

Chapter 14

Measures of Central Tendency and Dispersion

Past Trends

Attempt	Theory	Practical	Total
May 2018	4	3	7
Nov 2018	2	10	12
Jun 2019	3	9	12
Nov 2019	7	10	17
Nov 2020	5	4	9
Jan 2021	5	4	9
Jul 2021	1	11	12
Dec 2021	5	6	11
Jun 2022	3	6	9
Dec 2022	3	13	16
June 2023	0	15	15

Central Tendency - Basics

Meaning	<ul style="list-style-type: none"> Central Tendency is the tendency of a given set of observations to cluster around a single central or middle value. The single value that represents the given set of observations is described as a measure of central tendency.
Different Measures of Central Tendency	<ul style="list-style-type: none"> Arithmetic Mean (AM) Median (Me) Mode (Mo) Geometric Mean (GM) Harmonic Mean (HM)
Types of Formula based Questions	<ul style="list-style-type: none"> Discrete Observations Simple Frequency Distribution Grouped Frequency Distribution



Arithmetic Mean

Discrete Observations	$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n}$	$\bar{x} = \frac{\sum x}{n}$
Frequency Distribution	$\bar{x} = \frac{\sum fx}{N}$	
	In case of simple frequency distribution	$x = \text{individual values}$
	In case of grouped frequency distribution	$x = \text{mid-point of class intervals}$
	$N = \text{total number of observations}$	$N = \sum f$
Assumed Mean / Step-Deviation Method	AM using assumed mean / step deviation method $\bar{x} = A + \frac{\sum fd}{N} \times C$ where $d = \frac{x - A}{C}$, A is assumed mean, C is class length	
Property 1	If all the observations are constant, AM is also constant	
Property 2	the algebraic sum of deviations of a set of observations from their AM is zero	
Property 3	AM is affected both due to change of origin and scale If $y = a + bx$ then $\bar{y} = a + b\bar{x}$	
Property 4	Combined AM $\bar{x}_c = \frac{n_1\bar{x}_1 + n_2\bar{x}_2}{n_1 + n_2}$	
General Review	<ul style="list-style-type: none"> • AM is best measure of central tendency • AM is based on all observations • AM is affected by sampling fluctuations • AM is amenable to mathematical property • AM cannot be used in case of open end classification 	

ICAI SM, MTP Nov 20

(1)	Two variables assume the values 1,2, 3,.. 5 with frequencies as 1, 2, 3, ..5 , then what is the AM ?			
A	a.	11/3	b.	15/8
	c.	4.86	d.	10

PYQ May 18

(2)	If each item is reduced by 15 A. M is		
A	a.	Reduced by 15	
	b.	Increased by 15	
	c.	Reduced by 10	
	d.	None of these	



		<i>MTP Nov 21</i>	
(9) C	At ABC Ltd, the average age of employees is 36. Average age of male employees is 38 and that of females is 32. Find the ratio of female to male in the company.	a. 1:3 c. 1:2	b. 2:1 d. 3:1
		<i>PYQ June 19</i>	
(10) B ★	The AM of 15 observation is 9 and the AM of first 9 observation is 11 and then AM of remaining observation is	a. 11 c. 5	b. 6 d. 9
		<i>PYQ June 22</i>	
(11) D	When each value does not have equal importance then	a. A M b. G M c. H M d. Weighted Average	
		<i>PYQ June 22</i>	
(12) C ★	The mean of 20 observation is 38. If two observation are taken as 84 and 36 instead of 48 and 63 find new means.	a. 38.45 c. 37.55	b. 41.15 d. 40.05
		<i>MTP Nov 19</i>	
(13) C ★	The average weight of 8 person increases by 1.5 kg, if a person weighing 65 kg replaced by a new person, what would be the weight of the new person?	a. 76 kg c. 77 kg	b. 80 kg d. None of these



