AirPassengers" data. The periodogram is generated to identify the dominant frequencies in the data.
5. **Plotting the Spectral Density:**
   * We plot the spectral density using base R plotting functions. The x-axis represents the frequency, and the y-axis represents the spectral density.

### **Interpreting the Results**

* **Spectral Density Plot:**
  + The spectral density plot will display peaks at frequencies corresponding to periodic components in the "AirPassengers" data. These peaks indicate the presence of seasonal patterns or other periodicities.

**Example 2**

We'll use the Mauna Loa CO2 dataset again, but this time we'll generate and analyze a moving average (MA) series and an autoregressive (AR) series. We will plot the spectral density for both series to understand their frequency components.

### **Explanation of the Code**

1. **Loading Libraries:**
   * The necessary libraries (forecast, ggplot2, and tseries) are loaded. If they are not installed, the code will install them first.
2. **Downloading and Preprocessing Data:**
   * The Mauna Loa CO2 dataset is downloaded and preprocessed. Missing values in the average column are removed, and a time series object co2\_ts is created.
3. **Plotting Data:**
   * The original CO2 data is plotted using autoplot from the forecast package to visualize the CO2 concentration over time.
4. **Generating Moving Average (MA) Series:**
   * A moving average series is generated using the filter function with an order of 3. The sides = 2 parameter ensures a centered moving average.
5. **Generating Autoregressive (AR) Series:**
   * An autoregressive series of order 1 is generated using the arima.sim function with an AR coefficient of 0.7.
6. **Plotting Series:**
   * The original, moving average, and autoregressive series are plotted to visualize their behavior over time.
7. **Spectral Analysis:**
   * Spectral analysis is performed on the MA and AR series using the spectrum function from the tseries package.
   * The periodograms (plots of spectral density) for both the MA and AR series are plotted to identify the dominant frequencies in each series.

### **Interpreting the Results**

* **MA Series:**
  + The moving average series smooths the original data, reducing short-term fluctuations and highlighting longer-term trends.
  + The periodogram of the MA series will show the spectral density across frequencies, helping identify any dominant periodic components.
* **AR Series:**
  + The autoregressive series models the current value as a function of its previous values, capturing the dependency structure in the data.
  + The periodogram of the AR series will display peaks at frequencies corresponding to the autoregressive process's dominant cycles.