# Time Series Analysis (TSA) – Study Notes

Time Series Analysis (TSA) is a statistical method to analyze data points collected at regular intervals to find patterns, trends, and make forecasts. It is widely used in fields like weather forecasting, stock market prediction, signal processing, and economics.

## Objectives of Time Series Analysis

- Understand how variables change over time  
- Detect consequences/insights from time-based data  
- Predict future values using historical patterns  
- Key Assumption: Data should be stationary (mean and variance constant over time)

## Components of Time Series

1. Trend – Long-term increase or decrease in data.  
2. Seasonality – Regular repeating patterns at fixed intervals.  
3. Cyclical – Irregular but recurring movements (not fixed).  
4. Irregularity – Random and unpredictable variations.

## Stationarity in Time Series

A stationary series has constant mean, variance, and covariance over time. Non-stationary data needs transformation before modeling.  
Tests to check stationarity:  
- Augmented Dickey-Fuller (ADF)  
- KPSS  
Methods to convert non-stationary data:  
- Detrending  
- Differencing  
- Transformation (log, square root, etc.)

## Methods in Time Series Analysis

1. Moving Averages:  
 - SMA (Simple Moving Average)  
 - CMA (Cumulative Moving Average)  
 - EMA (Exponential Moving Average)  
  
2. Autoregression (AR) – Uses past values to predict future values.  
3. Moving Average (MA) – Uses past errors to forecast.  
4. ARMA (AR + MA) – For stationary series.  
5. ARIMA (AR + I + MA) – Works for both stationary & non-stationary series.

## ACF and PACF Interpretation

- ACF (Auto-Correlation Function): Correlation with lagged values.  
- PACF (Partial Auto-Correlation Function): Direct correlation after removing intermediates.  
  
Interpretation:  
- Gradual ACF decline & instant PACF drop → AR model  
- Instant ACF drop & gradual PACF decline → MA model  
- Both gradual declines → ARMA model  
- Both instant drops → Not suitable

## Deep Learning in Time Series

Recurrent Neural Networks (RNNs) are widely used for sequence forecasting.  
Advantages:  
- Remembers past information  
- Good for complex patterns  
- Handles missing values  
  
Disadvantages:  
- High computational cost  
- Longer training time

## Limitations of TSA

- Requires clean, complete data  
- Mainly supports univariate data  
- Needs transformation for non-linear data  
- Can be computationally expensive

## Key Takeaways

- TSA is essential for analyzing time-dependent data.  
- Identify components: Trend, Seasonality, Cyclic, Irregularity.  
- Stationarity is crucial for model performance.  
- Models: AR, MA, ARMA, ARIMA.  
- Advanced methods: Deep Learning (RNN, LSTM).