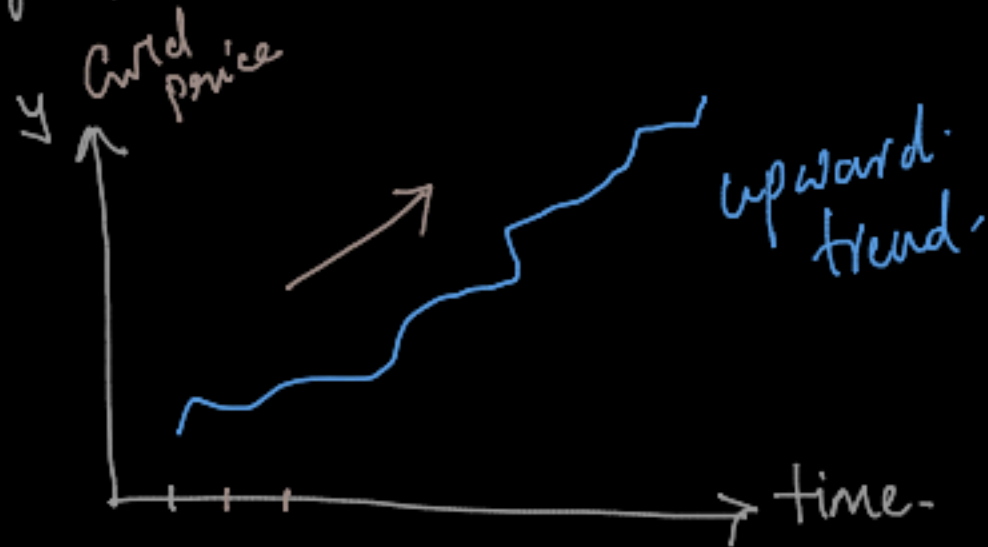
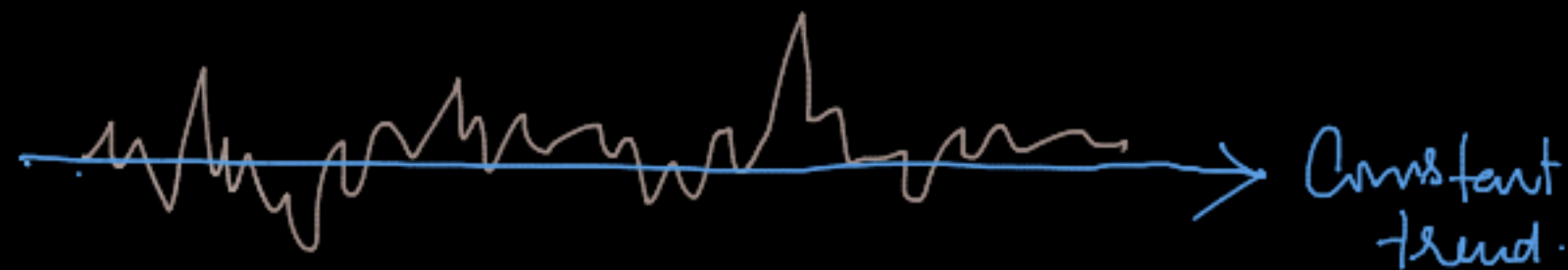
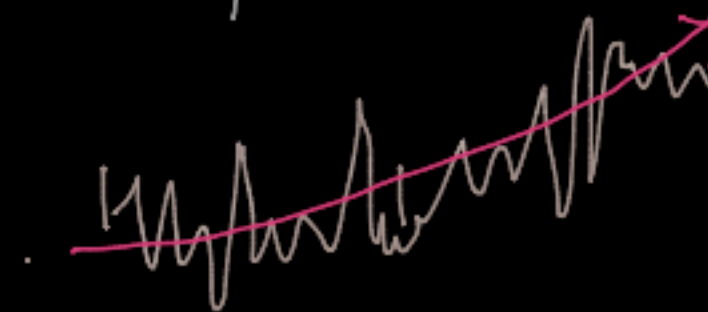


