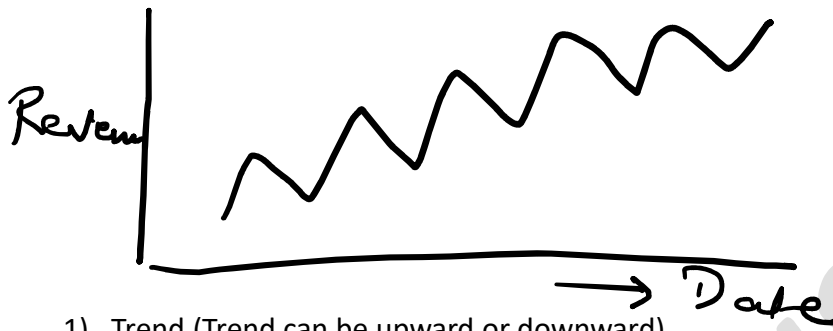


Time Series

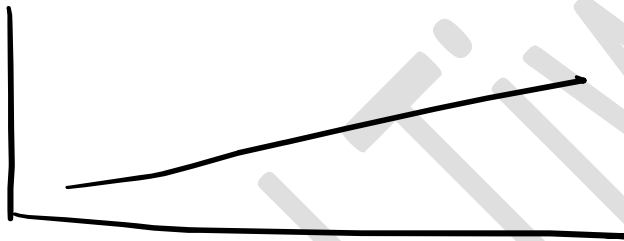
When we want to predict over the period of time, it is important for the businesses as well

There are four components of time series

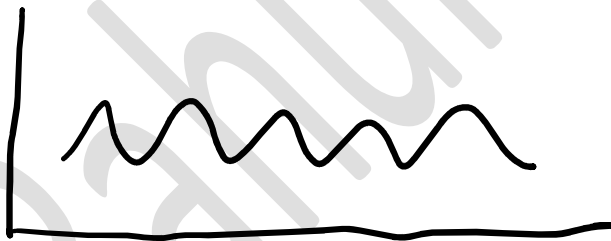
Time Series



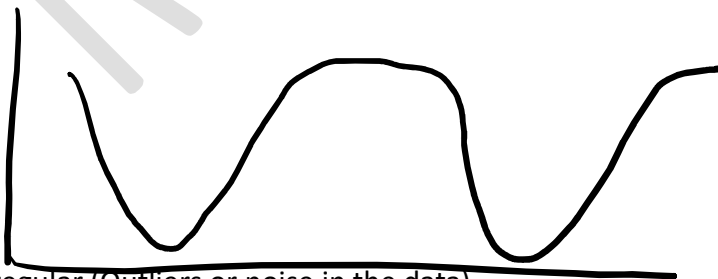
- 1) Trend (Trend can be upward or downward)



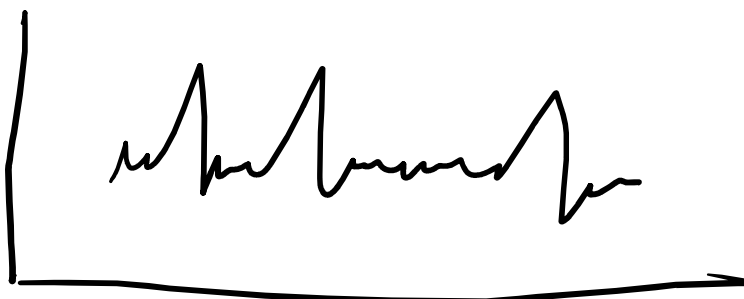
- 2) Seasonality (Season for ex: Every September the sales is increasing and every March the sales is decreasing)



- 3) Cyclical (We cannot predict this, like recession, Covid etc.)



