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Variance:—

It is denoted as σ^2. (Small Sigma)

The A.M. of the square of the deviation about arithmetic mean of a series is known as Variance.

i) Individual Series.

$$\sigma^2 = \frac{\Sigma(x-\bar{x})^2}{n}$$

ii) Discrete Series

$$\sigma^2 = \frac{\Sigma f(x-\bar{x})^2}{N}$$

iii) Continuous Series

$$\sigma^2 = \frac{\Sigma f(m-\bar{x})^2}{N}$$

Standard deviation (S.D) (σ)

SD denoted as σ.

The positive square root of the AM of the square of the deviation about a.m of a series is known as S.D. OR- The positive square root of the variance is called SD

$$S.D(\sigma) = \sqrt{\text{variance}(\sigma^2)}$$

i) Individual Series

$$\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$$

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ii) Discrete Series

$$\sigma = \sqrt{\frac{\Sigma f(x-\bar{x})^2}{N}}$$

iii) Continuous Series

$$\sigma = \sqrt{\frac{\Sigma f(m-\bar{x})^2}{N}}$$

Imp Coefficient of Variation

$$C.V = \frac{\sigma}{\bar{X}} \times 100$$

Q- Calculate SD & C.V. for the following data by
- Direct method, • without finding a deviations of the different observation from any point (i.e By taking deviation about horizon)
- Shortcut method.

3, 5, 6, 7, 8, 10, 11, 14

I) Direct method.

$$\sigma = \sqrt{\frac{\Sigma (x-\bar{x})^2}{n}}$$

X	$\bar{X}$	$x-\bar{x}$	$(x-\bar{x})^2$
3		-5	25
5		-3	9
6		-2	4
7	8	-1	1
8		0	0
10		2	4
11		3	9
14		6	36
$\Sigma X = 64$			$\Sigma(x-\bar{x})^2 = 88$

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$$\sigma = \sqrt{\frac{88}{8}} = \sqrt{11} = 3.317$$ Ans

$$Cv = \frac{\sigma}{\bar{x}} \times 100 \Rightarrow \frac{3.317}{8} \times 100 \Rightarrow 41.46\%$$

II) without finding the deviation $\Rightarrow \sigma = \sqrt{\frac{\Sigma x^2}{n} - \left(\frac{\Sigma x}{n}\right)^2}$

X	X^2
3	9
5	25
6	36
7	49
8	64
10	100
11	121
14	196
$\Sigma X = 64$	$\Sigma X^2 = 600$

$$\sigma = \sqrt{\frac{600}{8} - \frac{64 \times 64}{64}}$$

$$= \sqrt{75 - 64}$$

$$= \sqrt{11}$$

$$= 3.317$$

$$C.V = \frac{\sigma}{\bar{X}} \times 100 \Rightarrow \frac{3.317}{8} \times 100 = 41.46\%$$

III) Shortcut method $\sigma = \sqrt{\frac{\Sigma d^2}{n} - \left(\frac{\Sigma d}{n}\right)^2}$ where $d = x - a$

X	a	$d = X - a$	d^2
3		-7	49
5		-5	25
6		-4	16
7	10	-3	9
8		-2	4
10		0	0
11		1	1
14		4	16
$\Sigma X = 64$		$\Sigma d = -16$	$\Sigma d^2 = 120$

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$$\sigma = \sqrt{\frac{120}{8} - \frac{(-16)^2}{64}} \Rightarrow \sqrt{11} \Rightarrow 3.317 \text{ Ans}$$

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Q Sample of 5 items was taken from the production in a certain establishment
The length & the weight of those 5 item are as follows

Length (in cms) :	6	8	12	14	20
Weight (in kgs) :	5	7	10	11	12

Which of the series is more variable / consistance
Length is denoted by X
Weight is denoted by Y

