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* Arithmetic Mean :-
The sum of all the observations divided by no. of observations.

- AM denote by $\overline{X}$
- It

A.M → Individual Series, Discrete Series, Continuous Series

→ Individual Series (Only one Variable)
a) → Direct Method
b) → Short cut Method / Assuming Mean Method

a) Direct Method → $\overline{X} = \frac{\Sigma X}{N}$
where N is no. of observations.

b) Short cut Method → $\overline{X} = A + \frac{\Sigma d}{N}$
where $d = X - A$

Ex X (No. of Marks)
10
20
30
40
50

find Mean by Direct Method
Short cut Method

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1) DM → $\frac{\Sigma x}{N} = \frac{10+20+30+40+50}{5}$

$= \frac{150}{5} = 30$

2) SCM →

x	d → x − A
10	10 − 30 = −20
20	20 − 30 = −10
A $\boxed{30}$	30 − 30 = 0
40	40 − 30 = 10
50	50 − 30 = 20
	Σd = 0

$\bar{x} = 30 + \frac{0}{5}$

$= \boxed{30}$

Discrete Series → (two variable)

→ Direct Method → $\bar{x} = \frac{\Sigma fx}{N}$ where N is Σf

→ Short cut Method → $\bar{x} = A + \frac{\Sigma fd}{N}$ where $d = x - A$

Example:

X	F	xf	d	fd
3	4	12	1	4
A $\boxed{2}$	1	2	0	0
5	3	15	3	9
7	2	14	5	10
	$\Sigma f = 10$	$\Sigma fx = 43$		$\Sigma fd = 23$

By Direct Method $= \frac{43}{10} = 4.3$

By SCM → $2 + \frac{23}{10}$

$= 2 + 2.3$

$= 4.3$

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Continuous Series (in which Range is given)

0-10
10-20

→ Direct Method $\bar{x} = \frac{\sum mf}{N}$ ∴ where M is mid Value $= \frac{l_1 + l_2}{2}$

→ SCM $\bar{x} = A + \frac{\sum Fd}{N}$ where $d = x - m$

→ Step Deviation Method $\bar{x} = A + \frac{\sum fd'}{N} \times C$ where $d' = \frac{x-m}{c}$

Example:-

C.I	F	m	mf	d	fd	$d' = \frac{x-m}{c}$	fd'
0-10	3	5	15	-10	-30	-1	-3
10-20	1	$\boxed{15}$ A	15	0	0	0	0
20-30	2	25	50	+10	20	1	2
30-40	4	35	140	+20	80	2	8
	$\sum f = 10$		$\sum mf = 220$		$\sum fd = 70$		7

DM →

$\bar{x} = \frac{220}{10} = 22.$

SCM → $\bar{x} = 15 + \frac{70}{10} = 15 + 7 = 22$

SDM → $\bar{x} = 15 + \frac{7}{\cancel{10}} \times \cancel{10} = 22.$

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Continuous Series (in which Range is given)

0-10
10-20

- → Direct Method $\bar{x} = \frac{\Sigma mf}{N}$ ∴ where m is mid value $= \frac{l_1 + l_2}{2}$
- → SCM $\bar{x} = A + \frac{\Sigma Fd}{N}$ where $d = x - m$
- → Step Deviation Method. $\bar{x} = A + \frac{\Sigma fd'}{N} \times C$ where $d' = \frac{x-m}{C}$

Example:-

C.I	F	m	mf	d	fd	$d' = \frac{x-m}{C}$	fd'
0-10	3	5	15	-10	-30	-1	-3
10-20	1	$\boxed{15}$ A	15	0	0	0	0
20-30	2	25	50	+10	20	1	2
30-40	4	35	140	+20	80	2	8
	$\Sigma f = 10$		$\Sigma mf = 220$		$\Sigma fd = 70$		7

DM → $\bar{x} = \frac{220}{10} = 22.$

SCM → $\bar{x} = 15 + \frac{70}{10} = 15 + 7 = 22.$

SDM → $\bar{x} = 15 + \frac{7}{\cancel{10}} \times \cancel{10} = 22.$

Important Note :-

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• in case of Continuous series first u will have to see Range are proper or not like it should be 0-10, 10-20
Mean this should be same.

if these are same is known as Exclusive series
But if " " not " " " " Inclusive series
then in this case firstly convert Inclusive series to Exclusive series by (−) in Lower Limit 0.5
(+) " upper " 0.5.

