New Book

Arithematic Mean :-

It is find similar as average.

It is defined as "a - value obtained by dividing sum of observation by their number of observation"

$$A.M = \frac{\text{Sum of observation}}{\text{Number of observation}}$$

Remember:-

⟷ If we have data in form of population than the value obtain i.e arithematic will called parameter & it will be denoted by μ (mu).

$$\mu = \frac{x_1 + x_2 + \cdots + x_N}{N} = \frac{\sum_{i=1}^{N} x_i}{N}$$

→ But if we have sample than the arithematic mean obtained from that data will be called estimator / statistics

→ Represented by $\bar{x}$.

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n} = \sum_{i=1}^{n} \frac{x_i}{n}$$

It should be noted that population mean is a fixed quantity where as $\bar{x}$, sample mean is variable because different sample from same population tend to have different mean.

Geometrically arithematic mean represent a point at which the distribution or set of observation would be balanced.

Example # 3.1

45, 32, 37, 46, 39, 36, 41, 48, 36

Find A.M?

Solution: Since we know;

$$A.M = \frac{\sum x_i}{n}$$

$$\bar{x} = \frac{45+32+37+46+39+36+41+48+36}{9}$$

$$\bar{x} = \frac{360}{9}$$

$$\boxed{\bar{x} = 40}$$ Ans.

Weighted Arthematic Mean:-

If we have data along with their importances are also given. So to find average of sum number are called weighted arthematic mean.

" When different items of the series are weighted according to their relative importance, the average of such data/series is called weighted A.M.

For e.g GPA is weighted average of Mid, Final, Quizes & assignment etc

Mathematically:-

$$\bar{X}_w = \sum_{i=1}^{n} \frac{x_i w_i}{\sum_{i=1}^{n} w_i}$$

Example:- 3.2

Calculate the weighted mean of the follow.

items	Expenditure (R.s)	weight.
Food	290	7.5
Rent	54	2.0
Fuel & Lights	75	1.0
other	75	0.5
clothing	98	1.5

Sol:- The weighted mean can be calculated as,

Items	Expenditure (x_i)	Weights (w_i)	$x_i w_i$
Food	290	7.5	2175
Rent	54	2.0	108
Clothing	98	1.5	147
Fuel & light	75	1.0	75
Other Items	75	0.5	37
		$\Sigma w_i = 12.5$	$\Sigma w_i f x_i = 254$

Using formula;

$$\bar{x}_w = \frac{\Sigma w \cdot x_i}{\Sigma w} = \frac{2542\,5}{12.5}$$

$$\boxed{\bar{x}_w = 203.4}$$

(x) Properties of Arithematic mean:-

Property #1

The sum of deviation of observation x_i from their mean $\bar{x}$, with their proper sign is zero.

Mathematically; $\boxed{\Sigma(x_i - \bar{x}) = 0}$

For e.g. Consider exp # 3.1.

where data are

45, 32, 37, 46, 39, 36, 41, 48, 36 & $\bar{x} = 40$.

So, $= (45-40)+(32-40)+(37-40)+(46-40)+(39-40)+(36-40)+(41-40)+(48-40)+(36-40)$

$= 5-8-3+6-1-4+1+8-4 = 0$ [proved]

Proof of Property #1

$= \sum (x_i - \bar{x})$

$= \sum_{i=1}^{n} x_i - \sum_{i=1}^{n} \bar{x}$

As $\bar{x}$ is constant so $\sum \bar{x} = n\bar{x}$.

$= \sum_{i=1}^{n} x_i - n\bar{x}$

But $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$

$= \sum_{i=1}^{n} x_i - n \frac{\sum_{i=1}^{n} x_i}{n}$

$\sum (x_i - \bar{x}) = \sum_{i=1}^{n} x_i - \sum_{i=1}^{n} x_i$

$$\boxed{\sum (x_i - \bar{x}) = 0}$$

Property #02

Sum of the square deviation of observation & means is minimum.

Mathematically;

$\sum (x_i - \bar{x})^2$ is minimum.

or

$\sum (x_i - \bar{x})^2 \le (x_i - a)^2$

Where a is any number.