## Components of Time Series

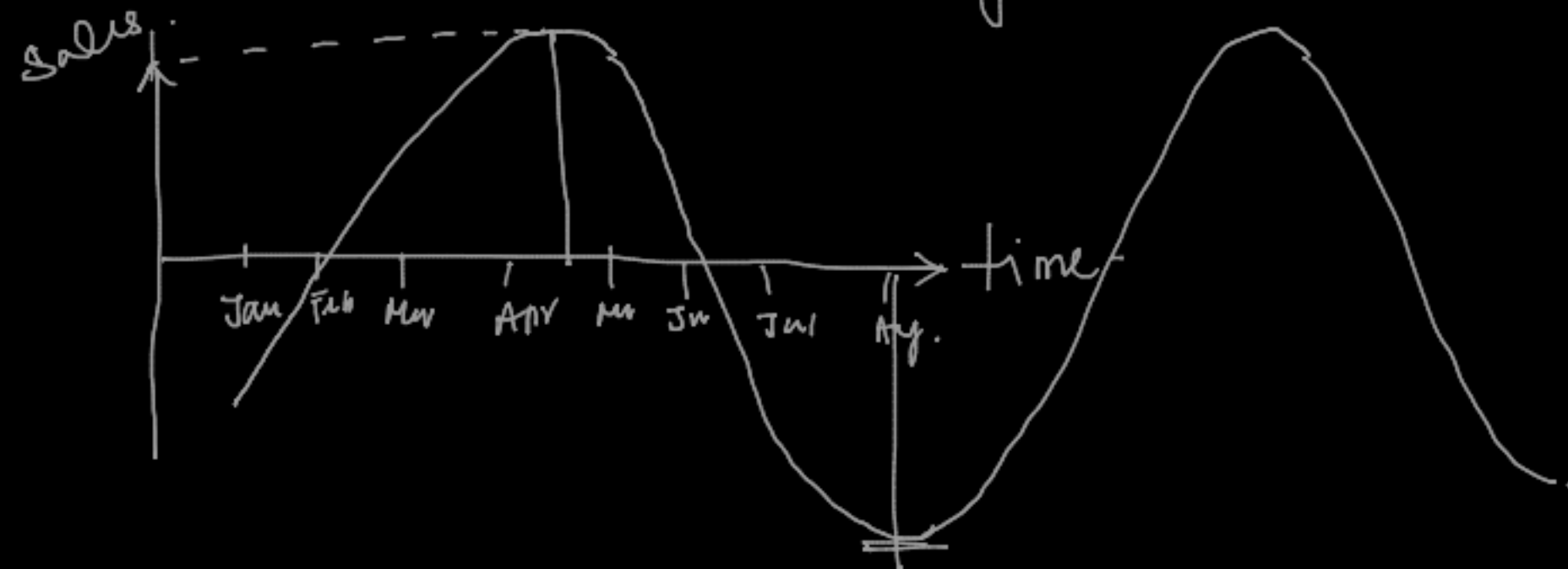
1. Level.
2. Trend
3. Seasonality
4. Cyclicity



Trend → over a longer period time



Seasonality → Measured  
Within a year -



Cyclicality → over a period of multiple years.