Then question done as usual.

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iv)

* Properties of AM

(i) If all the observation assumed by a variable constant, then AM is also K.
(Say K)

Ex → like all observation of 10 students is 30 each. then Mean is $\boxed{30}$

ii) Sum of deviations of a set of observations from their AM is zero

$\Sigma(X-\bar{X})=0$ if Individual Series

$\Sigma f(X-\bar{X})=0$ if frequency Series

iii) AM is affected by origin and Scale
(+, −) (÷, ×)

which implies that if the original variable X is change to another variable Y by affecting a Change of origin (a) & Scale b of x i.e

$y = \underset{\text{origin}}{a} + \underset{\text{Scale}}{bx}$

then AM of $y = a + b\bar{x}$

iv) Combined mean $\Rightarrow \bar{X}_{12} = \dfrac{n_1\bar{X}_1 + n_2\bar{X}_2}{n_1+n_2}$

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* Median – Partition Value

(Me) — Quartiles (Q), deciles (D), Percentiles (P)

Median :- Middle most value when observations are arranged (ascending or decending order)

Median → Individual Series, Discrete Series, Continuous Series

→ Individual Series → $Me = \frac{N+1}{2}$ where N → no. of observation

Example :- 8, 7, 3, 2, 15, 17, 20. find Median

Sol :- firstly arrange in acending order

X = 2, 3, 7, 8, 15, 17, 20

$Me = \frac{N+1}{2} = \frac{7+1}{2} = \frac{8}{2} = 4^{th}$ item = 8 Median

if observation is in even no. then.

Ex 8, 7, 3, 2, 15, 17, 20, 22.

Me :- 2, 3, 7, 8, 15, 17, 20, 22

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$\frac{N+1}{2} = \frac{8+1}{2} = \frac{9}{2} = 4.5$

4th item + .5 (5th item − 4th item)

= 8 + 0.5 (15 − 8)

= 8 + 3.5 = $\boxed{11.5 \text{ Median}}$

Discrete Series :- $\frac{N+1}{2}$ where N is Σf

Example :-

X	f
3	4
8	3
7	2
9	5
2	7
11	3

- firstly arrange in order.
- Make/find Cummulative frequency - (C.F)

find Median

X	f	Cf
2	7	7
3	4	11
$\boxed{7}$	2	$\boxed{13}$
8	3	16
9	5	21
11	3	24
Σf	24	

always same

$Me = \frac{N+1}{2} = \frac{24+1}{2} = 12.5$ → see in Cf series

It will be in 13. So Median is $\boxed{7}$

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* **Continuous Series** → $Me = L + \dfrac{\frac{N}{2} - Cf_p}{F} \times i$

where L → Lower Limit
i → Class Interval
Cf_p → Cumulative frequency previous
N ⇒ Σf

Me = 2 Step
1 step → $\frac{N}{2}$
2 step → whole Put in formula.

Exg

X	f	CF
0-10	3	$\boxed{3}$ Cf_p
L 10-20	$\boxed{2}$ f	$\boxed{5}$ CF
20-30	4	9
30-40	1	10
	$\Sigma f = 10$	

find Median

1 step ⇒ $\frac{N}{2} = \frac{10}{2} = 5$ → see in Cf

So Median = ~~5~~

$10 + \frac{5-3}{2} \times 10$

$= 10 + \frac{\cancel{2}}{\cancel{2}} \times 10 = \boxed{20}$

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* Partition Values

Quartiles : A Series which are divided in 4 equal Part.

Quartiles (Q_1, Q_2, Q_3)

- Individual → $K\left(\frac{N+1}{4}\right)$

  Where $K \rightarrow 1,2,3$

  " $N \rightarrow$ No. of Observations

- Discrete → $K\frac{(N+1)}{4}$

  Where N is Σf

- Continuous → $L_1 + \frac{\left(\frac{KN}{4} - Cf_p\right)}{F} \times C$

  For this first find $\frac{N}{2}$ then Put in formula.

Deciles :- A Series which are divided in 10 equal Part

Deciles $(D_1, D_2 \text{------} D_9)$

- Individual → $\frac{K(N+1)}{10}$

  Where $K \rightarrow 1,2,3,\text{---}9$

  $N \rightarrow$ No. of item

- Discrete → $\frac{K(N+1)}{10}$

  $N \Rightarrow \Sigma f$

- Continuous → $L_1 + \frac{\frac{KN}{10} - Cf_p}{F} \times i$

  3

Percentiles :- A Series which are divided into 100 equal Part.