Median

Discrete Observations	<ul style="list-style-type: none"> If $n = \text{odd}$, then middle term If $n = \text{even}$, average of two middle terms 								
Simple Frequency Distribution	<ul style="list-style-type: none"> First make column of less than cumulative frequency Apply same formula as discrete 								
Grouped Frequency Distribution	Median in case of grouped frequency distribution								
	Step 1	Prepare a less than type cumulative frequency distribution							
	Step 2	Calculate $\frac{N}{2}$ and check between which class boundaries it falls and call it as Median Class							
	Step 3	<table border="1" style="width: 100%; text-align: center;"> <tr> <td>l_1</td> <td>N_u</td> <td>N_l</td> <td>C</td> </tr> <tr> <td>LCB of Median Class</td> <td>Cum Freq. of Median Class</td> <td>Cum. Freq. of Pre-Median Class</td> <td>Class length of Median Class</td> </tr> </table>	l_1	N_u	N_l	C	LCB of Median Class	Cum Freq. of Median Class	Cum. Freq. of Pre-Median Class
l_1	N_u	N_l	C						
LCB of Median Class	Cum Freq. of Median Class	Cum. Freq. of Pre-Median Class	Class length of Median Class						
Step 4	Apply Formula $Me = l_1 + \left(\frac{\frac{N}{2} - N_l}{N_u - N_l} \right) \times C$								
Property 1	For a set of observations, the sum of absolute deviations is minimum, when the deviations are taken from the median. $\sum x - Me \text{ is minimum}$								
Property 2	Median is also affected by both change of origin and scale.								
General Review	<ul style="list-style-type: none"> Median is also called as positional average Median is not based on all observations Median is not affected by sampling fluctuations Median is best measure of central tendency in case of open-end classification 								

		PYQ Jun 23	
(14)	For a given data set: 5, 10, 3, 6, 4, 8, 9, 3, 15, 2, 9, 4, 19, 11, 4; what is the median?		
B	a. 8	b. 6	
	c. 4	d. 9	
		PYQ Nov. 18	
(15)	The median of the data 5, 6, 7, 8, 9, 10, 11, 12, 15, 18, 18 and 19 is		
A	a. 10.5	b. 10	
	c. 11	d. 11.5	



<p>Formula – Discrete Observations</p>	<ul style="list-style-type: none"> Rank Calculation $(n + 1)p^{th}$ term Value of p depends on partition value <table border="1" data-bbox="497 383 1348 582"> <thead> <tr> <th>#</th> <th>Median</th> <th>Quartile</th> <th>Decile</th> <th>Percentile</th> </tr> </thead> <tbody> <tr> <td>First</td> <td>1/2</td> <td>1/4</td> <td>1/10</td> <td>1/100</td> </tr> <tr> <td>Second</td> <td></td> <td>2/4</td> <td>2/10</td> <td>2/100</td> </tr> <tr> <td>...</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Last</td> <td></td> <td>3/4</td> <td>9/10</td> <td>99/100</td> </tr> </tbody> </table>	#	Median	Quartile	Decile	Percentile	First	1/2	1/4	1/10	1/100	Second		2/4	2/10	2/100	...					Last		3/4	9/10	99/100
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MTP May 19

(20) What is the value of the first quartile for observations 15, 18, 10, 20, 23, 28, 12, 16?

C

a.	17	b.	16
c.	12.75	d.	12



		PYQ June 22															
(21)	The 3 rd decile for the numbers																
B	15,10, 20, 25, 18, 11, 9, 12 is																
	a. 13	b. 10.70															
	c. 11.00	d. 11.50															
		MTP Nov 21															
(22)	Find D_6 for the following observations. 7, 9, 5, 4, 10, 15, 14, 18, 6, 20																
B	a. 11.40	b. 12.40															
	c. 13.40	d. 13.80															
		ICAI SM															
(23)	The third quartile and 65 th percentile for the following data are																
A																	
		<table border="1"> <thead> <tr> <th>Profits</th> <th><10</th> <th>10-19</th> <th>20-29</th> <th>30-39</th> <th>40-49</th> <th>50-59</th> </tr> </thead> <tbody> <tr> <td>No. of firms</td> <td>5</td> <td>18</td> <td>38</td> <td>20</td> <td>9</td> <td>2</td> </tr> </tbody> </table>		Profits	<10	10-19	20-29	30-39	40-49	50-59	No. of firms	5	18	38	20	9	2
Profits	<10	10-19	20-29	30-39	40-49	50-59											
No. of firms	5	18	38	20	9	2											
	a. 33.5 & 29.184	b. 33 & 28.68															
	c. 33.6 & 29	d. 33.25 & 29.25															