Proof:- $\sum (x_i - a)^2 = \sum (x_i - \bar{x} + \bar{x} - a)^2$

$= \sum ((x_i - \bar{x}) + (\bar{x} - a))^2$

$= \sum \left((x_i-\bar{x})^2 - 2(x-\bar{x})(\bar{x}-a) + (\bar{x}-a)^2 \right)$

Apply summation operator.

$= \sum(x_i-\bar{x})^2 - 2(x-\bar{x})\sum(\bar{x}-a) + \sum(\bar{x}-a)^2$

$= \sum(x_i-\bar{x})^2 - 2(\bar{x}-a)\sum(x-\bar{x}) + \sum(\bar{x}-a)^2$ (property 1)

$= \sum(x_i-\bar{x})^2 + \sum(\bar{x}-a)^2$

∴ As $(\bar{x}-a)$ is constant no. so

$= \sum(x_i-\bar{x})^2 + n(\bar{x}-a)^2$

$\sum(x_i-a)^2 = \sum(x_i-\bar{x})^2 + n(\bar{x}-a)^2$

So it is proved that $\sum(x_i-a)^2 \geq \sum(x_i-\bar{x})^2$

By amount $n(\bar{x}-a)^2$.

(ii) This property usually called minimum property of mean.

Property #03

If we have data of population having K sub groups with their observations $x_1, x_2, x_3, \ldots x_k$ and their corresponding means are $\bar{x}_1, \bar{x}_2, \bar{x}_3 \ldots \bar{x}_k$. So the mean of data can be calculated as;

$$\bar{x} = \frac{n_1\bar{x}_1 + n_2\bar{x}_2 + n_3\bar{x}_3 + \cdots + n_k\bar{x}_k}{n_1 + n_2 + n_3 + \cdots + n_k}$$

Property # 04

If you transform the observation (data given) than there will be also same transformation occur in mean.

For e.g

If $y_i = ax_i + b$ Then;

$\bar{y}_1 = a\bar{x} + b.$

This property is used when we have small number so we multiply (i.e transform) for easing.

Proof:- As;

$y_i = ax_i + b.$

Applying Σ operator on b/s.

$\Sigma y_i = a\Sigma x_i + \Sigma b.$

$\frac{\Sigma y_i}{n} = \frac{a\Sigma x_i}{n} + \frac{nb}{n}$ ∵ divide by n.

$$\boxed{\bar{y} = a\bar{x} + b}$$

[Proved]

∵ $\frac{\Sigma y_i}{n} = \bar{y}$

∵ $\frac{\Sigma x_i}{n} = \bar{x}$

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Example :- 3.3

The mean height and the number of students in three section of statistics class are given below.

Section	Number of boys	Mean height.
A	40	62"
B	37	58"
C	43	61.

Find over all height (mean) of 120 boys.

Solution :- Given data.

$n_1 = 40$ $\bar{x}_1 = 62"$

$n_2 = 37$ $\bar{x}_2 = 58"$

$n_3 = 43$ $\bar{x}_3 = 61"$

$\bar{x}_{Total} = ?$

Since $\bar{x}_T = \dfrac{n_1\bar{x}_1 + n_2\bar{x}_2 + n_3\bar{x}_3}{n_1 + n_2 + n_3}$

$\bar{x}_T = \dfrac{40(62) + 37(58) + 43(61)}{40 + 37 + 43.}$

$\boxed{\bar{x}_T = 60.4"}$

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Mean from Un group data:-

If we ungroup data than the mean can be find as;

$$\bar{x} = \frac{x_1 f_1 + x_2 f_2 + \cdots + x_n f_n}{f_1 + f_2 + f_3 + \cdots + f_n}$$

or

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i f_i}{\sum_{i=1}^{n} f_i}.$$

Mean from group data;

In case of group data we will first find mid points from corresponding intervals and than use this relation;

$$\bar{x} = \frac{x_1 f_1 + x_2 f_2 + x_3 f_3 + \cdots + x_n f_n}{f_1 + f_2 + f_3 + \cdots + f_n}$$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i f_i}{\sum_{i=1} f_i}$$

Example # 3.4 Calculate the mean w[illegible] [illegible]
from the given data

Weight (grams)	Frequency
65-84	9
85-104	10
105-124	17
125-144	10
145-164	5
165-184	4
185-204	5

