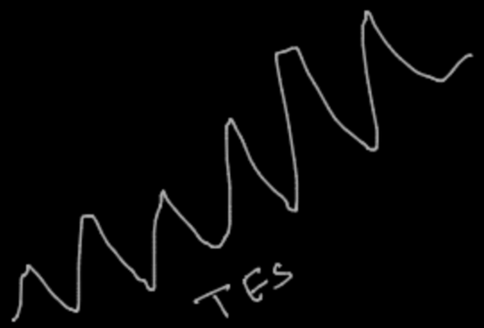
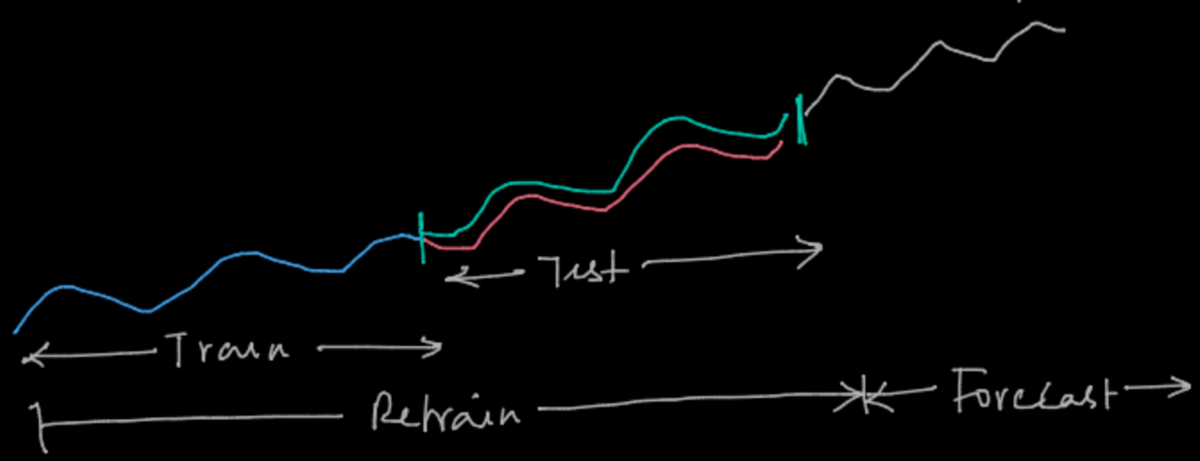
Exponential smoothing

1. Simple Exponential smoothing (SES).
   No Trend + No Seasonality
2. Double Exponential smoothing (Holt's technique)
   Trend + No seasonality
3. Triple Exponential smoothing (Holt-Winter technique)
   Trend + Seasonality

Trend < linear, non-linear

Seasonality < Additive, Multiplicative





Linear Regression ⇒

$\overline{y}$

x_1 ✓	x_2 ✓	x_3 ✓	y
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.

Time (t)	y_t		
1	.		
2	.		
3	.		
4	.		
5	.		
6 ✓	y_{t-4}	Sep	
	y_{t-3}	Oct	✓
	y_{t-2}	Nov	✓
Dec n	y_{t-1} ✓	—	✓

$y_t \rightarrow$.

$\alpha = 0.8$

$y_t = \alpha y_{t-1} + (1-\alpha) y_{t-2} + (1-\alpha)^2 y_{t-3} + (1-\alpha)^3 y_{t-4}$

$\Rightarrow 0.8\, y_{t-1} + 0.2\, y_{t-2} + 0.04\, y_{t-3}$

→ Trend + Seasonal

$R^2 \rightarrow$

y	$\hat{y}$	$(y-\hat{y})$	$(y-\hat{y})^2$	Abs $\lvert y-\hat{y} \rvert$	PE
			MSE =	MAE =	MAPE = ✓

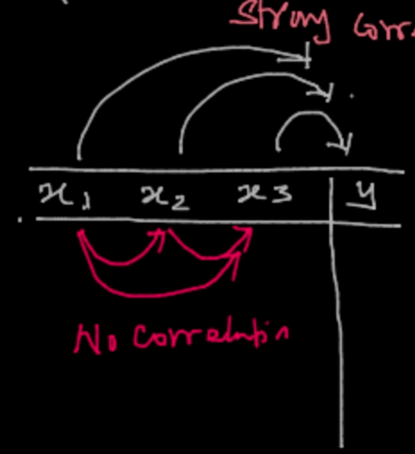
Auto Regression Models

- AR → Auto Regression -
- MA → Moving Average -
- ARMA → AR + MA .

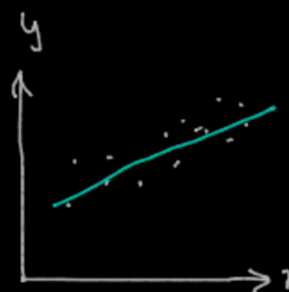
} Stationary .

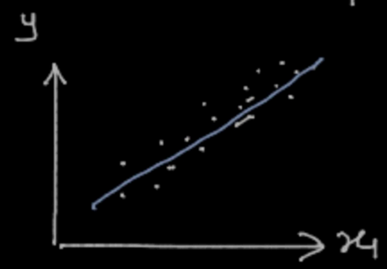
- ARIMA → Trend + No Seasonality
- SARIMA → Seasonal ARIMA .