X	Y	X^2	Y^2
6	5	36	25
8	7	64	49
12	10	144	100
14	11	196	121
20	12	400	144
$\Sigma X = 60$	$\Sigma Y = 45$	$\Sigma X^2 = 840$	$\Sigma Y^2 = 439$

$$\sigma_x = \sqrt{\frac{\Sigma X^2}{n} - \left(\frac{\Sigma X}{n}\right)^2}$$

$$= \sqrt{\frac{840}{5} - \left(\frac{60}{5}\right)^2}$$

$$= \sqrt{168 - 144}$$

$$= \sqrt{24}$$

$$= 4.8989$$

$$= 4.899 \text{ cm}$$

$$\sigma_y = \sqrt{\frac{\Sigma Y^2}{n} - \left(\frac{\Sigma Y}{n}\right)^2}$$

$$= \sqrt{\frac{439}{5} - \left(\frac{45}{5}\right)^2}$$

$$= \sqrt{87.8 - 81}$$

$$= \sqrt{6.8}$$

$$= 2.6076$$

$$= 2.608 \text{ kg}$$

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$\bar{x} = \frac{\sum x}{n} \Rightarrow \frac{60}{5} \Rightarrow 12$

$\bar{y} = \frac{\sum y}{n} \Rightarrow \frac{45}{5} \Rightarrow 9$

Coeff. of variation for $x = \frac{\sigma_x}{\bar{x}} \times 100 = \frac{4.899}{12} \times 100 \Rightarrow 40.825\%$

Coeff. of variation for $y = \frac{\sigma_y}{\bar{y}} \times 100 = \frac{2.608}{9} \times 100 \Rightarrow 28.98\%$

Here. $V_x > V_y$

Therefore, x is more variable than y.

It means, length is more variable than weight. Thny

Q The Runs scored by two batsman A & B in various innings are

A: 24 79 31 114 14 2 68 01 110 07

B: 5 18 42 53 9 47 52 17 81 56

who is better run getter? who is more consistant player?

A	B	A^2	B^2
24	5	576	25
79	18	6241	324
31	42	961	1764
114	53	12996	2809
14	9	196	81
2	47	4	2209
68	52	4624	2704
1	17	1	289
110	81	12100	6561
7	56	49	3136
$\sum A = 450$	$\sum B = 380$	$\sum A^2 = 37748$	$\sum B^2 = 19902$

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$\bar{A} = \frac{\Sigma A}{n} \Rightarrow \frac{450}{10} \Rightarrow 45$

$\bar{B} = \frac{\Sigma B}{n} \Rightarrow \frac{380}{10} \Rightarrow 38$

$A > B$ so A is better runner than B.

$\sigma_A = \sqrt{\frac{\Sigma A^2}{n} - \left(\frac{\Sigma A}{n}\right)^2} \Rightarrow \sqrt{\frac{37748}{10} - \left(\frac{450}{10}\right)^2} \Rightarrow \sqrt{3774.8 - 2025}$

$\sigma_A = \sqrt{1749.8} \Rightarrow 41.8306 \Rightarrow 41.831$

$\sigma_B = \sqrt{\frac{19902}{10} - \left(\frac{380}{10}\right)^2} \Rightarrow \sqrt{1990.2 - 1444} \Rightarrow \sqrt{546.2} \Rightarrow 23.3709$

$\sigma_B = 23.371$

Coeff. of variation A, $V_A = \frac{\sigma_A}{\bar{A}} \times 100 = \frac{41.931 \times 100}{45} = 92.958\,\%$

Coe. of variation B, $V_B = \frac{\sigma_B}{\bar{B}} \times 100 = \frac{23.371 \times 100}{38} = 61.502\,\%$

Here $\sigma_A > \sigma_B$

There fore σ_A is more consistent player than σ_B.

Ans

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Discrete Series

i) Direct Method : $\sigma = \sqrt{\frac{1}{N} \Sigma f (x - \bar{x})^2}$

ii) Shortcut Method: $\sigma = \sqrt{\frac{\Sigma f d^2}{\Sigma f} - \left(\frac{\Sigma f d}{\Sigma f}\right)^2}$ ∴ where, $d = x - a$

Continuous Series

i) Direct Method : $\sigma = \sqrt{\frac{1}{N} \Sigma f (m - \bar{x})^2}$

ii) Step-deviation method : $\sigma = \sqrt{\frac{\Sigma f u^2}{\Sigma f} - \left(\frac{\Sigma f u}{\Sigma f}\right)^2} \times h$ ∴ where $u = \frac{m-a}{x}$

Q Goals score by 2 team A & B in a football session work as follows

No. of goods scored in a total match	No. of football Team A	Team B
0	15	20
1	10	10
2	7	5
3	5	4
4	3	2
5	2	1
Total	42	42

which team is more consistant & why?

