Unit II

Summary Statistics: Measures of Central Tendency: Arithmetic Mean, Weighted Mean, Median and Mode. Index Numbers: Concept & Applications

Meaning of Measure of Central Tendency:

- A measure of central tendency is a single value that attempts to describe a set of data by identifying the central position within that set of data.
- Measures of Central tendency are sometimes called measures of central location or summary statistics.

ARITHMETIC MEAN:

- Arithmetic Mean represents the average value of the dataset.
- Arithmetic Mean is obtained by dividing the sum of the values of all items of a series by the number of items of that series by the number of items of that series.
- Normally, arithmetic mean is denoted by $\bar{X}$ which is read by ‘X bar’.

- Arithmetic Mean is of two types:

1. **Simple Arithmetic Mean**: is the value which we get by dividing the aggregate of all the items by the total number of items.

2. **Weighted Arithmetic Mean:** is obtained by applying to the items weights as judged by their relative importance.

- **Computation of Arithmetic Mean in an individual series (where frequencies are not given):**

DIRECT METHOD

STEP 1: Treat the given values of variable as X.
STEP 2: Enter the given values in a column headed as X.
STEP 3: Add together all the values of variable X and obtain the total i.e. $\sum X$.
STEP 4: Apply all the following formula:

$$\overline{X} = \frac{\sum X}{N}$$

where, $\overline{X}$ = Arithmetic Mean
$\sum X$ = Sum of all values of variable X
N = Number of individual observations

Exercise 1: The following table gives the monthly income of ten families in a town:

S. No.	Monthly Income (Rs.)
1	1,000
2	1,200
3	1,500
4	2,200
5	2,800
6	3,000
7	3,500
8	5,000
9	8,000
10	10,000

S. No.	Monthly Income (Rs.) X
1	1,000
2	1,200
3	1,500
4	2,200
5	2,800
6	3,000
7	3,500
8	5,000
9	8,000
10	10,000
Total	$\sum X = 38,200$

$$\bar{X} = \frac{\sum X}{N}$$

$\bar{X}$ = 38,200/10

= Rs 3,820

Calculate the mean for pH levels of soil

6.8, 6.6, 5.2, 5.6, 5.8

S. No.	pH level X
1	6.8
2	6.6
3	5.2
4	5.6
5	5.8
	$\sum X = 30$

$$\bar{X} = \frac{\sum X}{N}$$

=30/5

=6

SHORT-CUT METHOD

STEP 1 : Treat the given values of variable as X.

STEP 2 : Enter the given values in a column headed as X.

STEP 3 : Take any value as Assumed Mean (denoted as 'A')

STEP 4 : Take the deviations of the variable X from the assumed mean 'A' and denote these deviations (X-A) by **d** and enter the same in a column headed as **d.**

STEP 5 : Obtain the sum of these deviations i.e. $\sum d$.

STEP 6 : Apply the following formula :

$$\bar{X} = A + \frac{\sum d}{N} \quad .$$

where, $\bar{X}$ = Arithmetic Mean

A = Assumed Mean

$\sum d$ = Sum of deviations

N = Number of individual observations

S. No.	Monthly Income (Rs.) X	Deviation from Assumed Mean (A= 3,000) (X - A)
1	1,000	-2,000
2	1,200	-1,800
3	1,500	-1,500
4	2,200	-800
5	2,800	-200
6	3,000	0
7	3,500	500
8	5,000	2,000
9	8,000	5,000
10	10,000	7,000
		$\sum d$= 8,200

$$\bar{X} = A + \frac{\sum d}{N}$$

= 3,000+ 8200/10

= Rs 3,820

- **Computation of Arithmetic Mean in an Discrete series (where frequencies are given):**

DIRECT METHOD

STEP 1: Treat the given values of variable as X and frequencies as f.
STEP 2: Enter the given values of variable X in a column headed as X.
STEP 3: Enter the given frequencies f in a column headed as f and obtain the sum of these frequencies i.e. N or $\sum f$.
STEP 4: Multiply the variable of each row with the respective frequency and denote these products by fX and enter the same in a column headed as fX.
STEP 5: Obtain the sum of these products i.e. $\sum f$ X.
STEP 6: Apply the following formula:

$$\overline{X} = \frac{\sum fX}{N}$$

where, $\overline{X}$= Arithmetic Mean

$\sum fX$= Sum of products of frequency and value of variable

N = $\sum f$= Sum of frequencies

From the following data, calculate Arithmetic Mean:

Marks	No. of students
5	10
15	20
25	30
35	50
45	40
55	30

Marks	No. of students	fX
5	10	50
15	20	300
25	30	750
35	50	1750
45	40	1800
55	30	1650
	N=180	$\sum fX$ =6300

$$\overline{X} = \frac{\sum fX}{N}$$

= 6300/180

=35

Given the following frequency distribution, calculate the arithmetic mean

Marks	64	63	62	61	60	59
Number of students	8	18	12	9	7	6

Marks X	Number of Students f	fX
64	8	512
63	18	1134
62	12	744
61	9	549
60	7	420
59	6	354
	N= 60	$\sum fX$= 3713