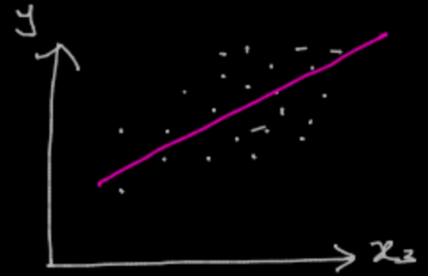
Regression :



$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$$



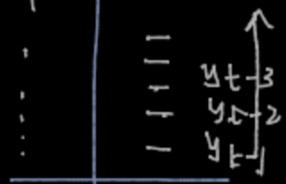




Correlation Co-eff (r) ⇒ Strength of the LINEAR Relationship between x_i & y

Auto regression

Time (t)	y
Jan 2001	1 — y_{t-306}
	2 —
	3 —
	4 —
	⋮
Dec 2023	— y_t
Jan 2024	? y_t ↓



X-values are past values of y.

y → future value of y.

$$\hat{y} = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots$$

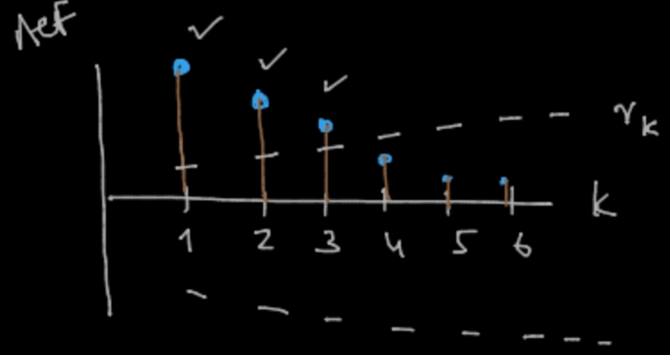
y_{t-1}	y_{t-2}	y_{t-3} . .	y_{t-306}	y_t
.	.	.		.

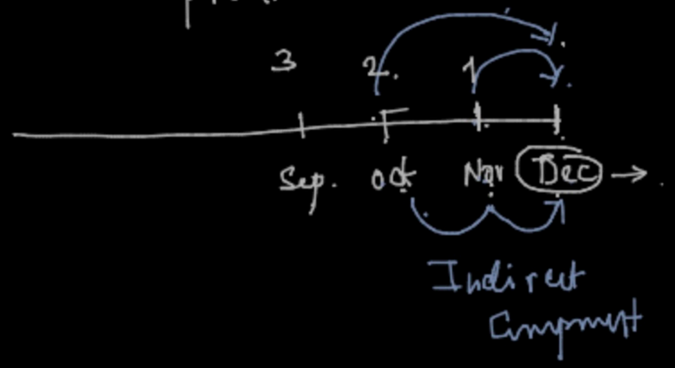
SE

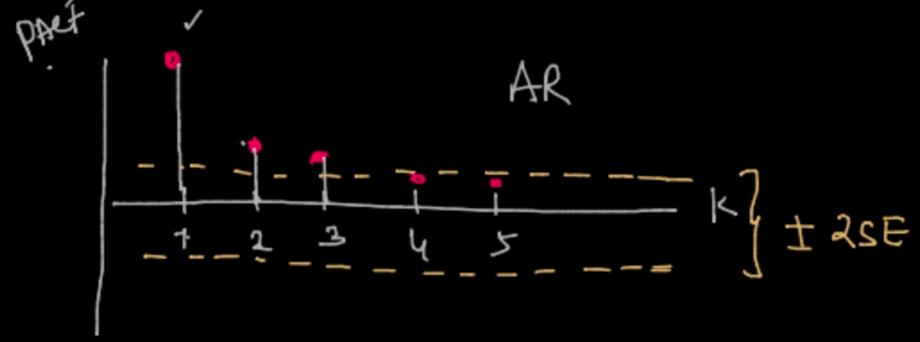
Partial ACF

ACF = Direct Component + Indirect Component

PACF = Direct Component







$$\hat{y}_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3}$$

Moving Average (MA) → Focuses on the Errors from previous periods

↳ Not Systematic

	y	$\hat{y}_t$	$y - \hat{y}_t$
W_1	12	10	2 ✓
W_2	9	11	−2 ✓
W_3	9	9	0
W_4		10	

$$\hat{y}_t = \phi_0 + \phi_1 \varepsilon_{t-1} + \phi_2 \varepsilon_{t-2} + \phi_3 \varepsilon_{t-3}$$

$\phi_0 = 10$; $\phi_1 = 0.5$

$$\hat{y}_t = \phi_0 + \phi_1 \varepsilon_{t-1}$$

$$= \boxed{10} + 0.5 \times 2$$

$$= 11$$

$$\hat{y}_t = \phi_0 + \phi_1 \varepsilon_{t-1}$$

$$= \boxed{10} + 0.5(-2)$$

$$= 10 - 1$$

ACF → How many error terms to include

ARMA → AR + MA (PACF. ACF)

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_{p-1} y_{t-p} + \phi_0 + \phi_1 \varepsilon_{t-1} + \phi_2 \varepsilon_{t-2}$$

PACF ↑ ACF ↓

Stationary → No trend
No Seasonality
Constant Variance