Meaning of Time Series:

Every process on earth is determine by a time variable. Time series refers to a series in which one variable is time. In time series, the value of variable are chronologically arranged or consecutive order.

For Example: If we observe production, sales, population, crime rate, dollar rate, imports, exports etc. at different point of time say over last 5 or 10 years. The set of observation formed shall constitute time series.

Hence, in the analysis of time series, time is most important factor because the variable is related to time which may be either year, month, week, days, hours or even minutes.

* NOTE: Time Series Analysis is done for the purpose of making forecasts for future & also for the purpose of evaluating past performance.

Definition of Time Series:

1. A set of data depending on time is called time series.

2. A time series is a set of statistical observations arrange in chronological order.

3. A time series consist of statistical data which are collected, recorded over successive increment of time.

* Utility of Time Series :

1. Analysis
2. Forecasting
3. Evaluation
4. Comparison.

* Component of Time Series :

There are 4 components of time series :

1. Secular Trend or Trend (T)
2. Seasonal Variation (S)
3. Cyclic Variation (C)
4. Irregular Variation (I)

1. Secular Trend : Continuous movement in a trend of a particular type i.e. upward trend or downward trend or gradual shift reflected in the time series over long period of time is called secular trend.

Eg. 1 → The population of India during the 50 years give an upward trend.

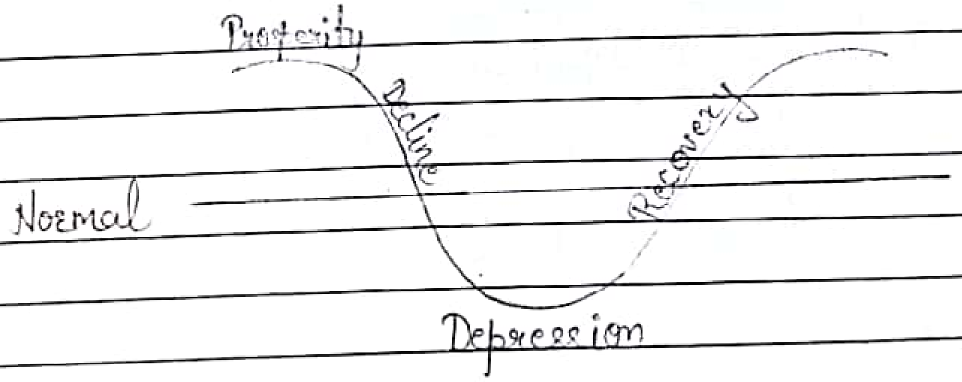
Eg. 2 → The child death rate over the last 20 years give an downward trend.

2. Seasonal Trend / Variation (S):

Generally seasonal variation are occur due to change in whether conditions, customers, traditions, fashion etc. Generally seasonal variation represent a periodic movement where time period is not longer than one year.

Eg. 1 → Sale of woollen cloths go up in winter.
Eg. 2 → Demand of electricity rises rapidly during summer every year.

3. Cyclic Variation (C): Different fluctuation moving up & down every few year throughout the length of time series are known as cyclic variation / fluctuation or business cycle. Duration of cycle may be 4 to 5 year or even higher but always more than a year.



Eg.: Production of certain item is stopped & new items are produced. Again old items are adopted. Such changes form cycles.

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4. **Irregular Variation (I):**

Factors other than above are known as irregular variation. They are random & are of non-recurring & unpredictable in nature.

Eg.: Unusual wether conditions, threat to international peace are example of irregular variation.

* Measurement of Trend:

1. Least Square Method.
2. Moving Average Method.
3. Graphical Method.

1. Least Square Method:

It is a mathematical method & with its help a trend line is fitted to the data in such a manner that the following two conditions are satisfied:

a. $\Sigma(Y-Y_c) = 0$ (i.e. sum of actual value of Y & computed value of Y is equal to zero).

b. $\Sigma(Y-Y_c)^2 =$ is least or minimum.

(i.e. sum of square of deviation of actual & computed value is least from this line & hence the name least square method). The line is obtain by this method is the line of best fit.

* Fitting of a Straight Line Method : trend :

The equation of straight line trend is:

$$Y_c = a + bx \rightarrow (1)$$

where a & b = constant to be determined

Normal eq^n are :

$$\Sigma Y = na + b\Sigma X \rightarrow (2)$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \rightarrow (3)$$

where, n = no. of years.