$$\overline{X} = \frac{\sum fX}{N}$$

=3713/60

=61.88

SHORT CUT METHOD

STEP 1: Treat the given values of variable as X and frequencies as f.
STEP 2: Enter the given values of variable X in a column headed as X.
STEP 3: Enter the given frequencies f in a column headed as f and obtain the sum of these frequencies i.e. N or $\sum f$.
STEP 4: Take any value as Assumed Mean (denoted as A)
STEP 5: Take the deviations of the variable 'X' from the Assumed Mean 'A' and denote these deviations (X-A) by 'd' and enter the same in a column headed as d.
STEP 6: Multiply the deviations of each row with the respective frequency and denote these products by fd and enter the same in a column headed as fd.
STEP 7: Obtain the sum of these products i.e. $\sum fd$
STEP 8: Apply the following formula:

$$\bar{X} = A + \frac{\sum fd}{N}$$

$\bar{X}$= Arithmetic Mean
A= Assumed Mean
$\sum fd$ = Sum of products of deviations and frequencies
N= Sum of frequencies

From the following data, calculate Arithmetic Mean:

Marks	No. of students
5	10
15	20
25	30
35	50
45	40
55	30

Marks	No. of students	d (X-A) ,A= 40	fd
5	10	-35	-350
15	20	-25	-500
25	30	-15	-450
35	50	-5	-250
45	40	5	200
55	30	15	450
	N = 180	-60	$\sum fd$ = -900

$$\overline{X} = A + \frac{\sum fd}{N}$$

=40+ (-900/180)
=35

COMPUTATION OF ARITHMETIC MEAN IN CASE OF CONTINUOUS SERIES (i.e. where class intervals and frequencies are given):

STEP 1: Enter the class intervals in the first column.
STEP 2: Calculate the mid-point of each class denote these mid-points as **m** and enter the same in a column headed as **m.**

$$\textbf{Mid-Points}= \frac{\boldsymbol{Lower\ Limit + Upper\ Limit}}{\mathbf{2}}$$

STEP 3: Enter the given frequencies f in a column headed as f and obtain the sum of these frequencies.
STEP 4: Multiply the mid-points of each row with respective frequency and denote these products by fm.
STEP 5: Obtain the sum of these products i.e. $\sum fm$.
STEP 6: Apply the following formula:

$$\bar{X}= \frac{\sum \boldsymbol{fm}}{\boldsymbol{N}}$$

Marks	No. of Students
0-10	10
10-20	20
20-30	30
30-40	50
40-50	40
50-60	30

Marks X	Mid-Points m	No. of Students	fm
0-10	5	10	50
10-20	15	20	300
20-30	25	30	750
30-40	35	50	1750
40-50	45	40	1800
50-60	55	30	1650
		N=180	6300

$$\overline{X} = \frac{\sum fm}{N}$$

= 6300/180
=35

SHORT CUT METHOD

STEP 1: Enter the class intervals in first column.
STEP 2: Calculate the mid-point of each class, denote these mid-points as m and enter the same in a column headed as m.

$$\textbf{Mid-Points}= \frac{\textbf{Lower Limit + Upper Limit}}{\textbf{2}}$$

STEP 3: Enter the given frequencies f in a column headed as f and obtain the sum of these frequencies
STEP 4: Take any value as Assumed Mean
STEP 5: Take the deviations of mid-points from the assumed mean and denote these deviations by d (i.e. m-A) and enter the same in a column headed as d.
STEP 6: Multiply the deviation of each row with the respective frequency and denote these products by fd and enter the same in a column headed as fd.
STEP 7: Obtain the sum of these products i.e. $\sum fd$.
STEP 8: Apply the following formula:

$$\bar{X}= \mathbf{A}+ \frac{\sum fd}{N}$$

$\bar{X}$= Arithmetic Mean
A= Assumed Mean
$\sum fd$ = Sum of products of deviations and frequencies
N= Sum of frequencies

Marks	No. of Students
0-10	10
10-20	20
20-30	30
30-40	50
40-50	40
50-60	30

Marks	Mid-points m	No. of students (f)	d (m-A) ,A= 40	fd
0-10	5	10	-35	-350
10-20	15	20	-25	-500
20-30	25	30	-15	-450
30-40	35	50	-5	-250
40-50	45	40	5	200
50-60	55	30	15	450
		N = 180		$\sum fd$ = -900

$$\overline{X} = A + \frac{\sum fd}{N}$$

=40+ (-900/180)
=35

STEP-DEVIATION METHOD

- This method is useful when mid-points of various classes are large. This method simplifies the calculations
- If the deviations from assumed mean have some common factor, a further reduction in the size of deviations is possible by dividing deviations by the common factor ‘c’ (i.e. the difference between upper limit and lower limit of a class).
- If all class intervals are equal, the class interval will be the common factor.

STEP 1: Enter the class interval in the first column

STEP 2: Calculate the mid-points of each class, denote these mid-points as m and enter the same in a column headed as m.

$$\textbf{Mid-Points} = \frac{\textbf{Lower Limit} + \textbf{Upper Limit}}{2}$$

STEP 3: Enter the given frequencies f in a column headed as f and obtain the sum of these frequencies

STEP 4: Take any value as Assumed Mean

STEP 5: Take the deviation of mid points from the assumed mean and enter in a column

STEP 6: Divide the deviation by the class interval denoted by 'c' and denote it by d and enter the same in the column headed as d

STEP 7: Multiply the deviation of each row with respective frequency and denote these products by fd and enter the same in a column headed as fd.