Team A

X_A	f_A	$f_A X_A$	$f_A X_A^2$	X_B	f_B	$f_B X_B$	$f_B X_B^2$
0	15	0	0	0	20	0	0
1	10	10	10	1	10	10	10
2	7	14	28	2	5	10	20
3	5	15	45	3	4	12	36
4	3	12	48	4	2	8	32
5	2	10	50	5	1	5	25
	$\Sigma f_A = 42$	$\Sigma f_A X_A = 61$	$\Sigma f_A X_A^2 = 181$		42	45	123

$\sigma_A = \sqrt{\frac{181}{42} - \left(\frac{61}{42}\right)^2}$

$= \sqrt{4.309 - 2.108}$

$= \sqrt{2.201} \Rightarrow 1.483$

$\sigma_B = \sqrt{\frac{123}{42} - \left(\frac{45}{42}\right)^2}$

$= \sqrt{2.928 - 2.893}$

$= \sqrt{0.035} = 0.187$

C. of V. $V_A = \frac{1.483 \times 100}{1.452}$

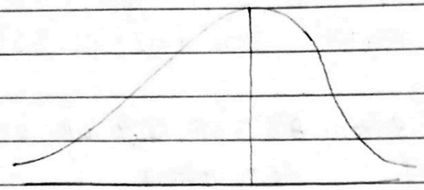
$V_A = 102.134$

C. of $V_B = 17.46$

$\boxed{V_A > V_B}$

Skewness.

- Skewness refers to departure form the symmetry.
- It distribution in which mean, median, mode do not consite each other such type of distribution is known as asymmetrical or skewed.
- On the other hand if mean, median, mode are identical to each other then such type of distribution is known as symmetrical distribution.



symmetrical distribution

$\bar{x} = M_d = Z$

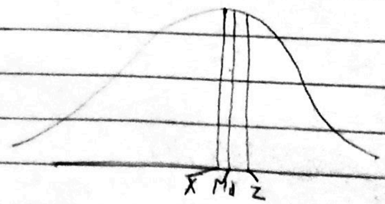
mean = median = mode.

Types

1. Positively Skewed distribution.
2. Negatively Skewed distribution.

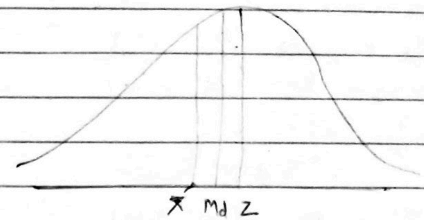
Positively Skewed Distribution

A distribution in which mean is maximum and mode is minimum and median lies in b/w them such type of distribution is known as Positively skewed distribution



2. Negatively Skewed Distribution

A distribution in which mode is maximum and mean is minimum and median lies in b/w them such type of distribution is known as -vely skewed distribution.



Q How skewness differs from dispersion.

Dispersion tells us the amount of variation but not direction whereas

Skewness tell us the amount of variation and as well as direction.

Measurment of skewness

- Absolute measure of skewness
- Relative measure of skewness

1. Absolute measure of skewness / Absolute S_k

The difference b/w the mean and mode is known as absolute skewness.

Absolute S_k = mean - mode

$= \bar{x} - Z$

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i) if mean > mode , +ve skewness
ii) if mean = mode , No skewness
iii) if mean < mode , -ve skewness

OR (Quatile)

$$\text{Absolute } S_k = Q_3 + Q_1 - 2Q_2$$

OR (Median)

$$\text{Absolute } S_k = Q_3 + Q_1 - 2Md$$

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2) Relative measure of Skewness

i) Karl pearson's coefficient of skewness
ii) Bowley's coefficient of skewness
iii) Kelly's coefficient of skewness.
iv) Skewness based on central moments

i) Karl Pearson's coefficient of skewness

$$S_{k_p} = \frac{\text{Mean} - \text{Mode}}{S.D}$$

Note:- The value of S_{k_p} is always lies between -1 to +1.