If, n = odd.

time (t)	Prod^n (Y)	$X = t - 1993$	XY	X^2	
1991		-2			
1992		-1			
1993	= Middle Yr.	0			
1994		1			
1995		2			
		$\Sigma X = 0$			

By shifting origin to middle years

eq^n 2 & 3 can be written as

from eq^n 2 $\rightarrow \Sigma Y = na \Rightarrow a = \frac{\Sigma Y}{n} = \bar{Y}$.

from eq^n 3 $\rightarrow \Sigma XY = b\Sigma X^2 \Rightarrow b = \frac{\Sigma XY}{\Sigma X^2}$

If, n = even

time (t)	Prod^n (Y)	$X = t - 1993.5$	XY	X^2
1991		-2.5		
1992		-1.5		
1993	→ Average	-0.5		
1994	= 1993.5	0.5		
1995		1.5		
1996		2.5		
		$\Sigma X = 0$		

Q1 Sol → The eq^n of straight line trend is

$$Y_c = a + bX \quad \rightarrow (1)$$

a, b = constant to be determined

Normal eq^n are

$$\Sigma Y = na + b\Sigma X \quad \rightarrow (2)$$
$$\Sigma XY = a\Sigma X + b\Sigma X^2 \quad \rightarrow (3).$$

$n = 5$, which is odd.

Year (t)	Prod^n (Y)	$X = t - 1989$	X^2	XY
1985	18	-4	16	-72
1987	21	-2	4	-42
1989	23	0	0	0
1991	27	2	4	54
1993	16	4	16	64
	105	0	40	4

from eq^n 2, $\Sigma Y = na + b\Sigma X$

$\Sigma Y = na$

$105 = 5a$

$\frac{105}{5} = a$

$\underline{\underline{a = 21}}$.

from eq^n 3. $\Sigma XY = a\Sigma X + b\Sigma X^2$

$\Sigma XY = b\Sigma X^2$

$4 = 10b$

$\frac{4}{10} = b$

$\underline{\underline{b = 0.1}}$

Put value of a & b in eq^n 1, we get straight line trend.

$Y_c = a + bX$

$\underline{\underline{Y_c = 21 + 0.1x}} \longrightarrow (4)$.

To estimate production in the year 1995 & 1997.

$t = 1995$	$t = 1997$
$X = t - 1989$	$X = t - 1989$
$X = 1995 - 1989$	$X = 1997 - 1989$
$X = \underline{\underline{6}}$	$X = \underline{\underline{8}}$
Put $x = 6$ in eq^n 4	Put $X = 8$ in eq^n 4
$Y_c = 21 + 0.1 \times 6$	$Y_c = 21 + 0.1 \times 8$
$\underline{\underline{Y_c = 21.6}}$	$\underline{\underline{Y_c = 21.8}}$

Q2. Sol → The eq^n of straight line trend is

$$Y_c = a + bX \rightarrow (1)$$

a, b are constant to be determined.

Normal eq^n are

$$\Sigma Y = na + b\Sigma X \rightarrow (2)$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \rightarrow (3)$$

n = 10, which is even.

Year (t)	Prod^n (Y)	$X = t - 1981.5$	X^2	XY
1977	75	-4.5	20.25	-337.5
1978	86	-3.5	12.25	-301
1979	98	-2.5	6.25	-245
1980	90	-1.5	2.25	-135
1981	96	-0.5	.25	-48
1982	108	0.5	.25	54
1983	124	1.5	2.25	186
1984	140	2.5	6.25	350
1985	150	3.5	12.25	525
1986	165	4.5	20.25	742.5
	1,132	0	82.5	791

from eq^n 2 → $\Sigma Y = na + b\Sigma X$

$$1{,}132 = 10a$$

$$\frac{1{,}132}{10} = a$$

$$a = 113.2$$

from eq^n 3 → $\Sigma XY = a\Sigma X + b\Sigma X^2$

$$791 = 82.5b$$

$$\frac{791}{82.5} = b$$

$$b = 9.58$$

Put value of a & b in eq^n 1, we get straight line trend.

$$Y_c = a + bx$$
$$Y_c = 113.2 + 9.58x \longrightarrow (1)$$

To estimate production in the year 1987.

$t = 1987$	Put $x = 5.5$ in eq^n 4.
$x = t - 1981.5$	
$x = 1987 - 1981.5$	$Y_c = 113.2 + 9.58 \times 5.5$
$x = 5.5$	$Y_c = 165.89$.

Tabulation of trend value

Year (t)	$x = t - 1981.5$	$Y_c = 113.2 + 9.58x$
1977	-4.5	$Y_c = 113.2 + 9.58(-4.5) = 70.09$
1978	-3.5	$Y_c = 113.2 + 9.58(-3.5) = 79.67$
1979	-2.5	$Y_c = 113.2 + 9.58(-2.5) = 89.25$
1980	-1.5	$Y_c = 113.2 + 9.58(-1.5) = 98.83$
1981	-0.5	$Y_c = 113.2 + 9.58(-0.5) = 108.41$
1982	0.5	$Y_c = 113.2 + 9.58(0.5) = 117.99$
1983	1.5	$Y_c = 113.2 + 9.58(1.5) = 127.57$
1984	2.5	$Y_c = 113.2 + 9.58(0.5) = 137.15$
1985	3.5	$Y_c = 113.2 + 9.58(3.5) = 146.73$
1986	4.5	$Y_c = 113.2 + 9.58(4.5) = 156.31$.