Solution:-

Weights	Mid point (x_i)	freq.	$x_i f_i$
65-84	74.5	9	670.5
85-104	94.5	10	945
105-124	114.5	17	1946.5
125-144	134.5	10	1345
145-164	154.5	5	722.5
165-184	174.5	4	698
185-204	194.5	5	972.5
		$\Sigma F = 60$	$\Sigma F x_i = 7300$

So;

$$\bar{X} = \frac{\Sigma F x_i}{\Sigma F} = \frac{7300}{60}$$

$$\bar{X} = 121.67$$

Where as from other definition i.e.

$$\bar{x} = \frac{\text{Sum of actual observation}}{\text{No. of Observation.}}$$

$$= \frac{7324}{60}$$ ∵ 7324 is given in questions.

$$\boxed{\bar{x} = 122.067}$$ Ans 2.

Conclusion:-

As by calculating mean from midpoint method & actual observations are approximately same that's why we consider midpoint.

Change of Origin & Scale:-

We use this process in order to transform given data and make it easy for calculation.

Let the given data is;

$x_1, x_2, x_3, \ldots, x_n$ & corresponding frequencies are $f_1, f_2, f_3, \ldots, f_k$.

so; $$u_i = \frac{x_i - a}{h} \longrightarrow (1)$$

where a is number (data) whose frequency is maximum.

h is Class width.

x_i is given corresponding data.

So the mean will be;

$$\bar{U} = \frac{\bar{x} - a}{h}.$$

$$\boxed{\bar{x} = \bar{U}h + a}$$

<u>Example #3.5</u> Given the following frequencies distribution of weights. Calculate mean by <u>Short method.</u>

Weights (gram)	Midpoints	f.
65 – 84	74.5	9
85 – 104	94.5	10
105 – 124	114.5	17
125 – 144	134.5	10
145 – 164	154.5	5
165 – 184	174.5	4
185 – 204	194.5	5

<u>Solution:-</u> As we know that; (short method)

$$\bar{x} = \bar{U}h + a \longrightarrow (1).$$

$$\bar{U} = \frac{\Sigma f_i U_i}{\Sigma f} \longrightarrow (2)$$

Weights	Mid point (x_i)	f_i	u_i	$f_i u_i$
65-84	74.5	9	-2	-18
85-104	94.5	10	-1	-10
105-124	114.5	17	0	0
125-144	134.5	10	1	10
145-164	154.5	5	2	10
165-184	174.5	4	3	12
185-204	194.5	5	4	20
		$\Sigma f = 60$		$\Sigma f_i u_i = 24$

eq ② ⇒

$$\bar{U} = \frac{24}{60} \Rightarrow 0.4$$

∴ Mean of transform data.

eq ① ⇒

$$\bar{x} = \bar{u}h + a$$

$$\bar{x} = (0.4)(20) + 114.5$$

$$\bar{x} = 8 + 114.5$$

$$\boxed{\bar{x} = 122.5}$$ Ans

This is mean of actual data.

Example 3.6

Compute the mean for the following frequency distribution of annual death rate.

Death rate	Frequency.
3.5 – 4.4	1
4.5 – 5.4	4
5.5 – 6.4	5
6.5 – 7.4	13
7.5 – 8.4	12
8.5 – 9.4	19
9.5 – 10.4	13
10.5 – 11.4	10
11.5 – 12.4	6
12.5 – 13.4	4
13.5 – 14.4.	1
	88.

Consider $a = 8.95$

Σu_i $\quad u_i = \frac{x_i - a}{h}$.

Solution:-

Death rate	Mid point	freq.	u_i	$f_i u_i$
3.5 – 4.4	3.95	1	-5	-5
4.5 – 5.4	4.95	4	-4	-16
5.5 – 6.4	5.95	5	-3	-15
6.5 – 7.4	6.95	13	-2	-26
7.5 – 8.4	7.95	12	-1	-12
8.5 – 9.4	8.95	19	0	0
9.5 – 10.4	9.95	13	1	13
10.5 – 11.4	10.95	10	2	20
11.5 – 12.4	11.95	6	3	18
12.5 – 13.4	12.95	4	4	16
13.5 – 14.4.	13.95	1	5	5.
		$\Sigma f = 88$		$\Sigma f_i u_i = -2$

$$\bar{u} = \frac{\sum f_i u_i}{\sum f}$$

$$= -\frac{2}{88}$$

$\bar{u} = 0.023$ → This is mean of transform data.