Mode

Meaning	Mode is the <i>value that occurs the maximum</i> number of times						
Special Thing about Mode	<ul style="list-style-type: none"> If two or more observations are having maximum frequency then there are multiple modes [multimodal distribution] If there are exactly two modes then distribution is called as Bimodal Distribution If all observations are having same frequency then distribution has no mode We can say that Mode is not rigidly defined 						
Grouped Frequency Distribution	<ul style="list-style-type: none"> Find Modal Class: Class with highest frequency and obtain below values <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>f_{-1}</th> <th>f_0</th> <th>f_1</th> </tr> </thead> <tbody> <tr> <td>frequency of pre modal class</td> <td>frequency of the modal class</td> <td>frequency of the post modal class</td> </tr> </tbody> </table> <ul style="list-style-type: none"> Apply Formula $Mo = l_1 + \left(\frac{f_0 - f_{-1}}{2f_0 - f_{-1} - f_1} \right) \times C$	f_{-1}	f_0	f_1	frequency of pre modal class	frequency of the modal class	frequency of the post modal class
f_{-1}	f_0	f_1					
frequency of pre modal class	frequency of the modal class	frequency of the post modal class					
Property 1	If all the observations are constant, mode is also constant						
Property 2	Mode is also affected both due to change of origin and scale						
General Review	<ul style="list-style-type: none"> Mode is not based on all observations Mode is not rigidly defined Mode is not amenable to Mathematical Property 						



		PYQ June 19	
(30)	For a symmetric distribution		
A	a.	Mean = Median = Mode	
	b.	Mode = 3 Median = 2 Mean	
	c.	Mode = $\frac{1}{3}$ Median = $\frac{1}{2}$ Mean	
	d.	None of these	
		PYQ Dec. 21	
(31)	For a moderately skewed distribution the median is twice the mean, then the mode is _____ times the median.		
B			
☆	a.	3	b. 2
	c.	2/3	d. 3/2
		MTP June 22	
(32)	If the difference between mean and mode is 33, then the difference between Mean and Median will be _____		
C			
☆	a.	63	b. 31.5
	c.	11	d. None of these

Geometric Mean

Definition	For a given set of n positive observations, the geometric mean is defined as the n^{th} root of the product of the observations
Formula – Discrete	$G = (x_1 \times x_2 \times \dots \times x_n)^{1/n}$
Formula – Frequency Distribution	$G = (x_1^{f_1} \times x_2^{f_2} \times \dots \times x_n^{f_n})^{1/N}$
Property 1	Logarithm of G for a set of observations is the AM of the logarithm of the observations $\log G = \frac{1}{n} \sum \log x$
Property 2	If all the observations are constant, GM is also constant
Property 3	If $z = xy$, then GM of $z = \text{GM of } x \times \text{GM of } y$
Property 4	If $z = x/y$, then GM of $z = \frac{\text{GM of } x}{\text{GM of } y}$

		PYQ Nov. 18	
(33)	The Geometric mean of 3, 6, 24 and 48 is		
B	a.	8	b. 12
	c.	24	d. 6



		MTP Nov 18
(34)	The Geometric mean of the series $1, k, k^2, k^3, \dots, k^n$ where k is constant is	
A	a. $k^{\frac{(n+1)}{2}}$	b. $k^{n+0.5}$
☆	c. k^{n+1}	d. k^{n+2}
		MTP March 21
(35)	G.M is a better measure than others when,	
☆	a. Ratios and percentages given	
A	b. Interval of scale is given	
	c. Both (a) and (b)	
	d. Either (a) or (b)	
		MTP Nov 21
(36)	If the rates return from three different shares are 100%, 200% and 400% respectively. The average rate of return will be.	
C	a. 350%	b. 233.33%
☆	c. 200%	d. 300%