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Percentiles (P_1, P_2 ---- P_{99})

Individual

$$\frac{k(N+1)}{100}$$

Discrete

$$\frac{k(N+1)}{100}$$

Continuous.

$$L + \frac{\frac{kN}{100} - cf_p}{F} \times i$$

Where k is 1,2,3 — 99

N = No. of obser.

N = ΣF

Example :- X = 3, 4, 8, 7, 6, 15, 11, 10

find Q_3, D_5, P_{20}

Solution

X
3
4
6
7
8
10
11
15

$$Q_3 = k\left(\frac{N+1}{4}\right) \Rightarrow 3\frac{(8+1)}{4} = 6.75$$

6^{th} item + 0.75(7^{th} item − 6^{th} item)

⇒ 10 + 0.75(11 − 10)

⇒ 10.75

$$D_5 = 5\frac{(8+1)}{10} = 4.5$$

4^{th} item + .5(5^{th} item − 4^{th} item)

⇒ 7 + .5(8 − 7)

= 7.5

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$$P_{20} = \frac{20(8+1)}{100} \Rightarrow 1.8$$

1^{th} item $+ .8(2^{nd}$ item $- 1^{th}$ item$)$

$\Rightarrow 3 + .8(4-3)$

$\Rightarrow 3.8$

Example :-

X	f	Cf
3	2	2
4	5	7
7	1	8
8	3	11
9	4	15
11	6	21

find Q_1, D_6, P_{19}

$$D_6 = \frac{K(N+1)}{10}$$

$= 6\frac{(21+1)}{10} = 13.2 \rightarrow$ See in Cf

and D_6 in X Series

$\Rightarrow$ So $\boxed{9}$

$$Q_1 = \frac{K(N+1)}{4}$$

$= 1\left(\frac{21+1}{4}\right)$

$= 5.5$ See in C.F

$\Rightarrow$ So $\boxed{4}$

$$P_{19} = \frac{K(N+1)}{100}$$

$\Rightarrow 19\frac{(21+1)}{100} = 4.18 \rightarrow$ See in Cf

$\Rightarrow \boxed{4}$

Properties of Median :-

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(i) X and Y are two Variable like $y = a + bx$
if X Median is given then find Median of Y
So $Y_{Me} = a + bX_{Me}$

2) Sum of deviations is minimum when deviations from the median $\Sigma(X - Me)$

Important Note:

Median with the help of diagram

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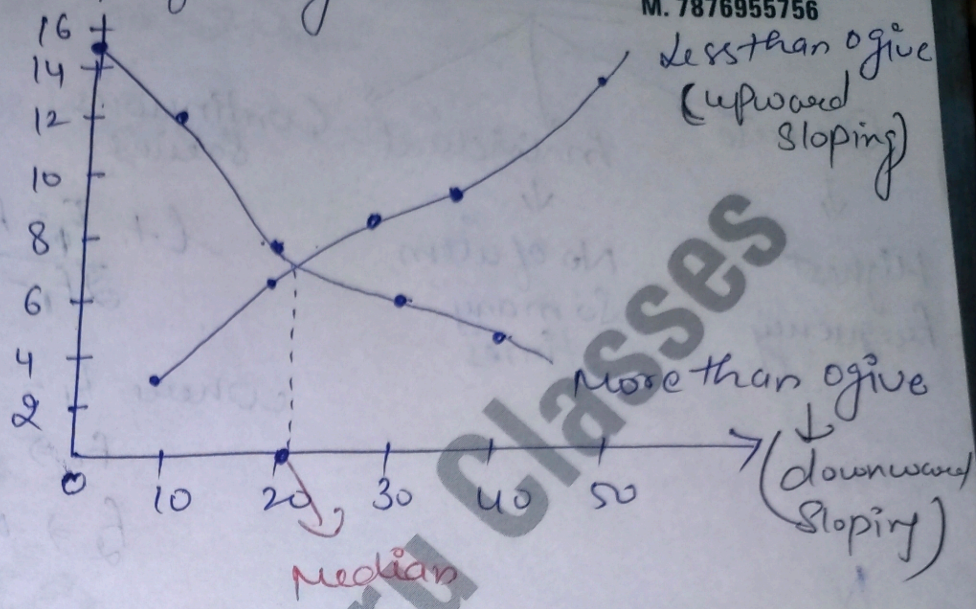
C.I	f
0-10	3
10-20	4
20-30	2
30-40	1
40-50	5