STEP 8: Obtain the sum of these products i.e. $\sum fd$.

STEP 9: Apply the following formula:

$$\bar{X} = A + \frac{\sum fd}{N} * c$$

$\bar{X}$= Arithmetic Mean

A= Assumed Mean

$\sum fd$ = Sum of products of deviations and frequencies

N= Sum of frequencies

c= Class- interval

Marks	No. of Students
0-10	10
10-20	20
20-30	30
30-40	50
40-50	40
50-60	30

Marks X	Mid-points m	No. of students (f)	d (m-A)/10 ,A= 45	fd
0-10	5	10	-4	-40
10-20	15	20	-3	-60
20-30	25	30	-2	-60
30-40	35	50	-1	-50
40-50	45	40	0	0
50-60	55	30	1	30
		N = 180		$\sum fd$ = -180

$$\bar{X} = A + \frac{\sum fd}{N} * c$$

=45 + (-180/180)*10

=35

	DIRECT METHOD	SHORT CUT	STEP- DEVIATION
Individual Series	$\bar{X} = \frac{\sum X}{N}$	$\bar{X} = A + \frac{\sum d}{N}$	-
Discrete Series	$\bar{X} = \frac{\sum fX}{N}$	$\bar{X} = A + \frac{\sum fd}{N}$	-
Continuous Series	$\bar{X} = \frac{\sum fm}{N}$	$\bar{X} = A + \frac{\sum fd}{N}$	$\bar{X} = A + \frac{\sum fd}{N} * c$

Calculation of Arithmetic Mean in Case of Less than Continuous Series

***** Convert the less than series into normal lower upper class interval.

Marks Less than	No. of Students
10	10
20	30
30	60
40	110
50	150
60	180

Marks Less than	No. of Students	Marks	No. of Students
10	10	0-10	10
20	30	10-20	20 (30-10)
30	60	20-30	30 (60-30)
40	110	30-40	50 (110-60)
50	150	40-50	40 (150-110)
60	180	50-60	30 (180-150)

Marks X	Mid-Points m	No. of Students	fm
0-10	5	10	50
10-20	15	20	300
20-30	25	30	750
30-40	35	50	1750
40-50	45	40	1800
50-60	55	30	1650
		N=180	6300

$$\overline{X} = \frac{\sum fm}{N}$$

= 6300/180
=35

Calculation of Arithmetic Mean in case of more than series:

Convert the more than series into normal lower-upper class series.

Marks more than	No. of students
0	180
10	170
20	150
30	120
40	70
50	30
60	0

Marks more than	No. of students	Marks	No. of students
0	180	0-10	10 (180-170)
10	170	10-20	20 (170-150)
20	150	20-30	30 (150-120)
30	120	30-40	50 (120-70)
40	70	40-50	40 (70-30)
50	30	50-60	30
60	0		

Marks X	Mid-Points m	No. of Students	fm
0-10	5	10	50
10-20	15	20	300
20-30	25	30	750
30-40	35	50	1750
40-50	45	40	1800
50-60	55	30	1650
		N=180	6300

$$\overline{X} = \frac{\sum fm}{N}$$

= 6300/180
=35

Calculation of Arithmetic Mean in case of Inclusive Series

Convert the inclusive Series by deducting half the difference between upper limit of a class and lower limit of next class from the lower limit of class and adding the same to upper limit of class.

Marks	No. of students
1-10	10
11-20	20
21-30	30
31-40	50
41-50	40
51-60	30

Marks	No. of students	Marks
1-10	10	0.5-10.5
11-20	20	10.5-20.5
21-30	30	20.5-30.5
31-40	50	30.5-40.5
41-50	40	40.5-50.5
51-60	30	50.5-60.5

Marks	Mid-point m	No. of students f	(m-A)/10 d; A=45.5	fd
0.5-10.5	5.5	10	-4	-40
10.5-20.5	15.5	20	-3	-60
20.5-30.5	25.5	30	-2	-60
30.5-40.5	35.5	50	-1	-50
40.5-50.5	45.5	40	0	0
50.5-60.5	55.5	30	1	30
		N= 180		$\sum fd$ = -180

$\bar{X} = A + \frac{\sum fd}{N} * c$

=45.5+ (-180/180) * 10

=35.5

Calculation of Arithmetic Mean in case of Continuous Exclusive Series when class intervals are unequal:

Adjust the frequencies to make the class intervals equal on the assumption that they are equally distributed throughout the class.

Marks	No. of students
0-10	20
10-30	30
30-60	60
60-70	10

Marks	No. of students	Marks	No. of students
0-10	20	0-10	20
10-30	30	10-20	15 (30/2)
30-60	60	20-30	15 (30/2)
60-70	10	30-40	20 (60/3)
		40-50	20 (60/3)
		50-60	20 (60/3)
		60-70	10

Marks	No. of students
0-10	10
10-30	60
30-40	50
40-50	40
50-60	20

Marks	Mid-point m	No. of students f	(X-A)/10 d; A=45	fd
0-10	5	10	-4	-40
10-20	15	30	-3	-90
20-30	25	30	-2	-60
30-40	35	50	-1	-50
40-50	45	40	0	0
50-60	55	20	1	20
		N= 180		$\sum fd$ = -220

$\bar{X} = A + \frac{\sum fd}{N} * c$

=45+ (-220/180) * 10

=32.8

COMPUTATION OF COMBINED AVERAGE OF TWO OR MORE RELATED GROUPS:

STEP 1: Calculate Arithmetic Mean of each group and denote the same as $\bar{X}_1, \bar{X}_2$ and so on.