Harmonic Mean

Definition	For a given set of non-zero observations, harmonic mean is defined as the reciprocal of the AM of the reciprocals of the observation
Formula – Discrete	$H = \frac{n}{\sum\left(\frac{1}{x}\right)}$
Formula – Frequency Distribution	$H = \frac{N}{\sum\left(\frac{f}{x}\right)}$
Property 1	If all observations are constant HM is also constant
Property 2	$\text{Combined HM} = \frac{n_1 + n_2}{\frac{n_1}{H_1} + \frac{n_2}{H_2}}$



PYQ Nov. 20

(37) Given the weights for the numbers 1, 2, 3n are respectively $1^2, 2^2, 3^2, \dots, n^2$ then weighted HM is _____

C
★

- a. $\frac{2n+1}{4}$
- b. $\frac{2n+1}{6}$
- c. $\frac{2n+1}{3}$
- d. $\frac{2n+1}{2}$

PYQ Nov. 20

(38) The harmonic mean A and B is $1/3$ and harmonic mean of C and D is $1/5$. The harmonic mean of ABCD is

B
★

- a. $8/15$
- b. $1/4$
- c. $1/15$
- d. $5/3$

MTP May 18

(39) A man travels from Delhi to Agra at an average speed of 30km per hour and back at an average speed of 60 km per hour. What's the average Speed.

B

- a. 48 km/hr
- b. 40 km/hr
- c. 45 km/hr
- d. 35 km/hr

MTP Nov 20

(40) If there are two groups with 75 and 65 as harmonic means containing 15 and 13 observation, then combined HM is given by

A

- a. 70
- b. 72.25
- c. 78
- d. 76

Use of GM and HM

Both	Both are used for calculating average rates
GM	Appropriate for rates having percentages
HM	Appropriate for rates other than percentages

Relationship between AM, GM, and HM

Relation	Scenario	Relation
	When all the observations are same	$AM = GM = HM$
	When observations are distinct	$AM > GM > HM$
	In question is silent	$AM \geq GM \geq HM$



Special Relation	<p>If there are only two observations:</p> $AM \times HM = (GM)^2$
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		MTP May 19
(41)	Which of the following results hold for a set of distinct positive observations?	
C	a.	$AM \geq GM \geq HM$
	b.	$HM \geq GM \geq AM$
	c.	$AM > GM > HM$
	d.	$GM > AM > HM$
		PYQ Nov. 20
(42)	If the AM and HM of two numbers are 6 and 9 respectively, then GM is	
A	a.	7.35
	b.	8.5
	c.	6.75
	d.	None of these

Weighted Average

When to use	If the observations are not of equal importance and we need to treat observations according to their hierarchical importance, then we use Weighted Average	
Formulas	Weighted AM	$\frac{\sum wx}{\sum w}$
	Weighted GM	$(x_1^{w_1} \times x_2^{w_2} \times x_3^{w_3} \times \dots \times x_n^{w_n})^{\frac{1}{\sum w}}$
	Weighted HM	$\frac{\sum w}{\sum \left(\frac{w}{x}\right)}$

Measures of Dispersion

Meaning of Measure of Dispersion	<ul style="list-style-type: none"> • Dispersion for a given set of observations may be defined as • the amount of deviation of the observations, • usually, from an appropriate measure of central tendency
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Types of Measure of Dispersion	Absolute Measures of Dispersion	<ul style="list-style-type: none"> • These are with units • These are not useful for comparison of two variables with different units. • Example: Range, Mean Deviation, Standard Deviation, Quartile Deviation
	Relative Measures of Dispersion	<ul style="list-style-type: none"> • These are unit free measures • These are useful for comparison of two variables with different units. • Example: Coefficient of Range, Coefficient of Mean Deviation, Coefficient of variation, Coefficient of Quartile Deviation