- 4) Irregular (Outliers or noise in the data)



How to check the accuracy in the time series

There are four major measure which we can use to check the accuracy of the model

- a) Mean Absolute Error (MAE) – This should be less

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_{iA} - y_{iP}|$$

n = Total records

y_{iA} = Actual data

y_{iP} = Predicted data

- b) Mean Absolute Percentage Error (MAPE) – This should be less

$$MAPE = \frac{1}{n} \sum_{i=1}^n \frac{|y_{iA} - y_{iP}|}{y_{iA}}$$

n = Total records

y_{iA} = Actual data

y_{iP} = Predicted data

- c) Mean Squared Error (MSE) – This should be less

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_{iA} - y_{iP})^2$$

n = Total records

y_{iA} = Actual data

y_{iP} = Predicted data

- d) Root Mean Squared Error (RMSE) – This should be less

$$RMSE = \sqrt{MSE}$$

- e) Akaike Information criteria (AIC) and Bayesian Information criteria (BIC) - This should be less

There are various models which we have for time series

- a) Single Exponential Smoothing – Winter's model (Peter Winters) – We are just taking the averages and we are not considering the Trend as well seasonality
- b) Double Exponential Smoothing – Holt's model (Charles Holt) – We are considering the trend
- c) Triple Exponential Smoothing – Holt's and Winter's model – We are considering both trend and seasonality

Tools like Tableau it uses Double or Triple Exponential Smoothing

Machine Learning Algorithms

- a) Auto Regressive (AR Model)

- b) **Moving Average (MA Model)**
- c) **Auto Regressive Moving Average (ARMA Model)**
- d) **Auto Regressive Integrated Moving Average (ARIMA Model)**
- e) **Auto Regressive Integrated Moving Average with External Factor (ARIMAX)**

There is one assumption that the time series is stationary so we can apply any of the algorithms and if the time series is not stationary in that case, we have to apply ARIMA



How we will get to know that the time series is stationary or not, we have a statistical test that is **Augmented Dickey Fuller Test (ADF Test)**

H_0 : Time Series is not Stationary

H_a : Time Series is Stationary

$P < 0.05 \rightarrow$ Time Series is stationary

Let's assume our time series is not stationary

	ADF	ADF	ADF
T_1	150	Null	NULL
T_2	90	-60	NULL
T_3	100	10	70
T_4	120	10	0
T_5	140	20	10
T_6	170	30	10
T_7	120	-50	-80
T_8	180	60	110
T_9	70	-110	-170
T_{10}	90	20	130
$P > 0.05$	$P > 0.05$	$P < 0.05$	

After two differencing the time series is becoming stationary

AR

I

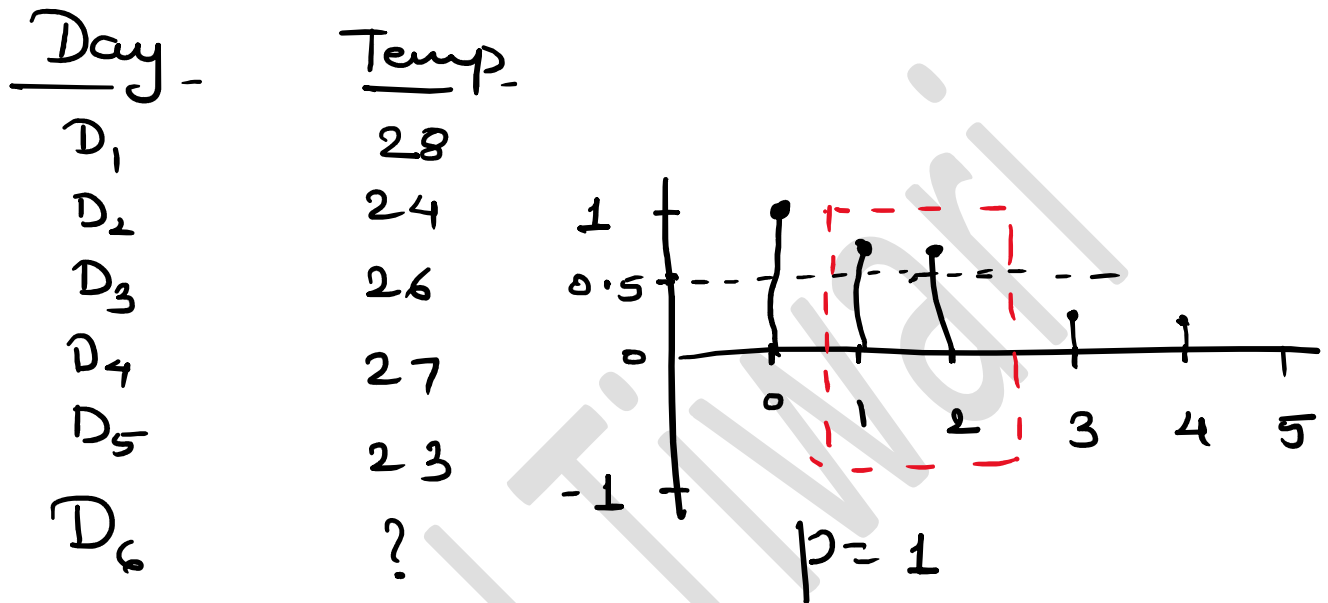
MA

(p,P)