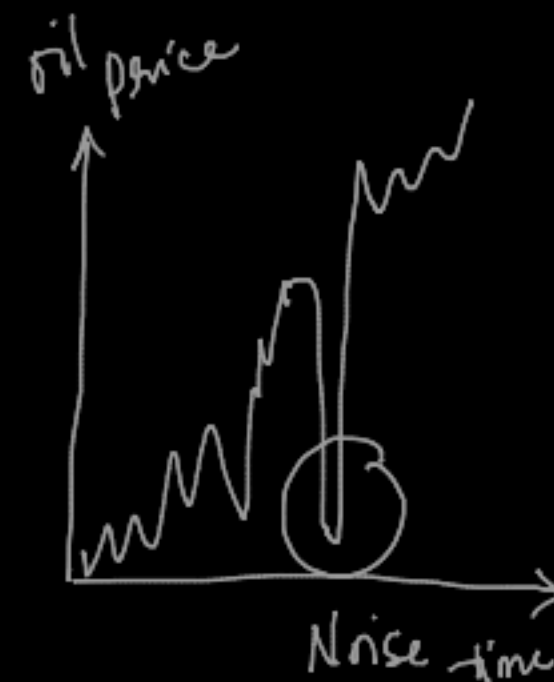
Time series

Systematic

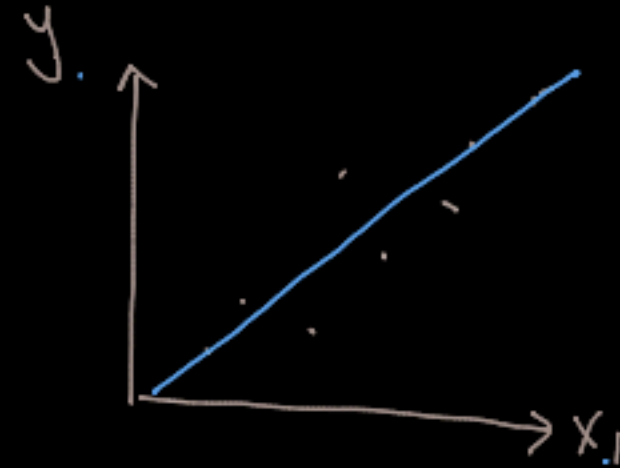
- Level
- Trend
- Seasonality
- Cyclicality

Non-systematic

— Noise —



Trend  $\begin{cases} \text{linear} \\ \text{exponential} \\ \text{polynomial} \end{cases}$



Seasonality  $\begin{cases} \text{non-seasonal} \\ \text{Additive Seasonality} \\ \text{Multiplicative Seasonality} \end{cases}$

Lag plot:  $y_{t+k}$  Vs  $y_t$

$y_t$	$y_{t-1}$	$y_{t-2}$	$y_{t+1}$
$x_1$	$x_2$	$x_3$	$y$

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

	Time (t)	Sales (y)
Jan 2000	1	
Feb 2000	2	
	3	
	$\vdots$	
	$\vdots$	
Dec 2021	n	
Jan 2022		$y_{t+1}$
Feb 2022		$y_{t+2}$