STEP 2: Denote the total number of observations in each group as N_1, N_2 and so on.

STEP 3: Apply the formula:

$$\bar{X}_{12....} = \frac{\bar{X}_1 N_1 + \bar{X}_2 N_2 + ...}{N_1 + N_2 + ...}$$

$\bar{X}_{12}$ = Combined Mean of the two group

$\bar{X}_1$ = Arithmetic Mean of the first group

$\bar{X}_2$ = Arithmetic Mean of the second group

N_1 = Number of observations in the first group

N_2 = Number of observations in the second group

An average daily wages of 10 workers in a factory ‘A’ is Rs. 30 and an average daily wages of 20 workers in a factory ‘B’ is Rs. 15. Find the average daily wages of all workers of both the factories.

$$\bar{X}_{12} = \frac{(10*30) + (20*15)}{10+20}$$

$$= 600/30$$

$$= 20$$

$\bar{X}_1 = 30$
$\bar{X}_2 = 15$
$N_1 = 10$
$N_2 = 20$

An average daily wages of all the 90 workers in a factory is Rs. 60. An average daily wages of females workers is Rs. 45. Calculate an average daily wages of male workers if one-third workers are male.

$$60 = \frac{30^* \bar{X}_1 + 60^*45}{30 + 60}$$

$$5400 = 30 * \bar{X}_1 + 2700$$

$$\bar{X}_1 = 2700/30$$

$$= 90$$

$\bar{X}_{12} = 60$

$\bar{X}_2 = 45$

N_1 (Male) = 30 (90/3)

N_2 (Female) = 60

CORRECTING INCORRECT VALUES:

STEP 1: Calculate incorrect $\sum X$ as follows:

$$\text{Incorrect } \sum X = \text{Incorrect N} * \text{Incorrect } \bar{X}$$

STEP 2: Calculate correct $\sum X$ and correct N as follows:

$$\text{Correct } \sum X = \text{Incorrect } \sum X - \text{Wrong items} + \text{Correct items}$$

$$\text{Correct N} = \text{Incorrect N} - \text{Extra items} + \text{Omitted items}$$

STEP 3: Calculate correct mean as follows:

$$\text{Correct } \bar{X} = \frac{\text{Correct } \sum X}{\text{Correct N}}$$

The mean marks of 99 students was found to be 60. Later on it was discovered that a score of 35 was misread as 53 and another score was taken as 63 instead of 36 and score of 5 was not taken into account. Find the correct mean.

Incorrect $\sum X$ = Incorrect N * Incorrect $\bar{X}$

= 99*60

= 5940

Correct $\sum X$ = Incorrect $\sum X$ − Wrong items + Correct items

= 5940 – 53+35 -63 +36 + 5

= 5900

Correct N = Incorrect N – Extra items + Omitted items

= 99+1

$$\text{Correct } \bar{X} = \frac{\text{Correct } \sum X}{\text{Correct N}}$$

= 5900 / 100

= 59

WEIGHTED ARITHMETIC MEAN

- The term weight stands for the relative importance of the different items of the series.
- Weighted Arithmetic Mean refers to the arithmetic mean calculated after assigning weights to different values of variable.

A consumer buys a commodity @ Rs. 4.80, Rs 6, Rs 8, Rs 12 and Rs 24 per unit in each of five successive years. Calculate the average cost per unit if he buys

(a) 1000 units each year

(b) 1000 units, 800 units, 600 units, 400 units and 200 units in each of five successive years.

(A)

Cost per unit	No. of units	WX
4.80	1000	4800
6	1000	6000
8	1000	8000
12	1000	12000
24	1000	24000
	$\sum W = 5000$	$\sum WX = 54800$

$$\bar{X} = \frac{\sum wx}{\sum w}$$

$$= 54800/5000$$

$$= \text{Rs. } 10.96 \text{ per unit}$$

Cost per unit	No. of units	WX
4.80	1000	4800
6	800	4800
8	600	4800
12	400	4800
24	200	4800
	$\sum W = 3000$	$\sum WX = 24000$

$$\bar{X} = \frac{\sum wx}{\sum w}$$

=24000/3000

=Rs. 8 per unit

Suppose a student has secured the following marks in three tests:

Type of test	Marks (x)	Relative weight (w)
Mid Term Test	30	2
Laboratory Test	25	3
Final	20	5

Type of test	Marks (x)	Relative weight (w)	xw
Mid Term Test	30	2	60
Laboratory Test	25	3	75
Final	20	5	100
		10	235

$$\bar{X} = \frac{\sum wx}{\sum w}$$

=235/10

=23.5 marks

MEDIAN:

- Median is the central value of the variable that divides the series into two equal parts in such a way that half of the items lie above this value and the remaining half lie below this value.
- It is also known as positional average because it is based on the position of a given observation in a series arranged in an ascending or descending order and the position of the median is such that an equal number of items lie on either side of it.