Note:- Skewness in case of ill-defined mode
(when grouping method fail)

$$S_{k_p} = \frac{3(\text{Mean} - \text{Median})}{S.D}$$

i) if $S_{k_p} > 0$ then , +ve skewness
ii) if $S_{k_p} = 0$ then , ~~Symm~~ No skewness when the distribution will be symmetric
iii) if $S_{k_p} < 0$ then the distribution will be asymmetric -ve skewness.

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ii) Bowley's coefficient of skewness

$$S_{k_B} = \frac{Q_3 + Q_1 - 2Q_2}{Q_3 - Q_1} \qquad Q_2 = Md$$

a) if $Q_3 - Q_2 > Q_2 - Q_1$ then, +ve skewness
b) if $Q_3 - Q_2 = Q_2 - Q_1$ then, no skewness
c) if $Q_3 - Q_2 < Q_2 - Q_1$ then, -ve skewness

iii) Kelly's coefficient of skewness

$$S_{k_K} = \frac{P_{90} + P_{10} - 2P_{50}}{P_{90} - P_{10}}$$

$$S_{k_K} = \frac{D_9 + D_1 - 2D_5}{D_9 - D_1}$$

a) if $S_{k_K} = 0$, no skewness
b) if $S_{k_K} > 0$, +ve skewness
c) if $S_{k_K} < 0$, -ve skewness.

iv) Skewness is based on central moments

Moments

a) About any point a : $\mu_r'(a)$
b) About mean/central moments : μ_r
c) About origin : μ_r' or $\mu_r'(0)$.

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(A) Now, moments about any point a :-

i) for Individual series

$$\mu_r'(a) = \frac{1}{n} \Sigma (x-a)^r$$

where, $r = 1,2,3,4$

when

$r=1$, $\mu_1'(a) = \frac{1}{n} \Sigma (x-a)^1$

$r=2$, $\mu_2'(a) = \frac{1}{n} \Sigma (x-a)^2$

$r=3$, $\mu_3'(a) = \frac{1}{n} \Sigma (x-a)^3$

$r=4$, $\mu_4'(a) = \frac{1}{n} \Sigma (x-a)^4$

The arithmetic mean of the r^{th} power of the deviation about any orbitrary point a of all values of a variable is known as r^{th} moment about any point a. It is denoted by $\mu_r'(a)$.

ii) for discrete series

$$\mu_r'(a) = \frac{1}{N} \Sigma f(x-a)^r$$

where, $r = 1,2,3,4$

when, $r=1$

$$\mu_1'(a) = \frac{1}{N} \Sigma f(x-a)$$

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iii) for Continuous Series

$$\mu_r'(a) = \frac{1}{N}\Sigma f(m-a)^r$$

where, $r=1,2,3,4$

when, $r=1$

$$\mu_1'(a) = \frac{1}{N}\Sigma f(m-a)$$

when, $r=2$

$$\mu_2'(a) = \frac{1}{N}\Sigma f(m-a)^2$$

⋮

(B) Moments about mean / Central moments:

i) Individual Series

$$\mu_r = \frac{1}{n}\Sigma(X-\bar{X})^r$$

where, $r=1,2,3,4$

when, $r=1$

$$\mu_1 = \frac{1}{n}\Sigma(X-\bar{X})^1$$

$r=2$

$$\mu_2 = \frac{1}{n}\Sigma(X-\bar{X})^2 \Rightarrow \text{Variance}$$

$r=3$

$$\mu_3 = \frac{1}{n}\Sigma(X-\bar{X})^3$$

$$\mu_4 = \frac{1}{n}\Sigma(X-\bar{X})^4$$

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The arithmetic mean of the r^{th} power of the deviation about mean of all values of a variable is called r^{th} moment about mean or r^{th} central moment.