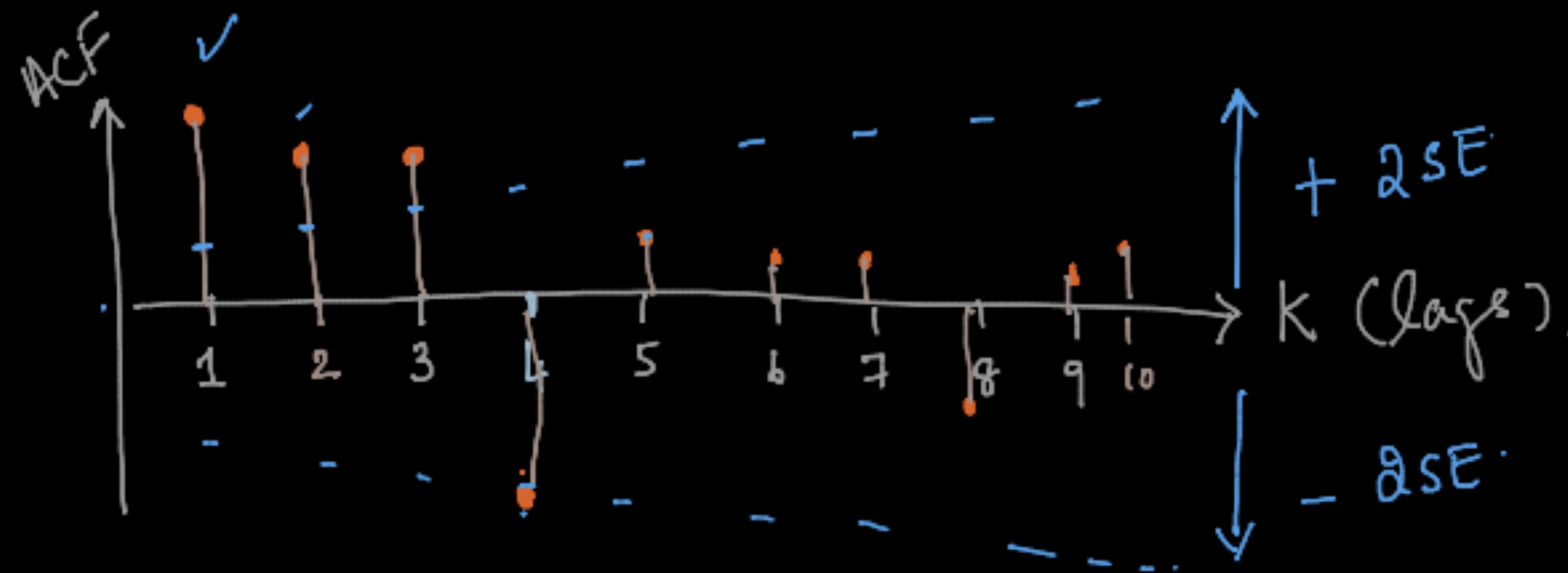
$y_{t-k}$  (with arrow pointing to row 3)  
 $y_{t-1}$  (with arrow pointing to row n)  
 $y_t$  (with arrow pointing to row n)  
 Past Values 'y'  
 Future 'y'

$$y_{t+1} = \beta_0 + \beta_1 y_t + \beta_2 y_{t-1} + \beta_3 y_{t-2} + \dots + \beta_n y_{t-3} + \beta_5 y_{t-4} + \dots + y_{t-2k}$$

22 yts  
→ 264

## Auto Correlation Factor (ACF)

— How many lagged terms should be included in your model



AR : Auto Regression  
MA →

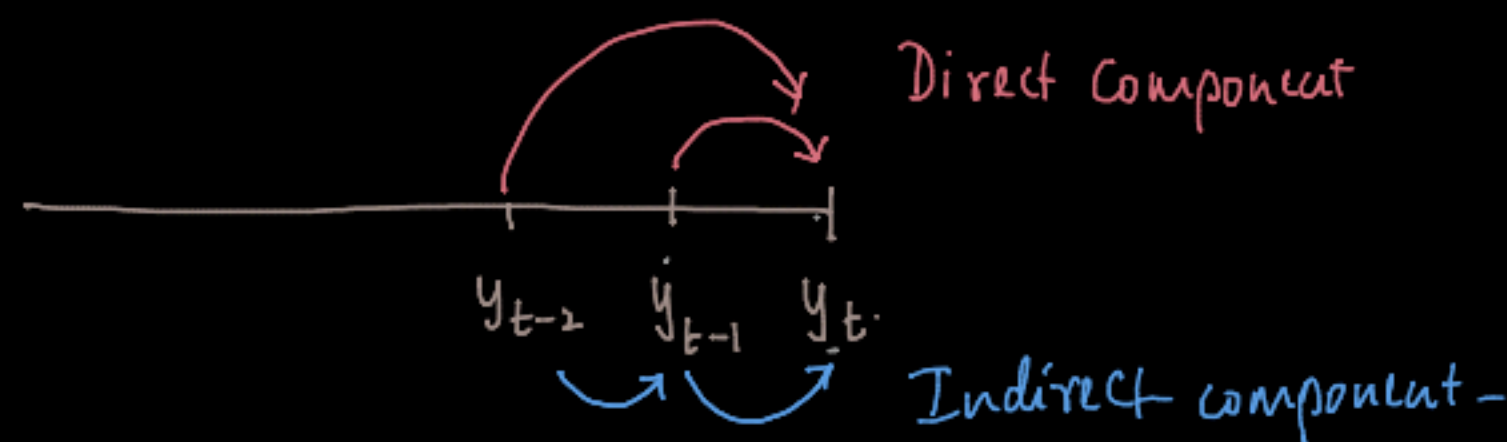
$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3} + \beta_4 y_{t-4} \quad \text{--- (1)}$$