Computation of Median in Case of an individual series:

STEP 1: Arrange the size of item in ascending or descending order.

STEP 2: Calculate Median as follows:

(a) If total number of observation is odd: $\left(\frac{N+1}{2}\right) th\ term$

(b) If total number of observation is even: $\frac{\left[\left(\frac{N}{2}\right) th\ term + \left\{\left(\frac{n}{2}\right)+1\right\} th\right]}{2}$

Roll No.	1	2	3	4	5	6
Marks	25	55	5	45	15	35

STEP 1: Arranging the size of item in ascending order:

Marks	5	15	25	35	45	55

STEP 2: Ascertaining $\frac{\left[\left(\frac{N}{2}\right)th\ term+\left\{\left(\frac{n}{2}\right)+1\right\}th\right]}{2}$

$= \frac{\text{3rd item + (3+1)th item}}{2}$

$= (25+35) / 2$

STEP 3: Median= 30

From the following data, calculate Median:

Roll no.	1	2	3	4	5	6	7
Marks	25	55	5	45	15	35	60

STEP 1 :Arranging the size of item in ascending or descending order

Marks	5	15	25	35	45	55	60

STEP 2: $\left(\frac{N+1}{2}\right)$ ***th term***

$= \left(\frac{7+1}{2}\right)$ ***th term***

$= \left(\frac{8}{2}\right)$ ***th term***

$= 4^{th}$ **term**

Median =35

COMPUTATION OF MEDIAN IN CASE OF DISCRETE SERIES (WHEN FREQUENCIES ARE ALSO GIVEN ALONGWITH THE SIZE OF ITEMS)

STEP 1: Arrange the size of item in the ascending or descending order.
STEP 2: Calculate Cumulative Frequencies (c.f.)
STEP 3: Ascertain $\left(\frac{N+1}{2}\right)$ ***th term***
STEP 4: Ascertain the cumulative frequency which includes $\left(\frac{N+1}{2}\right)$ ***th term***
STEP 5: Calculate Median as follows:

Median =size of the item corresponding to the cumulative frequency which includes $\left(\frac{N+1}{2}\right)$ ***th term***

From the following data, calculate Median:

Marks	45	55	25	35	5	15
No. of students	40	30	30	50	10	20

STEP 1: Arrange the size of item in the ascending or descending order

Marks	5	15	25	35	45	55
No. of students	10	20	30	50	40	30

STEP 2: Calculate Cumulative Frequencies (c.f.)

Marks	No. of students	CF
5	10	10
15	20	30
25	30	60
35	50	110
45	40	150
55	30	180

STEP 3: Ascertain $\left(\frac{N+1}{2}\right)$ ***th term***

$= \left(\frac{180+1}{2}\right)$ ***th term***

= 90.5th term

STEP 4: Cumulative Frequency which includes 90.5th term

= 110

STEP 5: Calculate Median as follows:

Median = 35

COMPUTATION OF MEDIAN IN CASE OF CONTINUOUS SERIES

STEP 1: Calculate Cumulative Frequencies (c.f.)

STEP 2: Ascertain $\left(\frac{N}{2}\right)$ ***th term***

STEP 3: Ascertain the cumulative frequency which includes $\left(\frac{N}{2}\right)$ ***th term,*** the corresponding class frequency (f) and Lower Limit (L) of that class, the interval (*i*) Between the upper limit and lower limit of class and cumulative frequency of the preceding class (c.f.)

STEP 4: Calculate Median as follows:

$$\text{Median} = L + \left[\frac{\frac{N}{2} - cf}{f}\right] * i$$

Marks	No. of Students
0-10	10
10-20	20
20-30	30
30-40	50
40-50	40
50-60	30

Marks	No. of Students	No. of Students (cf)
0-10	10	10
10-20	20	30
20-30	30	60
30-40	50	110
40-50	40	150
50-60	30	180

$\left(\frac{N}{2}\right)$ ***th term*** **=180/2**

= 90th term

Cumulative frequency which includes 90th term = 110

Class corresponding to 110 is 30-40

$$\text{Median} = L + \left[\frac{\frac{N}{2} - cf}{f}\right] * i$$

$$= 30 + \left[\frac{\frac{180}{2} - 60}{50}\right] * 10$$

$$= 30 + (30*10) / 50$$

$$= 30 + 6$$

$$= 36$$

Calculation of Median in Case of Less than Continuous Series

***** Convert the less than series into normal lower upper class interval.

Marks Less than	No. of Students
10	10
20	30
30	60
40	110
50	150
60	180

Marks Less than	No. of Students	Marks	No. of Students
10	10	0-10	10
20	30	10-20	20 (30-10)
30	60	20-30	30 (60-30)
40	110	30-40	50 (110-60)
50	150	40-50	40 (150-110)
60	180	50-60	30 (180-150)

Marks	No. of Students	No. of Students (cf)
0-10	10	10
10-20	20	30
20-30	30	60
30-40	50	110
40-50	40	150
50-60	30	180

$\left(\frac{N}{2}\right)$ ***th term*** **=180/2**

= 90th term

Cumulative frequency which includes 90th term = 110

Class corresponding to 110 is 30-40

$$\text{Median} = L + \left[\frac{\frac{N}{2} - cf}{f}\right] * i$$

$$= 30 + \left[\frac{\frac{180}{2} - 60}{50}\right] * 10$$

$$= 30 + (30*10) / 50$$

$$= 30 + 6$$

$$= 36$$

Calculation of Median in case of more than series:

Convert the more than series into normal lower-upper class series.