It is denoted by μ_r.

ii) Continuous Series

$$\mu_r = \frac{1}{N}\Sigma f(m-\bar{X})^r$$

where, $r=1,2,3,4$
and $N=\Sigma f$

when, $r=1$

$$\mu_1 = \frac{1}{N}\Sigma f(m-\bar{X})^1$$

$r=2$

$$\mu_2 = \frac{1}{N}\Sigma f(m-\bar{X})^2$$

⋮

iii) Discreate Series

$$\mu_r = \frac{1}{N}\Sigma f(X-\bar{X})^r$$

where, $r=1,2,3,4$
$N=\Sigma f$

when, $r=1$

$$\mu_1 = \frac{1}{N}\Sigma f(X-\bar{X})^1$$

$r=2$

$$\mu_2 = \frac{1}{N}\Sigma f(X-\bar{X})^2$$

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(C) Moments about origin.

i) Individual series

$$\mu_r' = \frac{1}{n}\Sigma x^r \qquad \text{where, } r = 1,2,3,4$$

OR

$$\mu_r' = \frac{1}{n}\Sigma (x-0)^r$$

when, $r=1$

$$\mu_1' = \frac{1}{n}\Sigma x$$

$r=2$

$$\mu_2' = \frac{1}{n}\Sigma x^2$$

The arithmetic mean of the r^{th} power of all values of a variable is known as r^{th} moments about origin.
It is denoted as μ_r'.

ii) Discrete Series

$$\mu_r' = \frac{1}{N}\Sigma f x^r \qquad \text{where, } r=1,2,3,4$$

when, $r=1$

$$\mu_1' = \frac{1}{N}\Sigma f x$$

$r=2$,

$$\mu_2' = \frac{1}{N}\Sigma f x^2$$

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iii) Continuous series

$$\mu_r' = \frac{1}{N}\Sigma f m^r \qquad \text{where, } r=1,2,3,4$$

when, $r=1$

$$\mu_1' = \frac{1}{N}\Sigma f m$$

$r=2$

$$\mu_2' = \frac{1}{N}\Sigma f m^2$$

skewness based on central moments.

I) Absolute measure is μ_3

if $\mu_3 > 0$, +ve skewness
if $\mu_3 = 0$, no skewness
if $\mu_3 < 0$, -ve skewness.

II) Relative measure (coeff. of skewness)

i) $\beta_1 = \frac{\mu_3^2}{\mu_2^3}$ But it does not give the sign of skewness.

ii) $\gamma_1 = \sqrt{\beta_1}$

$$= \sqrt{\frac{\mu_3^2}{\mu_2^3}}$$

$$= \sqrt{\frac{\mu_3^2}{\mu_2^3}}$$

$$= \frac{\mu_3}{\sqrt{\mu_2^3}}$$

$$\gamma_1 = \frac{\mu_3}{(\mu_2^3)^{1/2}}$$

$$\boxed{\gamma_1 = \frac{\mu_3}{\mu_2^{3/2}}}$$

$$\gamma_1 = \frac{\mu_3}{(\sigma^2)^{3/2}} \Rightarrow \frac{\mu_3}{\sigma^3}$$

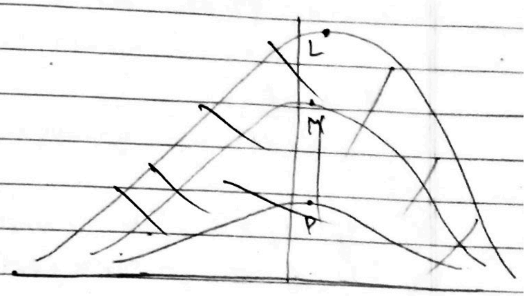
$$\boxed{\gamma_1 = \frac{\mu_3}{(S.D)^3}}$$