Now use this eqn.

$$\bar{x} = \bar{u}h + a$$

$$\bar{x} = (0.023)(1) + 8.95$$

$$\boxed{\bar{x} = 8.973}$$ Mean of required data.

Geometric mean:-

If we have data i.e $x_1, x_2, x_3, \ldots, x_n$ that behave geometrically;

So;

$$G.M = (x_1 x_2, x_3 \ldots x_n)^{1/n}$$

Taking log on b/s.

$$\log G.M = \frac{1}{n} \log (x_1 x_2 x_3 \ldots x_n).$$

$$\log G.M = \frac{1}{n} (\log x_1 + \log x_2 + \ldots + \log x_n)$$

$$\log G.M = 1/n \sum_{i=1}^{n} \log x_i$$

$$\log G.M = \sum_{i=1}^{n} \frac{\log x_i}{n}$$

$$G.M = \text{Antilog}\left(\sum_{i=1}^{n} \frac{\log x_i}{n}\right)$$

So G.M is antilog of logarithm of Arithematic data

For group data :-

Let we have grouped data $x_1, x_2, \dots x_k$ having frequencies $f_1, f_2, \dots f_k$.

So $G.M = \left(x_1^{f_1}\, x_2^{f_2}\, x_3^{f_3} \dots x_k^{f_k}\right)^{1/n}$.

$$\log G.M = \frac{1}{n} \log\left(x_1^{f_1}\, x_2^{f_2}\, x_3^{f_3} \dots x_k^{f_k}\right).$$

$$= \frac{1}{n}\left(f_1 \log x_1 + f_2 \log x_2 + \dots f_k \log x_k\right).$$

$$= \frac{1}{n} \sum_{i=1}^{n} \log f_i x_i$$

$$G.M = \text{Antilog}\left(\frac{1}{n} \sum_{i=1}^{k} \log x_i f_i\right)$$

For weighted mean:-

$$\log G_w = \frac{1}{\sum w_i}\left[\sum w_i \log x_i\right].$$

Exp #3.7 Find geometric mean of
45, 37, 32, 46, 39, 36, 41, 48, & 36.

Sol:- As $GM = (x_1 x_2 x_3 \ldots x_k)^{1/n}$

Where n = no. of observation

$G.M = (45 \cdot 37 \cdot 32 \cdot 46 \cdot 39 \cdot 36 \cdot 41 \cdot 48 \cdot 36)^{1/9}$

$\log G.M = \frac{1}{9} \log (45 \cdot 37 \cdot 32 \cdot 46 \cdot 39 \cdot 36 \cdot 41 \cdot 48 \cdot 36)$

$= \frac{1}{9} (\log 45 + \log 37 + \log 32 + \ldots + \log 36)$

$G.M = \text{Antilog}(1.59856)$

$G.M = 39.68$

Exp #3.8 Given the following frequency distribution of weights, Calculate the G.M.

Weights (grams)	65-84	85-104	105-124	125-144	145-164	165-184	185-204
f	9	10	17	10	5	4	5

Sol:- As we know that

$G.M = \text{Antilog} \left(\frac{1}{n} \sum f_i \log x_i\right)$

First we will find $\log x_i$ & f_i

Weights	x_i (M.P)	f_i	$\log x_i$	$f \log x_i$
65-84	74.5	9	1.872	16.848
85-104	94.5	10	1.970	19.75
105-124	114.5	17	2.0589	35
125-144	134.5	10	2.1287	21.287
145-164	154.5	5	2.1889	10.9445
165-184	174.5	4	2.2416	8.9672
185-204	194.5	5	2.2889.	11.445.
		60		$\sum f \log x_i = 124.2412$

$\sum f \log x_i = 124.2412.$

$n = \sum f$

$= 60.$

$\log G.M = \frac{1}{n} \sum f \log x_i$

$= \frac{124.2412}{60}$

$G.M = \text{Anti}\log(2.0707)$

$G.M = 117.67$ Ans.