Marks more than	No. of students
0	180
10	170
20	150
30	120
40	70
50	30
60	0

Marks more than	No. of students	Marks	No. of students
0	180	0-10	10 (180-170)
10	170	10-20	20 (170-150)
20	150	20-30	30 (150-120)
30	120	30-40	50 (120-70)
40	70	40-50	40 (70-30)
50	30	50-60	30
60	0		

Marks	No. of Students	No. of Students (cf)
0-10	10	10
10-20	20	30
20-30	30	60
30-40	50	110
40-50	40	150
50-60	30	180

$\left(\frac{N}{2}\right)$ ***th term*** **=180/2**

= 90th term

Cumulative frequency which includes 90th term = 110

Class corresponding to 110 is 30-40

$$\text{Median} = L + \left[\frac{\frac{N}{2} - cf}{f}\right] * i$$

$$= 30 + \left[\frac{\frac{180}{2} - 60}{50}\right] * 10$$

$$= 30 + (30*10) / 50$$

$$= 30 + 6$$

$$= 36$$

Calculation of Median in case of Inclusive Series

Convert the inclusive Series by deducting half the difference between upper limit of a class and lower limit of next class from the lower limit of class and adding the same to upper limit of class.

Marks	No. of students
1-10	10
11-20	20
21-30	30
31-40	50
41-50	40
51-60	30

Marks	No. of students	Marks	No. of students (cf)
1-10	10	0.5-10.5	10
11-20	20	10.5-20.5	30
21-30	30	20.5-30.5	60
31-40	50	30.5-40.5	110
41-50	40	40.5-50.5	150
51-60	30	50.5-60.5	180

$\left(\frac{N}{2}\right)$ ***th term*** **=180/2**

= 90th term

Cumulative frequency which includes 90th term = 110

Class corresponding to 110 is 30.5-40.5

$$\text{Median} = L + \left[\frac{\frac{N}{2} - cf}{f}\right] * i$$

$$= 30.5 + \left[\frac{\frac{180}{2} - 60}{50}\right] * 10$$

$$= 30.5 + (30*10) / 50$$

$$= 30.5 + 6$$

$$= 36.5$$

Calculation of Median in case of Continuous Exclusive Series when class intervals are unequal:

Adjust the frequencies to make the class intervals equal on the assumption that they are equally distributed throughout the class.

Marks	No. of students
0-10	10
10-30	60
30-40	50
40-50	40
50-60	20

Marks	No. of students f	Cf
0-10	10	10
10-20	30	40
20-30	30	70
30-40	50	120
40-50	40	160
50-60	20	180

$\left(\frac{N}{2}\right)$ ***th term*** **=180/2**

= 90th term

Cumulative frequency which includes 90th term = 120

Class corresponding to 120 is 30 - 40

$$\text{Median} = L + \left[\frac{\frac{N}{2} - cf}{f}\right] * i$$

$$= 30 + \left[\frac{\frac{180}{2} - 70}{50}\right] * 10$$

$$= 30 + (20*10) / 50$$

$$= 30 + 4$$

$$= 34$$

MODE

- Mode is said to be that value in a series which occurs most frequently or which has greatest frequency.
- It may be noted that a distribution may have one mode or two mode or several mode.

- **UNIMODAL:** A distribution is said to be unimodal if it has only one mode.
- **BIMODAL:** A distribution is said to be bimodal if it has two modes.
- **MULTIMODAL:** A distribution is said to be multimodal if it has more than two modes.

CALCULATION OF MODE IN CASE OF INDIVIDUAL SERIES:

STEP 1: Count the number of times the various values of the series repeat themselves.
STEP 2: Ascertain the number occurring the maximum number of times.
STEP 3: Mode = Value occurring the maximum number of times.

Roll No.	Marks	Size of item	Number of times it occurs
1	20	20	1
2	30	25	2
3	31	30	3
4	32	31	2
5	25	32	2
6	25		
7	30		
8	31		
9	30		
10	32		

The item 30 occurs the maximum numbers of times i.e. 3, hence the modal marks are 30 OR Mode = 30.

CALCULATION OF MODE IN CASE OF DISCRETE SERIES:

STEP 1: Ascertain maximum frequency.

STEP 3: Ascertain the value of the item corresponding to maximum frequency.

STEP 4: Mode = Value of the item corresponding to maximum frequency.

Marks	No. of students
5	10
15	20
25	30
35	50
45	40
55	30

The maximum frequency is 50, the mode corresponding to this value is 35.

CALCULATION OF MODE IN CASE OF CONTINUOUS SERIES:

STEP 1: Ensure that the given series is a continuous exclusive series having equal class intervals. If the given series is not a continuous series then change the series in continuous exclusive series.