# Partial Auto correlation Factor (PACF)

Parsimonious

miser → kangos

Potential  
10.20 am



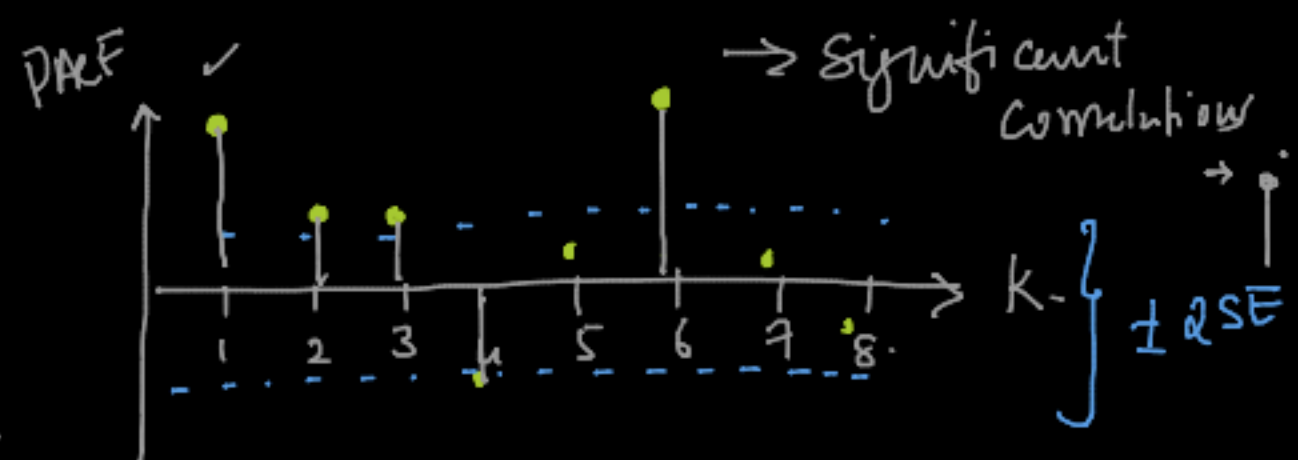
$$ACF = \text{Direct} + \text{Indirect}$$

$$k=1; \quad \boxed{ACF = PACF}$$

$$PACF = \text{Direct Component}$$

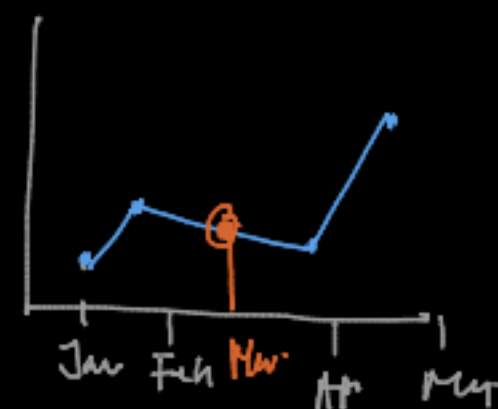
$$y = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3} + \beta_4 y_{t-4}$$

→ AR Eq<sup>n</sup>



- Pre processing
1. Look for missing data.
  2. Convert into required frequency. (Resampling).
  3. Visualize the data.
  4. Transformations  $\rightarrow$  Linear trend