Less than Series

	CF
Less than 10	3
" " 20	7
" " 30	9
" " 40	10
" " 50	15

More than Series

	CF
More than 0	15
" " 10	12
" " 20	8
" " 30	6
" " 40	5

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iv)

* Mode (Z)

Discrete → Highest Frequency

Individual → No of item so many times

Continuous Series

$$l + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times i$$

where f_1 = higest frequency
f_0 ⇒ above/Previous of f_1
f_2 ⇒ Lower of f_1

Important Properities of Mode

(i) Same as mean Property (i)
ii) $y = a+bx$ then Mode of $Y_z = a + bx_z$
iii) affect of Change of origin or Scale.

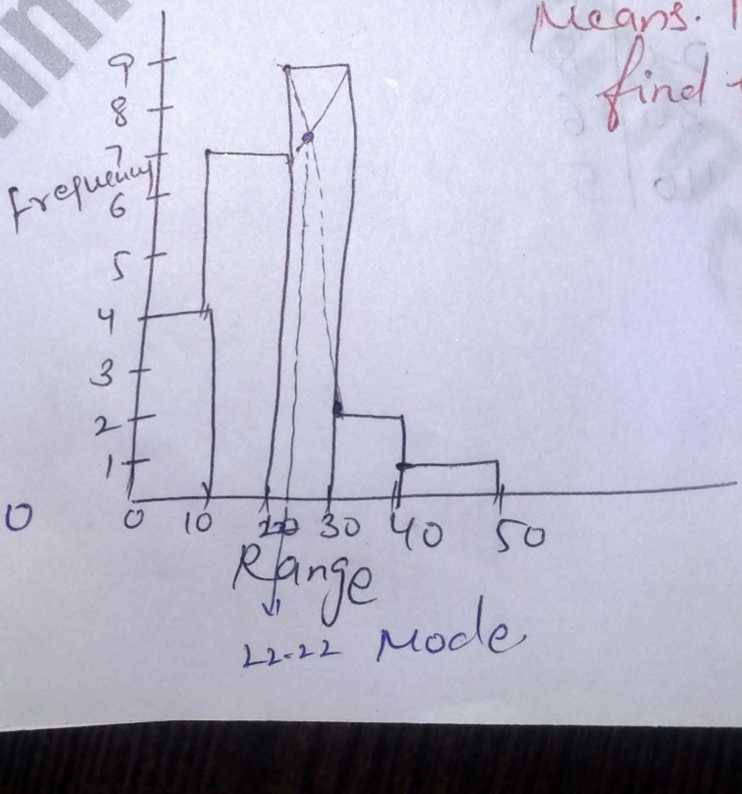
Ex:-

C.I	f
0–10	4
10–20	7 f_0
20–30	9 f_1
30–40	2 f_2
40–50	1

find Mode

$$Z = 20 + \frac{9-7}{2\times 9-7-2} \times 10$$

$= 22.22.$



Means: Mode Can be find from Histogram diagram.

iv) Relationship b/w Mean, Median Mode

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$$\text{Mode} = 3\,\text{Median} - 2\,\text{Mean}$$

$\boxed{\text{or}}$

$$\text{Mean} - \text{Mode} = 3[\text{Mean} - \text{Median}]$$

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* Geometric Mean

GM Mean the n^{th} root of the product of the Observations.

GM

- Individual
  $(x_1 \times x_2 \times x_3 \text{---} x_n)^{1/n}$
  (where N is no. of Oberservation
- Discrete
- Continuous → if in this series then first find mid value and use same formula as Disc. series. x → replace with m.

Discrete / Continuous:
$(x_1^{F_1} \times x_2^{F_2} \times x_3^{F_3} \text{----} x_n^{F_n})^{1/N}$
where N is ΣF

Ex:-

x
3
2
5
6
7

find GM.

$(3 \times 2 \times 5 \times 6 \times 7)^{1/5}$

solve it by using <u>5 step</u> for Power.

x	F
2	1
3	2
4	5
5	4
	$\Sigma F = 12$

find GM.

$(2^1 \times 3^2 \times 4^5 \times 5^4)^{1/12}$

solve it.