$G.M = 117.67$ gram.

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Hormonic Mean:-

Hormonic mean is defined as reciprocal of arithematic mean of the reciprocal of the values.

$$H = \text{Reciprocal} \frac{\left(\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_n}\right)}{n}$$

or

$$H = \left\{ \frac{\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_n}}{n} \right\}^{-1}$$

or

$$H = \left(\frac{\sum_{i=1}^{n} \frac{1}{x_i}}{n} \right)^{-1}$$

Exp # 3.9 Find the hormonic mean from the following frequency distribution

Weight (gram)	65-84	85-104	105-124	125-144	145-164	165-184	185-204
f	9	10	17	10	5	4	5.

Solution:-

As we know that;

$$H.M = \left(\frac{\sum_{i=1}^{n} f_i \frac{1}{x_i}}{n} \right)^{-1} \quad \text{——} (1)$$

Weight (grams)	x_i (Mid Point)	f_i	$f(1/x_i)$
65-84	74.5	9	0.1208
85-104	94.5	16	0.10582
105-124	114.5	17	0.14847
125-144	134.5	10	0.07435
145-164	154.5	5	0.03236
165-184	174.5	4	0.02292
185-204	194.5	5	0.02571

$\Sigma f(1/x_i) = 0.53044$

$n = \Sigma f$

$$H.M = \left(\frac{0.53044}{60}\right)^{-1}$$

$$= (8.84067 \times 10^{-3})^{-1}$$

H.M = 113.11 gram

<u>Example 3.10</u>

Compute the Geometric and Hormonic mean for the following distribution annual

x_i	3.95	4.95	5.95	6.95	7.95	8.95	9.95	10.95	11.95	12.95	13.95
f_i	1	4	5	13	12	19	13	10	6	4	1

<u>Solution:-</u>

As we know the Geometric and hormonic mean are

$$G.M = \text{Antilog}\left(\frac{1}{n}\sum_{i=1}^{n} f_i \log x_i\right) \longrightarrow (1).$$

&

$$H.M = \left(\frac{\sum_{i=1}^{n} f_i \frac{1}{x_i}}{n}\right)^{-1} \longrightarrow (2).$$

First we will construct a table.

x_i	f_i	$f_i\left(\frac{1}{x_i}\right)$	$\log x_i$	$f \log x_i$
3.95	1	0.25316	0.5966	0.59660
4.95	4	0.80808	0.69461	2.77844
5.95	5	0.84035	0.77452	3.87260
6.95	13	1.87044	0.84198	10.94574
7.95	12	1.50948	0.90037	10.80444
8.95	19	2.12287	0.95182	18.08458
9.95	13	1.30650	0.99782	12.97166
10.95	10	0.91320	1.03945	10.39450
11.95	6	0.50208	1.0774	6.46440
12.95	4	0.30888	1.11229	4.44916
13.95	1	0.07168	1.14459	1.1446

$n = \sum f = 88$ $\quad \sum f_i\left(\frac{1}{x_i}\right) = 10.50672$ $\quad \sum f_i \log x_i = 82.50.$

$n = \sum f_i$

Using eq (1) & (2).

$$G.M = \text{Antilog}\left(\frac{1}{88}(82.50)\right) \Rightarrow \boxed{G.M = 8.65}$$

$$H.M = \left(\frac{10.50672}{88}\right)^{-1} \Rightarrow \boxed{H.M = 8.37}$$

Ans

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Median:-

Consider if we such like data

1, 2, 3, 70, 80, 90 & 1000

So

$$A.M = \frac{1+2+3+70+80+90+1000}{7}$$

$$A.M = 178.$$

Which not exact or appropiate central tendency. So In order to get appropiate mean we used median.

"Median ~~Mean~~ of data is a number at or below which 50% of ordered data lies."

→ Usually mean tells about that value which lie in mid of given data while median also locate that value from data.

Rules:- (For Raw data)

If $n/2$ is not integer than the ~~ave~~ median is $\left(\frac{n}{2}+1\right)$ while if $n/2$ is ~~odd~~ integer than median is average of $n/2$ & $\frac{n}{2}+1$

→ **Note:-** In order to find median the data should be arranged in accending order

Example # 3.11

Find the median & Quartile?