STEP 2: Ascertain the modal class (the class with maximum frequency is the modal class)

STEP 3: Calculate the mode as follows:

(a) By interpolation formula (in case of unimodal):

$$\textbf{Mode} = L + \frac{[|f_1 - f_0|]}{[|2f_1 - f_0 - f_2|]} * i$$

L = Lower limit of the modal class

$f_0 = Frequency\ of\ the\ preceding\ modal\ class$

$f_1 = Frequency\ of\ the\ modal\ class$

$f_2 = Frequency\ of\ the\ succeeding\ modal\ class$

I **= Class interval of modal class**

(b) By Empirical Relationship Formula (in case of bimodal or multimodal):

Mode= 3 Median – 2 Mean

Marks	No. of Students
0-10	10
10-20	20
20-30	30 (f_0)
30-40	50 (f_1)
40-50	40 (f_2)
50-60	30

- Maximum frequency = 50
- The Modal class is 30-40

L = 30

$f_0 = 30$

$f_1 = 50$

$f_2 = 40$

I = 10

- **Mode** $= 30 + \frac{[|50 - 30|]}{[|2*50 - 30 - 40|]} * 10$

= 30 + (20*10)/30

= 30 + 6.667

= 36.667

GROUPING TABLE AND ANALYSIS TABLE:

To avoid an error of judgement in the calculation of Mode by inspection in those cases where the difference between the maximum frequency and the frequency preceding it or succeeding it is very small. Modal class should be located by preparing a grouping table and analysis table.

GROUPING TABLE:

STEP 1: Column I: Enter the frequencies against each class and put the maximum frequency in the circle.

STEP 2: Column II: Group the frequencies in two's and enter their totals and put the maximum total in the circle.

STEP 3: Column III: Leave the first frequency and then group the remaining frequencies in two's and enter their totals and put the maximum total in the circle.

STEP 4: Column IV: Group the frequencies in three's and enter their totals and put the maximum total in the circle.

STEP 5: Column V: Leave the first frequency and then group the remaining frequencies in three's and enter their totals and put the maximum total in the circle.

STEP 6: Column VI: Leave first two frequencies and then group the remaining frequencies in three's and enter their totals and put the maximum total in the circle.

ANALYSIS TABLE:

STEP 1: Put column number vertically on the left hand side.

STEP 2: Put the values of the items (or classes) horizontally on the right-hand side.

STEP 3: Ascertain one value against the maximum total circled in Column I in the Grouping Table and then enter 1 tally bar in the first row of Analysis Table against the relevant value.

STEP 4: Ascertain two values against the maximum total circled in Column II in the grouping table and then enter 2 tally bars in the second row of Analysis Table against the relevant value.

STEP 5: Ascertain two values against the maximum total circled in Column III in the grouping table and then enter 2 tally bars in the third row of Analysis Table against the relevant value.

STEP 6: Ascertain three values against the maximum total circled in Column IV in the grouping table and then enter 3 tally bars in the fourth row of Analysis Table against the relevant value.

STEP 7: Ascertain three values against the maximum total circled in Column V in the grouping table and then enter 3 tally bars in the fifth row of Analysis Table against the relevant value.

STEP 8: Ascertain three values against the maximum total circled in Column VI in the grouping table and then enter 3 tally bars in the sixth row of Analysis Table against the relevant value.

STEP 9: Total the number of bars placed in each column of Analysis Table.

STEP 10: Put the maximum total in the circle.

Calculation of Mode:

Mode or Modal Class = Value corresponding to the maximum total of tally bars.

Calculate Mode:

Marks	No. of students
5	4
10	6
11	5
12	10
13	20
14	22
15	24
16	6
18	2
20	1

Grouping Table

Marks	Column I	Column II	Column III	Column IV	Column V	Column VI
5	4	10		15		
10	6		11		21	
11	5	15				35
12	10		30	52		
13	20	42			66	
14	22		46			52
15	24	30		32		
16	6		8		9	
18	2	3				
20	1					

ANALYSIS TABLE

Marks / Column No.	5	10	11	12	13	14	15	16	18	20
1							1			
2					1	1				
3						1	1			
4				1	1	1				
5					1	1	1			
6						1	1	1		
Total				**1**	**3**	**5**	**4**	**1**		

The highest total in the analysis table is 5. The item corresponding to it is 14. Therefore, the mode is 14

Calculate Mode if Mean is 20 and Median 23.

Calculate Mean if Median is 54 and Mode is 62.

Calculate Median if Mean is 12 and Mode is 15.

Calculate Mode if Mean is 20 and Median 23.

Mode = 3 Median – 2 Mean
Mode = (3*23) – (2*20)
Mode = 29

Calculate Mean if Median is 54 and Mode is 62.

Mode = 3 Median – 2 Mean
62 = (3*54) – (2*Mean)
2*Mean = 162 – 62
Mean = 50

Calculate Median if Mean is 12 and Mode is 15.

Mode = 3 Median – 2 Mean
15 = (3*Median) – (2*12)
3*Median = 15 + 24
Median = 13

Find the missing frequency from the following data:

Marks	No. of students
0-10	10
10-20	20
20-30	?
30-40	50
40-50	40
50-60	30

Arithmetic Mean is 35 marks.