Properties of GM:-

i) if all observations are constant then GM is constant

ii) GM of xy = GM of x × GM of Y

3) GM of Ratio of two variable is the Ratio of the GM of the two variable ie $GM_Z = \dfrac{GM \text{ of } x}{GM \text{ of } Y}$

4)* Relationship b/w AM / H.M / G.M.

- AM ≥ GM ≥ HM. [equality sign occurs when all the observations are equal.]
- AM × H.M = (G.M)² if any set of Positive observation then AM > GM > HM

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if 2 no. are given then $AM = \frac{a+b}{2}$

$G.M = (a \times b)^{1/2}$

$HM = \frac{2}{\frac{1}{a}+\frac{1}{b}}$

* Harmonic Mean

For the set of Non-Zero Observations, HM is defined as reciprocal of AM of the reciprocals of the observations.

~~HM~~

HM → Individual, Discrete, Continuous → In this case find mid value & m replace with x.

Individual ↓

⇒ $\frac{n}{\frac{1}{x_1}+\frac{1}{x_2}+\frac{1}{x_3}----\frac{1}{x_n}}$

where n is no. of Observations

Discrete / Continuous:

$\frac{N}{\frac{F_1}{x_1}+\frac{F_2}{x_2}+\frac{F_3}{x_3}---\frac{F_n}{x_n}}$

where N is ΣF

Ex

x
3
2
4
5
6
7

$\frac{6}{\frac{1}{3}+\frac{1}{2}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}+\frac{1}{7}}$

Solve it

x	f
3	6
4	2
5	3
7	5
	Σf = 16

$\frac{16}{\frac{6}{3}+\frac{2}{4}+\frac{3}{5}+\frac{5}{7}}$

Solve it

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* Properties of H.M

i) If all observations are constant then HM also Constant

ii) Combined $HM = \dfrac{n_1+n_2}{\dfrac{n_1}{H_1}+\dfrac{n_2}{H_2}}$

3) $1, \frac{1}{2}, \frac{1}{3} - - \frac{1}{n} = \frac{2}{(n+1)}$ is HM.

* Weighted Average (all the observations are not equally importance)

- Weighted AM → $\frac{\sum w_1 x_1}{\sum w}$ → $\frac{3n(n+1)}{2(2n+1)}$
- Weighted HM → $\frac{\sum w_1}{\sum\left(\frac{w_1}{x_1}\right)}$ → $\frac{2n+1}{3}$
- Weighted GM → Antilog$\left(\frac{\sum w_1 \log x}{\sum w_1}\right)$

if given first n. natural no. & their weight is equal to square of the corresponding no.

Ex ⇒ $X \rightarrow 1, 2, 3, --- n$

$W \rightarrow 1^2, 2^2, 3^3 --- n^2$.

* General Review of Central Tendency.

① Best measure Central tendency is A-M, it is rigidity, defined, based on all the observations, easy to calculate & amen have some mathematical properties. It's have two drawback.

→ easily affected by sampling fluctuation & cannot be advocated for open end classification.

② Median → easy to calculate, defined, not based on all observations

→ Not affected by sampling fluctuation

→ Most appropriate measure in open end classification.

③ mode → Popular measure of central tendency but not defined
→ also affected by sampling fluctuation

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④ GM & HM. → are also based on all observations but difficult to compute & comprehend & have limited applications for the computation of average rates & ratios

⑤ if firm registers both profits & losses then GM cannot be considered.

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Dispersion

- Dispersion measures the extent to which the items vary from some central value. (Mean, Median, Mode)
- Dispersion is also known as scatter, spread or variation

Dispersion

Absolute Measures (Same Unit)
→ Range
→ Standard Deviation (Best)
→ Mean Deviation
→ Quartile Deviation

Relative Measures (Unit free)
→ coefficient of Range
→ " " SD
→ " " MD
→ " " QD

Comparision Case → use Relative Measure.

Characteristics of Dispersion
→ Properly Defined, easy to comprehend (Understand), simple to compute, based on all observation, Unaffected by sample fluctuation

* Range

defined as the difference b/w largest & Smallest of observations.

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Range ⇒ $\alpha - S$ where α = Largest Value, S = Smallest Value.

Cofficient of Range = $\frac{\alpha - S}{\alpha + S} \times 100$

Range
- Individual
- Discrete
- Continuous

No uses of frequency.