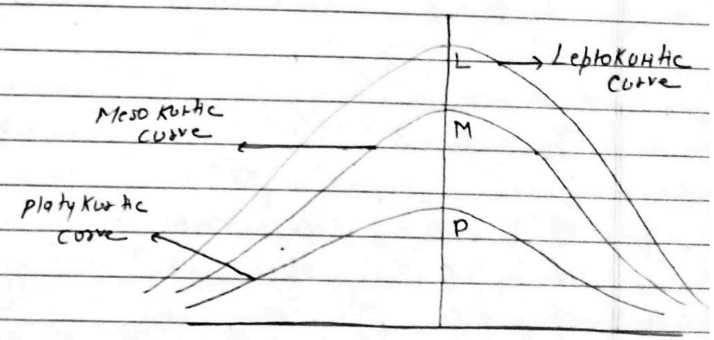
i) if $\gamma_1 > 0$, +ve skewness
ii) if $\gamma_1 = 0$, no "
iii) if $\gamma_1 < 0$, -ve "

3) Coefficient of Skewness.

$$\frac{\beta_1(\beta_1+3)}{2(5\beta_2 - 6\beta_1 - 9)}$$

Kurtosis





Kurtosis means sulginess. It refers to the degree of flatness or peakedness in the region about mode of the frequency curve. if the curve is more peaked than the normal curve is called Lepto Kurtic curve.

If the curve is more flat topped than the normal curve is called Platy Kurtic curve.

The normal curve itself is known as Meso Kurtic curve.

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Measurment of Kurtosis :

1. $\beta_2 = \frac{\mu_4}{\mu_2^2}$

i) if $\beta_2 > 3$, The curve will be Leptokurtic curve.
ii) if $\beta_2 = 3$, Mesokurtic curve
iii) if $\beta_2 < 3$ Platy kurtic curve.

2. $\gamma_2 = \beta_2 - 3$

i) if $\gamma_2 > 0$, Leptokurtic.
ii) if $\gamma_2 = 0$, Meso kurtic
iii) if $\gamma_2 < 0$, Platy kurtic

Unit-2

Time Series Analysis / Historical Series / Chronological series.

A series which is depending on time is known as time series.

Component of time series (Y)

- Long term movements OR fluctuation OR variation OR Secular trend OR Trend (T)
- Short term fluctuation
  - Regular short term fluctuation
    - seasonal (S)
    - cyclical (C)
  - Irregular short term fluctuation OR Random fluctuation OR Erratic fluctuation (I)

Model of time series

1. Additive Model of time series

$$Y = T + S + C + I$$

Here all the components are independent to each other. One component is not effect to another

where, T is the trend,
S is the seasonal variation
C is the cyclical fluctuation
and I is the random fluctuation.

2) Multiplicative model of time series

$$Y = T \times S \times C \times I$$

Here, all the component may be dependent to each other.
It means that, one component may be effect to ~~each~~ another.

Measurement of trend.

1. Graphical method
2. Semi - average method
3. moving average method
4. method of Least - squares.

~~only this metho~~.

Method of Least squares

Equation of straight line

$$Y = a + bX$$

it is normal equation are,

$$\Sigma y = na + b\Sigma x \quad \text{--- (1)}$$
$$\Sigma xy = a\Sigma x + b\Sigma x^2 \quad \text{--- (2)}$$

Here, we can solve the equation (1) and (2), we can find out the values of a & b, after that putting there values in the eqn of the straight line.

$$Y_c = a + bX$$

This eqn is trend line.

Q Calculate the trend values by the method of Least squares.

Year	2018	2019	2020	2021	2022	2023	2024
Production ('000 tonnes)	80	92	94	93	90	83	98

Method of Least squares

Equation of straight line

$$Y = a + bx$$

it's normal equation $\Sigma Y = na + b\Sigma X$ --- (1)

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

Here, n = 7 (odd)

Year	Production ('000 tonnes)	X Year−2021	X^2	XY
2018	80	−3	9	−240
2019	92	−2	4	−184
2020	94	−1	1	−94
2021	93	0	0	0
2022	90	1	1	90
2023	83	2	4	166
2024	98	3	9	294
	$\Sigma Y = 630$	$\Sigma X = 0$	$\Sigma X^2 = 28$	$\Sigma XY = 32$

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Now,

$$\Sigma Y = na + b\Sigma X$$
$$630 = 7a + b \times 0$$
$$a = 90$$

and,

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$
$$32 = 90 \times 0 + 28b$$
$$b = 1.142 \leftarrow \text{slope}$$

b is a slope, slope is 1.142

Now, Putting the value of a and b in equation of straight line $Y = a + bx$

$$Y_c = 90 + 1.142X \longleftarrow \text{Trend Line}$$

Trends values.