Jan -  
Feb -  
Mar -  
Apr -  
May -



5. Build the model-

1. Naive Models.
2. Moving Average.
3. Smoothing technique
  - Simple Exp. Smoothing
  - Double Exp. Smoothing (Holt's method).
  - Triple Exp. Smoothing (Holt-Winters Method)

4. Auto Regression Models

- AR Model.
- MA Model
- ARMA Model
- ARIMA Model



# 1. Naive Model

$$y_{t+1} = y_t$$

$$y_{t+3}$$

$$y_{t+k} = y_t$$

$$k = 1, 2, 3, 4, \dots$$

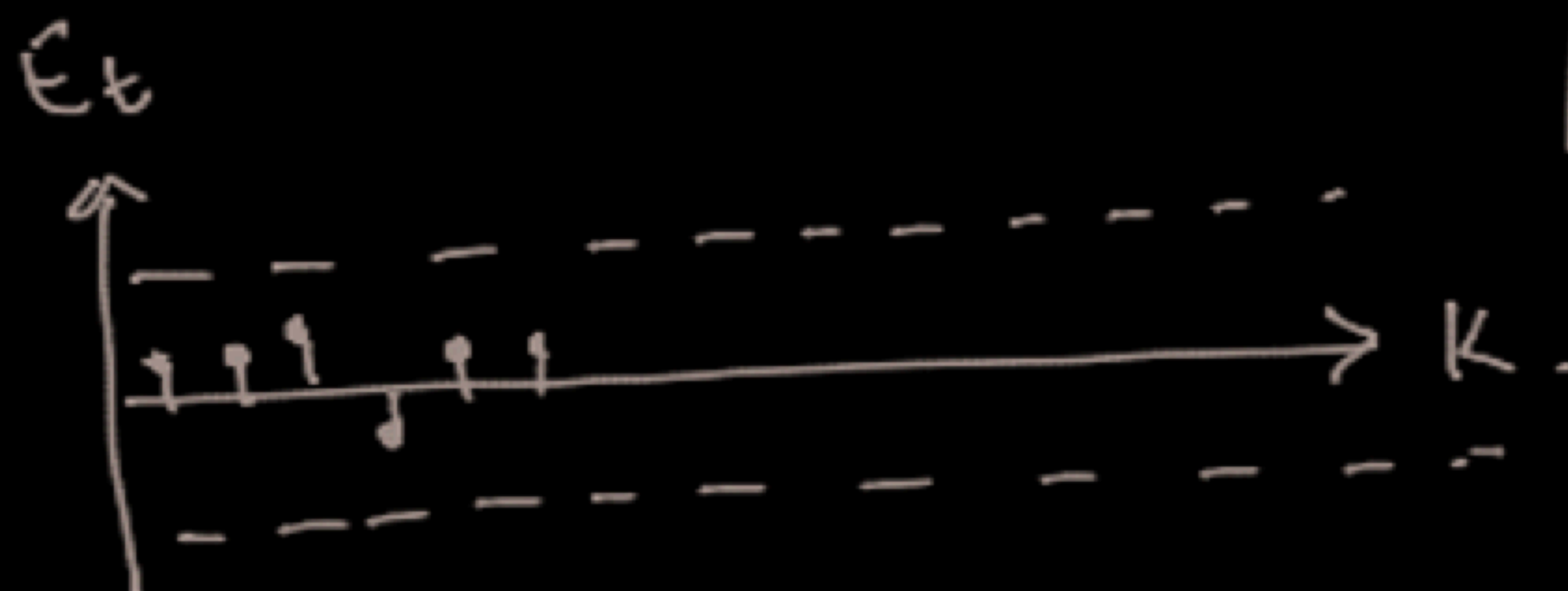
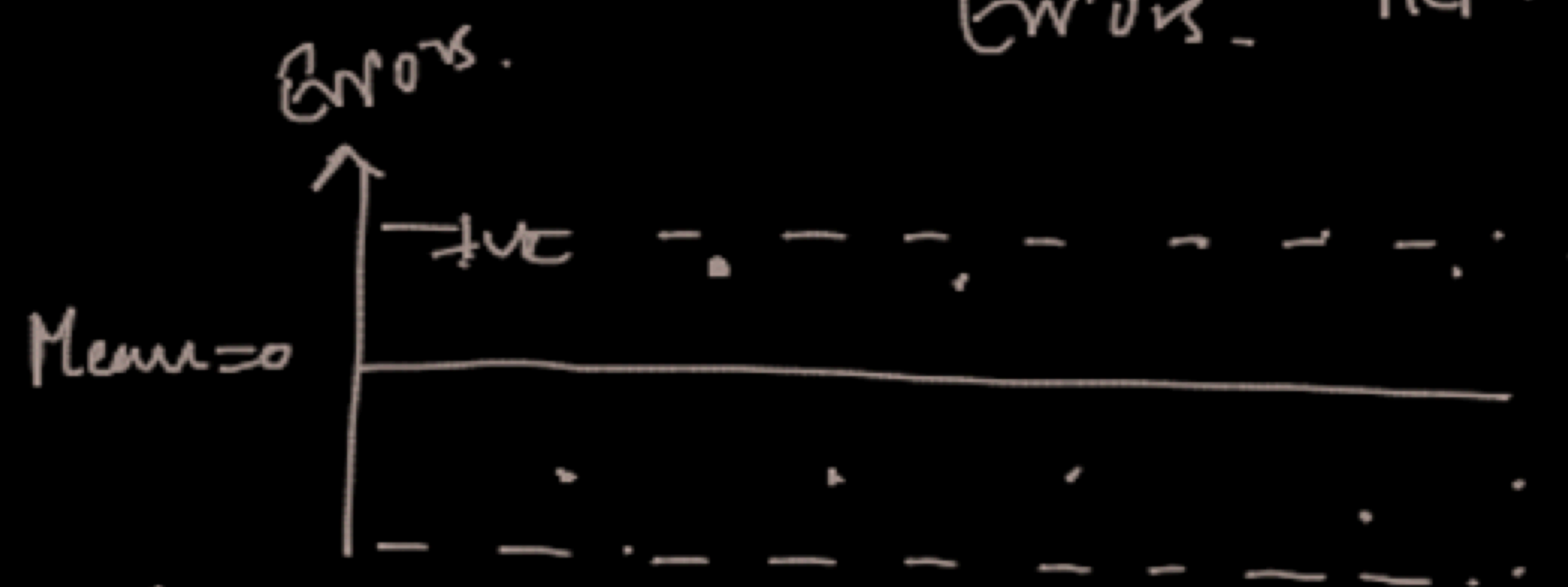
Time (t)	Stock Price (y)	$\hat{y}$	Error ( $y - \hat{y}$ )
Jan 2020	25		
Feb →	28	25	3
Mar	27	28	-1
→ Apr	26	27	-1
May			
Jun			
⋮			
⋮			
⋮			

1. Mean = 0

2. Constant Variance -

3. Random (Nor. Dist.)

4. No auto correlation between Errors. ACF.



Error Metrics → Time Series

Time (t)	Price y	$\hat{y}$	$e = y - \hat{y}$	Abs. $ e $	$e^2$	Abs. Percent. Err.
1	20	16	4	4	16	4/20
2	25	27	-2	2	4	-2/25
3	32	31	1	1	1	1/32
4	27	23	4	4	16	4/27
⋮	63	68	-5	5	25	-5/63
⋮			⋮	⋮	⋮	
n						

$\overline{ME} =$        $\overline{MAE} =$        $\overline{MSE} =$        $\overline{MAPE} =$

↳  $RMSE = \sqrt{\overline{MSE}}$