Individual

X = 3, 8, 12

$\alpha = 12$
$S = 3$
$\Rightarrow 12 - 3$
$= 9$ Range

Discrete

x	f
2	1
3	2
4	3
5	4

$\alpha = 5$
$S = 2$
$5 - 2 = 3$

Continuous

x	f
0-10	3
10-20	4
20-30	5

Extreme lower & upper Points in Exclusive series.

So ⇒ $\alpha = 30$, $S = 0$
$30 - 0 = 30$

Properties of Range

(i) If all observation are same then Range 0

(ii) Change of origin are not affected but change of scale are affected. $y = a + bx$

$R_y = |b| \times R$

Ex $2x + 3y = 10$ and Range of x is = 15, find Range of y

$3y = 10 - 2x$

$y = \frac{10}{3} - \frac{2x}{3}$

$R_y = |b| x_R$

$= |-\frac{2}{3}| \times 15 \Rightarrow \frac{2}{3} \times 15 = 10$

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* Mean Deviation

Mean Deviation is defined as the AM of the absolute deviations of the observations from an appropriate measure of Central Tendency.

Mean Deviation through
- Mean
- Median

Mean Deviation through Mean
- Individual Series
  $= \frac{\Sigma|X-\bar{X}|}{N}$ N is No. of observation
- Discrete/continuous
  $= \frac{\Sigma f|X-\bar{X}|}{N}$ → N → is Σf

MD through Median
- Individual Series
  $= \frac{\Sigma|X-M|}{N}$
- frequency Distribution
  $= \frac{\Sigma f|X-M|}{N}$

Cofficient of $MD_{\bar{X}} = \frac{MD_{\bar{X}}}{\bar{X}}$

Coffecient of $MD_M = \frac{MD_M}{M}$

Properties of MD

(i) MD is minimum value when the deviations are taken from the median

(ii) Unaffected by Origin but affected by scale

$y = a + bx$

$MD \text{ of } Y = |b| \text{ of } MD_X$

* Standard Deviation (σ)

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The Set of observation is defined as the root mean square deviation when the deviations are taken from the A.M of the observations.

SD

Individual Series

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

or

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

where n is no. of observation

Frequency Series

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

or

$$\Rightarrow \sqrt{\frac{\Sigma fx^2}{N} - (\bar{x})^2}$$

where N is ΣF

* Square of SD is known as Variance (σ^2)

$$S^2 = \frac{\Sigma(x-\bar{x})^2}{n}$$ mean SD का Root Remove Ho jayega

Coefficient of Variation (CV) = $\frac{\sigma}{\bar{x}} \times 100$ or $\frac{SD}{AM} \times 100$

* $SD = \sqrt{\frac{\Sigma dx^2}{N}}$ where $dx = x - \bar{x}$
N = No of observations

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Properties of SD

1) SD of two no. a & b is $\frac{|a-b|}{2}$

2) SD of first n natural no $\sqrt{\frac{n^2-1}{12}}$

3) Short cut in case of continuous series

$$S = \sqrt{\frac{\Sigma f(d')^2}{N} - \left(\frac{\Sigma fd'}{N}\right)^2}$$

4) If all observations are constant then SD, Range and Mean Deviation = 0

5) SD affected due to change of scale not affected due to change of origin $y = a + bx$

$$S_y = |b| S_x$$

6) Combined SD →

$$SD_{12} = \sqrt{\frac{n_1 s_1^2 + n_2 s_2^2 + n_1 d_1^2 + n_2 d_2^2}{n_1 + n_2}}$$

where n_1 = No of item in series 1
n_2 = " " " " " 2
S_1 = SD of series 1
S_2 = " " " 2
$d_1 = \bar{X}_{12} - \bar{X}_1$ where $\bar{X}_{12}$ = combined mean.
$d_2 = \bar{X}_{12} - X_2$