Range

Discrete – Formula	$L - S$ where L: Largest Observation, S: Smallest Observation
Grouped Frequency Distribution – Formula	$L - S$ where Largest Observation = UCB of last class interval, Smallest Observation = LCB of first-class interval
Coefficient of Range	$\frac{L - S}{L + S} \times 100$
Property 1	<ul style="list-style-type: none"> • Not affected by change of origin • Affected by change of scale (only value) • No impact of sign of change of scale • Note: Measure of Dispersion can never be negative
General Review	<ul style="list-style-type: none"> • Not Based on All Observations • Easy to Compute

h **MTP May 19 Series II**

(43) The range of 15, 12, 10, 9, 17, 30 is

D

a. 5	b. 12
c. 13	d. 21

MTP Mar 21, MTP Apr 21

(44) What is the coefficient of range for the following distribution?

D

Class	10-19	20-29	30-39	40-49	50-59
Freq.	11	25	16	7	3

a. 22	b. 50
c. 75.82	d. 72.46



		PYQ July 21	
(45)	If the relationship between x and y is given by $2x + 3y = 10$ and the range of y is 10, then what is the range of x ?		
D	a. 10	b. 18	
	c. 8	d. 15	
		PYQ Nov. 18	
(46)	If the range of a set of values is 65 and maximum value in the set is 83, then the minimum value in the set is		
C	a. 74	b. 9	
	c. 18	d. None of these	

Mean Deviation

Meaning	<ul style="list-style-type: none"> Mean deviation is defined as the arithmetic mean of the absolute deviations of the observations from an appropriate measure of central tendency
Formula – Discrete	$MD_A = \frac{1}{n} \sum x - A $ <p>where, $A =$ Appropriate Central Tendency Measure</p>
Formula – Frequency Distribution	$MD_A = \frac{1}{N} \sum f x - A $
Coefficient of Mean Deviation	<p>Coefficient of Mean Deviation: $\frac{\text{Mean Deviation about } A}{A} \times 100$</p>
Property 1	Mean Deviation takes its minimum value when deviations are taken from Median
Property 2	Change of Origin – No Affect , Change of Scale – Affect of value not sign
General Review	<ul style="list-style-type: none"> Based on all observations Improvement over Range Difficult to compute Not amenable to Mathematical Property because of usage of Modulus

		PYQ July 21	
(47)	The mean deviation of the numbers 3, 10, 6, 11, 14, 17, 9, 8, 12 about the mean is (correct to one decimal place):		
C	a. 8.7	b. 4.2	
	c. 3.1	d. 9.8	



		<i>PYQ June 22</i>																	
(48)	Mean Deviation of data 3, 10, 10, 4, 7, 18, 5 from mode is																		
C	a. 4.39	b. 4.70																	
	c. 4.14	d. 5.24																	
		<i>ICAI SM</i>																	
(49)	Mean Deviation of data 82, 56, 75, 70, 52, 80, 68 from median is																		
C	a. 16.49	b. 12.45																	
	c. 87.14	d. 78.45																	
		<i>MTP Dec 22 – Series I</i>																	
(50)	Which measure of dispersion is based on the absolute deviation only?																		
C	a. Range																		
	b. Standard Deviation																		
	c. Mean Deviation																		
	d. Quartile Deviation																		
		<i>ICAI SM</i>																	
(51)	What is the mean deviation about median for the following data?																		
D	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td><i>x</i></td> <td>3</td> <td>5</td> <td>7</td> <td>9</td> <td>11</td> <td>13</td> <td>15</td> </tr> <tr> <td><i>f</i></td> <td>2</td> <td>8</td> <td>9</td> <td>16</td> <td>14</td> <td>7</td> <td>4</td> </tr> </table>			<i>x</i>	3	5	7	9	11	13	15	<i>f</i>	2	8	9	16	14	7	4
<i>x</i>	3	5	7	9	11	13	15												
<i>f</i>	2	8	9	16	14	7	4												
	a. 2.50	b. 2.46																	
	c. 2.43	d. 2.37																	