(d=2,D=1)

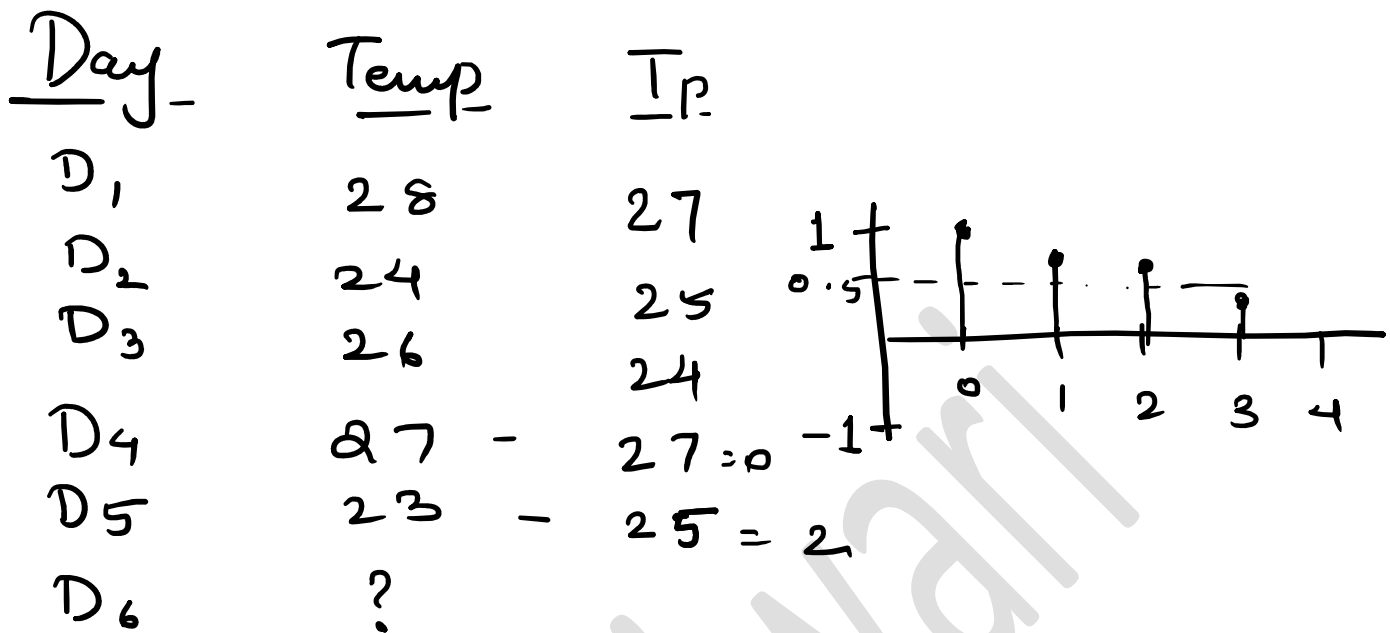
(q,Q)

Auto Regressive (p, P) – PACF (Partial Auto Correlation Function)



$$T_{D_6} = \beta_1 t_{D_5} + \beta_2 t_{D_4} + \varepsilon_{\text{mor}}$$

Moving Average (q, Q) – ACF (Auto Correlation Function)



$$\begin{aligned}
 T_{t+1} &= \alpha_1 \varepsilon_t + \alpha_2 \varepsilon_{t-1} + \dots + \mu \\
 &= 0.9 \times 2 + 0.8 \times 0 + 25.6 \\
 &= 1.8 + 0 + 25.6 \\
 &= 27.4^\circ \text{C}
 \end{aligned}$$

If we have previous days important and no errors important in that case we are running AR model

If we have previous errors important and no days important in that case we are running MA model

If we have previous errors important and previous days important in that case we are running ARMA model

If we have time series not stationary in that case we have to use ARIMA model