7) Corrected SD

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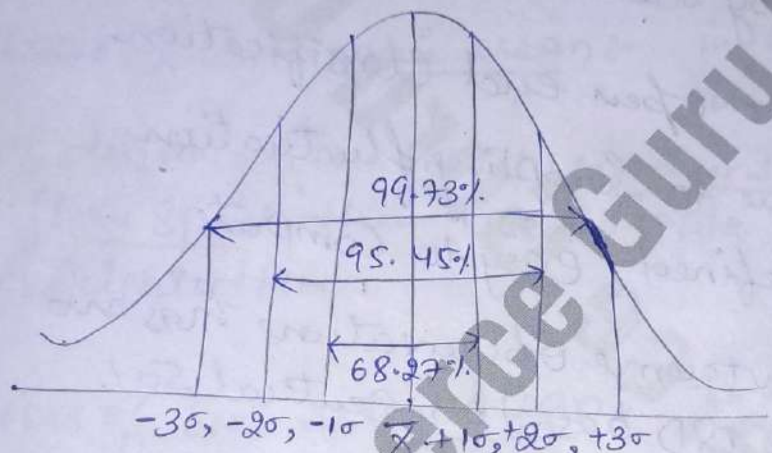
$$\underset{(Correct)}{\Sigma x^2} = \underset{incorrect}{\Sigma x^2} - \left(\begin{matrix}Incorrect\\item\end{matrix}\right)^2 + \left(\begin{matrix}Correct\\item\end{matrix}\right)^2$$

Correct Mean

$$\underset{(Correct)}{\bar{X}} = \frac{\Sigma X(\text{wrong}) - \left(\begin{matrix}incorrect\\item\end{matrix}\right) + \left(\begin{matrix}Correct\\item\end{matrix}\right)}{N}$$

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

8)



Relationship in Percentage basis.

$\bar{X} \pm 1\sigma$ covers 68.27% item
$\bar{X} \pm 2\sigma$ " 95.45% "
$\bar{X} \pm 3\sigma$ " 99.73% "

⑨ Relation of SD with other measure of Dispersion

Most Imp

$QD = \frac{2}{3}\sigma$ and $M.D = \frac{4}{5}\sigma$

in Percentage basis

$\bar{X} \pm QD$ covers 50% item, $\bar{X} \pm MD$ covers 57.51% item.

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* Quartile Deviation (Semi-inter quartile)

$$QD = \frac{Q_3 - Q_1}{2}$$

$$\text{coefficient of } QD = \frac{Q_3 - Q_1}{Q_3 + Q_1} \times 100$$

Properties of QD

1) If all observation are equal then QD=0
2) QD are affected by scale not by origin.
3) Best measure for open end classification
4) Less affected due to sampling fluctuation
5) QD is rigidly defined, easy to compute
6) No presence of extreme observations has no impact on QD since QD based on central 50% of observation

Some Extra

→ widely & commanly used SD.
→ Range is quickest to compute has its application in statistical quality control.
· Based on only two observations and too much affected by extreme observation.

→ M.D rigidly defined, base on all observation and not affected by sampling fluctuation

- It is difficult to comprehend and its computation is also time consuming.
- SD does not follow/ possess mathematical properties

Most Important

1. Median = $Q_2 = D_5 = P_{50}$

2. Uses of Harmonic Mean :- in average speed, rate or velocity
If distance travelled remains same in each given speed then use simple HM. otherwise weighted HM.

3. Uses of Geometric Mean :- To find out the percentage of increase or decrease in the data
- also uses in compound rate i.e increase in population or increase in salary.
- also used in when dep. charged on diminishing Balance method.
- Provide Best average while constructing Index no.
- GM is preferred when large weight are assigned to small item and vice versa.

4 Selection of Best Suitable Average → No one average can be considered as best for all circumstances → So selection bases on some factors i.e i) Purpose

2) Computation

3) Nature of data. Mean if data is very skewed avoid mean, if there is a gap in the data in the middle avoid median, if there are unequal class intervals avoid mode.

A.M not use in case of open end class interval series.

Median use in open end class series or when there are high or low extreme item in the data

Mode is not affected by extreme items of the data. It is mostly used in by the business houses to know the saleable item, size, height etc

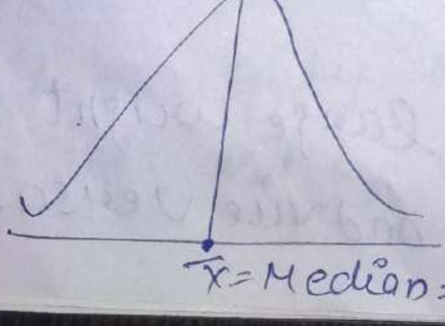
(5) Uses of Range:- i) Quality control i.e production of goods.

2) weather forcasts i.e temperature

iii) fluctuation of in the prices of shares

(6) Detail see in Normal Distribution

ND is a symmetrical shape (bell shape)



$\bar{x}$ = Median = Mode

M. 7988304262
M. 7876955756