2018	$90 + 1.142(-3) =$	86.574	86.58
2019	$90 + 1.142(-2) =$	87.716	87.72
2020	$90 + 1.142(-1) =$	88.858	88.86
2021	$90 + 1.142(0) =$	90	90
2022	$90 + 1.142(1) =$	91.142	91.14
2023	$90 + 1.142(2) =$	92.284	92.28
2024	$90 + 1.142(3) =$	93.426	93.42

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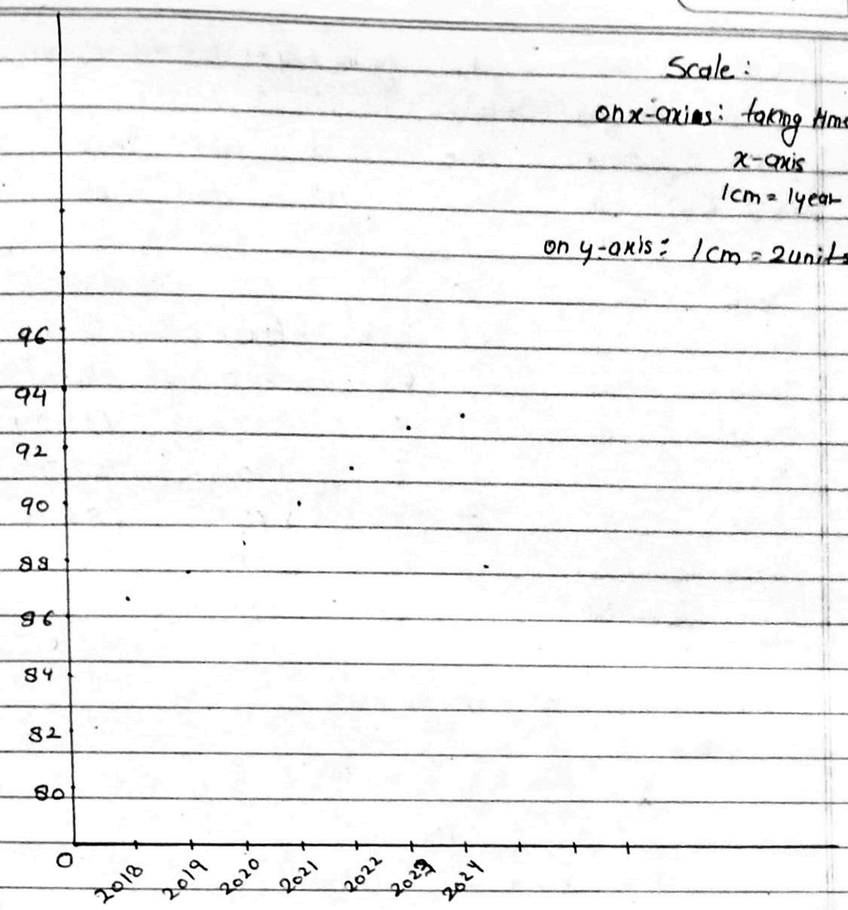
Scale:
on x-axis: taking time along x-axis
1cm = 1year
on y-axis: 1cm = 2units



Also, findout the production for the year 2030

$$X = 2030 - 2021 = 9$$

$$Y_{2030} = 90 + 1.142(9) = 100.278 \quad (\text{'000 tonnes})$$

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Q. Calculate the trend values by method of L.S. are estimate sales for the year 2030:

Year	2019	2020	2021	2022	2023	2024
Sale (Rs. Lakhs)	120	140	150	170	180	200

Year	Sales (Rs. Lakhs) (Y)	X	X^2	XY	Trend values.
2019	120	-5	25	-600	121.43
2020	140	-3	9	-420	136.858 / 136.87
2021	150	-1	1	-150	152.29
2022	170	1	1	170	167.71
2023	180	3	9	540	183.14
2024	200	5	25	1000	198.57
	$\Sigma Y = 960$	$\Sigma X = 0$	$\Sigma X^2 = 70$	$\Sigma XY = 540$	

for, Number of years are even then

$$X = \frac{\text{Year} - \frac{1}{2}(2021+2022)}{1/2}$$

$$X = 2\,\text{year} - (2021+2022)$$

for year 2019

$X = 2\times2019 - (2021+2022)$
$= 38 - 43$
$= -5$

for year 2020

$X = 2\times2020 - (2021+2022)$
$= 40 - 43$
$= -3$

for year 2021

$X = 2\times2021 - (2021+2022)$
$= 42 - 43 \Rightarrow -1$

for year 2022

$X = 2\times2022 - (2021+2022)$
$= 44 - 43$
$= 1$

same as foll year

Now $\Sigma Y = na + b\Sigma X$
$960 = 6a + b(0)$
$a = 160$

and, $\Sigma XY = a\Sigma X + b\Sigma X^2$
$540 = 160\times0 + b\,70$
$540 = 70b$
$b = 7.714$ slope

Now, Putting the value of a and b in eq^n of straight line $Y = a + bX$

$Y_c = 160 + 7.714X$ ← Trend Line

for, the year 2030:–

$X = 2(2030) - (2021+2022) \Rightarrow 60 - 43 \Rightarrow 17$

Sales for the year 2030

$Y_{2030} = 160 + 7.714(17)$
$= 291.14$ (Lakhs)

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Fitting a Parabolic or Non Linear trend.

Equation of second degree parabola.

$$Y = a + bx + cx^2$$

it's normal eq^n

$$\Sigma Y = na + b\Sigma X + c\Sigma X^2 \quad \text{—— (1)}$$
$$\Sigma XY = a\Sigma X + b\Sigma X^2 + c\Sigma X^3 \quad \text{—— (2)}$$
$$\Sigma X^2Y = a\Sigma X^2 + b\Sigma X^3 + c\Sigma X^4$$

Solve the eq^n 1st, 2nd and 3rd we get the values of a, b and c after that putting these values in the eq^n of second degree parabola then we get the eq^n of non linear trend line.

Q. fit a second degree parabola for the following data and calculate trend values.

Year	2020	2021	2022	2023	2024
(values) Y	10	12	13	10	8

Year	Values Y	X	X^2	X^3	X^4	XY	X^2Y	Trend values
2020	10	-2	4	-8	16	-20	40	10.086
2021	12	-1	1	-1	1	-12	12	12.057
2022	13	0	0	0	0	0	0	12.314
2023	10	1	1	1	1	10	10	10.857
2024	8	2	4	8	16	16	32	7.686
	$\Sigma Y = 53$	$\Sigma X = 0$	$\Sigma X^2 = 10$	$\Sigma X^3 = 0$	$\Sigma X^4 = 34$	-6	94	

for the number of years are odd then,

$$\Sigma Y = na + b\Sigma X + c\Sigma X^2$$
$$53 = 5a + b \times 0 + c \times 10$$
$$53 = 5a + 10c \quad \text{—— (1)}$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 + c\Sigma X^3$$
$$-6 = a \times 0 + b \times 10 + c \times 0$$
$$-6 = 10b$$
$$b = -0.6$$

$$\Sigma X^2Y = a\Sigma X^2 + b\Sigma X^3 + c\Sigma X^4$$
$$94 = a \times 10 + b \times 0 + c \times 34$$
$$94 = 10a + 34c \quad \text{—— (2)}$$

eq^n (1) and (2)

$$\cancel{5a} + 10c = 53$$
$$\cancel{5a} + 17c = 47$$
$$-7c = 6$$
$$c = -0.857$$

$$5a + 10c = 53$$
$$5a + 10 \times -0.857 = 53$$
$$a = \cancel{8.336}\ 12.314$$

$$Y_c = a + bx + cx^2$$
$$Y_c = 12.314 + (-0.6)x + (-0.857)x^2$$
$$Y_c = 12.314 - 0.6x - 0.857x^2$$