45, 32, 37, 46, 39, 36, 41, 48 & 36.

Solution:- First arrange data in assending order

32, 36, 36, 37, 39, 41, 45, 46, 48.

No. of data = 9.

$\frac{n}{2} = \frac{9}{2} = 4.5$ as not Integer

So therefore the median will be;

$\frac{n+1}{2} \Rightarrow \frac{9+1}{2} \Rightarrow$ (5).

The 5th position data is 39.

So median is 39.

For Quartile:-

$\frac{n}{4} = \frac{9}{4} = 2.25$ not integer.

So; $\frac{n}{4} + 1 \Rightarrow \frac{9}{4} + 1 = 2.25 + 1 = 3.25$.

So marks obtain by 3rd student is

quartile ~~median~~ = 36. Ans

Median for ungroup frequency distributions:-

→ First organized data in accending order.

(*) find cumulative frequency.

(*) Now if $\frac{n}{2}$ is integer for e.g let the value that we get is 17 so we will see in Com. freq. column the value if not found. So we take its range that This value which is lie b/w 15 & 20. So take 20 C.frequency & infront of that c.freq. we get the median of that value

Second Case:-

If we find $\frac{n}{2}$ and than give such value which present in c.frequency than we will take average of that value which is infront of that found value and preceding value. Note those average values should be in x – column.

If $\frac{n}{2}$ is not Integer:- (odd).

If we have odd number or we get number i.e not integer than we use $\frac{n+1}{2}$ if we get such value which is not c. freq. column so we will consider range and take preceding one as median.

& if it is present in c. freq. column so we will consider that value which infront of that c. freq.

For group frequency Distribution:-

- 1st step is to introduce class boundries.

2- Find cumulative frequency column.

3. Find $n/2$ and locate in c. freq column to find median class.

Then used this formula for median class

Median Class (Class boundry) (LB - UB) $= l + \frac{h}{f}\left(\frac{n}{2} - c\right)$

∴ l = lower boundry.

h = Class wedth.

f = frequency of median class.

c = c. frequency of prevous or preceeding class.

Example 3.12

The following distribution relates to the number of assistant in 50 total establishment.

No. of Assistants	0	1	2	3	4	5	6	7	8	9
f	3	4	6	7	10	6	5	5	3	1

Find the median number of assistants.

Also compute quartile & 7th decile.

Sol:- As this is example of ungrouped frequency distribution. So first we will find c. freq. row.

No. of Assistants	0	1	2	3	4	5	6	7	8	9
Frequency	3	4	6	7	10	6	5	5	3	1
C. frequency	3	7	13	20	30	36	41	46	49	50

Since

$$\frac{n}{2} = \frac{50}{2} = 25 \rightarrow \text{Integer.}$$

As there is 25 in c.frequency. So will consider c. freq. 30 column. In front of 30 we have 4.

So median is = 4.

For quartile $= \frac{n}{4} = \frac{50}{4} = 12.5$ Not integer.

So consider 13-th c. freq. by $\frac{n+1}{2}$ rule so quartile is

2.

Example # 3.13 :-

Find the median, quartiles and 8th decile for distribution of marks given below.

Marks	30-39	40-49	50-59	60-69	70-79	80-89	90-99
No. of students	8	87	190	304	211	85	20

Solution:-

For grouped frequency distribution we need class boundries, cumulative frequencies.

Class Boundries	Frequency	Cum. Frequency
29.5 - 39.5	8	8
39.5 - 49.5	87	95
49.5 - 59.5	190	285
59.5 - 69.5	304	589
69.5 - 79.5	211	800
79.5 - 89.5	85	885
89.5 - 99.5.	20	905

Median will be lie in.

$= \frac{905}{2} = 452.5^{th}$ by $\frac{n+1}{2}$th rule

which is non integer so

The median class will be 59.5-69.5

Now use Formula i.e.

$$Median = l + \frac{h}{f}\left(\frac{n}{2} - c\right)$$

$l = 59.5$

$h = 10$

$f = 304$

$\frac{n}{2} = 452.5$

$c = 285$

— By putting values.

$$Median = 59.5 + \frac{10}{304}(452.5 - 285)$$

Median = 65

Ans