Standard Deviation

Meaning	<ul style="list-style-type: none"> Improvement over Mean Deviation It is defined as the root mean square deviation when the deviations are <u>taken from the AM</u> of the observations
Formula – Discrete	$\sigma_x = SD_x = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$ $\sigma_x = SD_x = \sqrt{\frac{\sum x^2}{n} - (\bar{x})^2}$
Formula – Frequency Distribution	$\sigma_x = SD_x = \sqrt{\frac{\sum f(x - \bar{x})^2}{N}}$ $\sigma_x = SD_x = \sqrt{\frac{\sum fx^2}{N} - (\bar{x})^2}$
Coefficient of Variation	$\frac{SD_x}{\bar{x}} \times 100$
SD for any two numbers	$SD = \frac{Range}{2}$
SD for first n natural numbers	$s = \sqrt{\frac{n^2 - 1}{12}}$



MTP May 19 Series II											
(58) C	If the profits of a company remain the same for the last ten months, then the standard deviation of profits for these ten months would be? a. positive b. negative c. zero d. A or C										
ICAI SM, MTP May 19 Series II											
(59) C	If x and y are related by $y = 2x + 5$ and the SD and AM of x are known to be 5 and 10 respectively, then the coefficient of variation of y is a. 25 b. 30 c. 40 d. 20										
MTP Nov 19											
(60) A	If the values of all observations are equal then the Standard Deviation of the given observations is a. 0 b. 2 c. 1 d. None of these										
MTP March 21											
(61) C ★	The sum of squares of deviation from mean of 10 observations is 250. Mean of the data is 10. Find the coefficient of variation a. 10% b. 25% c. 50% d. 0%										
hv MTP Dec 22 – Series I											
(62) C ★	What is the SD of the following series : <table border="1" style="margin-left: 20px;"> <tr> <td>Meas.</td> <td>0-10</td> <td>10-20</td> <td>20-30</td> <td>30-40</td> </tr> <tr> <td>Freq.</td> <td>1</td> <td>3</td> <td>4</td> <td>2</td> </tr> </table> a. 81 b. 7.6 c. 9 d. 2.26	Meas.	0-10	10-20	20-30	30-40	Freq.	1	3	4	2
Meas.	0-10	10-20	20-30	30-40							
Freq.	1	3	4	2							

Quartile Deviation

Formula	$QD_x = \frac{Q_3 - Q_1}{2}$
Calculation	Quartiles are calculated same as we studied in Central Tendency
Coefficient of Quartile Deviation	$\frac{Q_3 - Q_1}{Q_3 + Q_1} \times 100$
General Review	<ul style="list-style-type: none"> It is the best measure of dispersion for open-end classification It is also less affected due to sampling fluctuations Like other measures of Dispersion, QD is also not affected by change of origin but affected by scale ignoring sign



<i>Relationship between SD, MD and QD</i>	$4SD = 5MD = 6QD$ or $SD : MD : QD = 15 : 12 : 10$
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		<i>MTP May 19</i>
(63)	<i>The quartiles of a variable are 45, 52 and 65 respectively. Its quartile deviation is</i>	
A	a. 10	b. 20
	c. 25	d. 8.30
		<i>PYQ June 23</i>
(64)	<i>If the first quartile is 42.75 and the third quartile is 74.25, then the coefficient of quartile deviation is:</i>	
D	a. 29.62	b. 15.75
	c. 17.57	d. 26.92
		<i>PYQ June 19</i>
(65)	<i>Coefficient of quartile deviation is 1/4 then Q_3 / Q_1 is</i>	
A	a. 5/3	b. 4/3
☆	c. 3/4	d. 3/5
		<i>MTP Apr 21</i>
(66)	<i>Interval Quartile Range is ____ of Quartile Deviation</i>	
B	a. Half	b. Double
☆	c. Triple	d. Equal
		<i>MTP Dec 22 – Series I</i>
(67)	<i>The approximate ratio of SD, MD, QD is</i>	
C	a. 2:3:4	b. 3:4:5
	c. 15:12:10	d. 5:6:7

CA. PRANAV