Marks	No. of students	m	fm
0-10	10	5	50
10-20	20	15	300
20-30	? (X)	25	25X
30-40	50	35	1750
40-50	40	45	1800
50-60	30	55	1650
	N = 150 + X		$\sum fm = 5550 + 25X$

$$\bar{X} = \frac{\sum fm}{N}$$

$$35 = \frac{5550+25X}{150+X}$$

$$35\,(150+X) = 5550 + 25X$$

$$5250 + 35X = 5550 + 25X$$

$$10X = 300$$

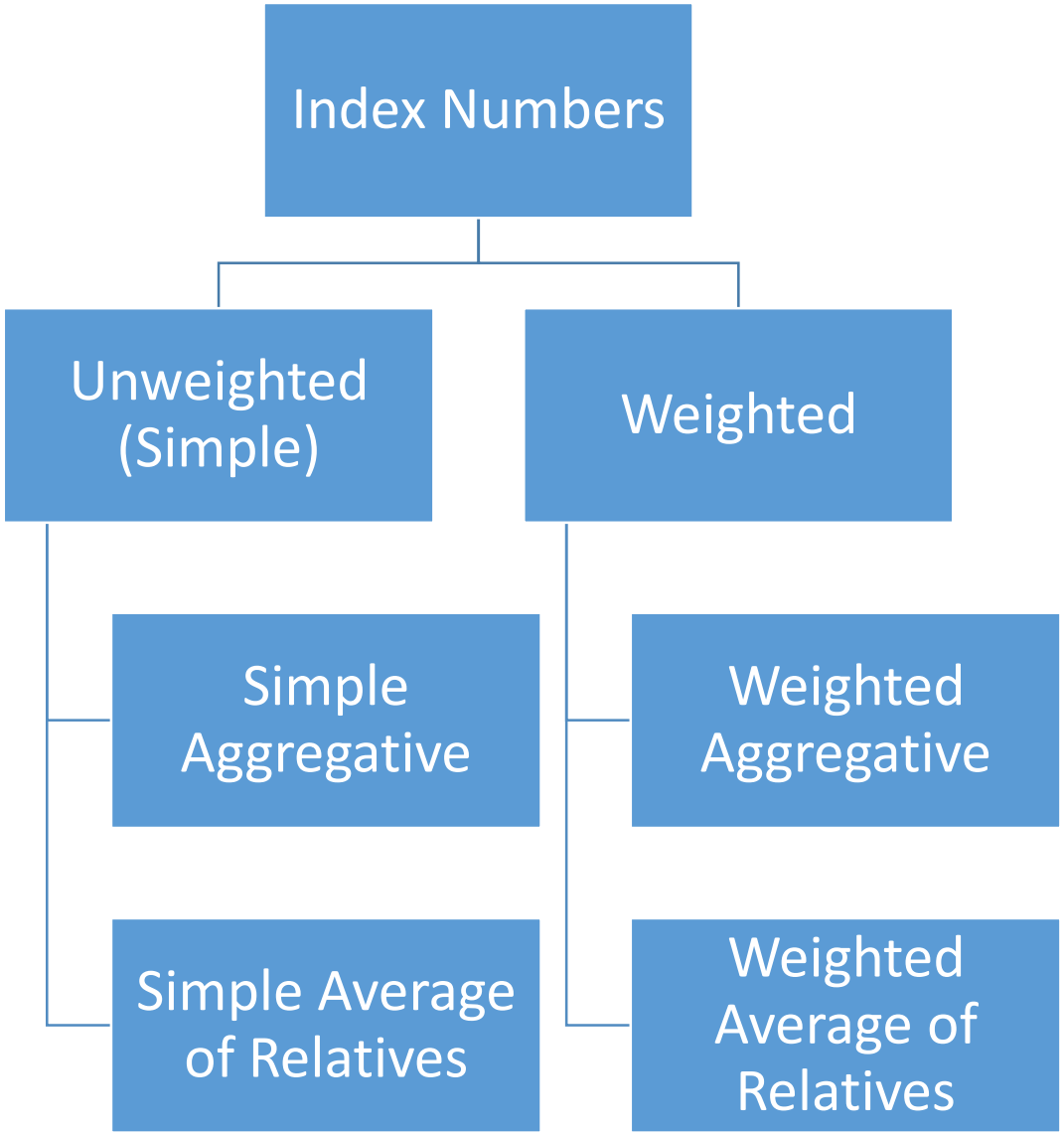
$$X = \frac{300}{10}$$

$$X = 30$$

INDEX NUMBERS

- An index number is a statistical measure designed to show changes in variables or a group of related variables with respect to time, geographic location or other characteristics such as income, profession etc.
- An index may be Univariate Index or Composite Index.
- **Univariate Index:** It is computed from a single variable.
- **Composite Index:** It is computed from a group of variables.

- **METHODS OF CONSTRUCTING INDEX NUMBERS:**



SIMPLE AGGREGATIVE METHOD:

- Simple Aggregative Method is based on the assumption that the various items and their prices are quoted in the same unit.
- Equal importance is given to all the items.
- Under this method, the total of current year prices for the various commodities is divided by the total of base year prices and the quotient is multiplied by 100.

Price Index: $p_{01} = \frac{\sum p_1}{\sum p_0} * 100$

p_{01} = Current year price Index

$\sum p_1$ = Total of current year prices for various commodities

$\sum p_0$ = Total of base year prices for various commodities

STEPS INVOLVED IN THE COMPUTATION OF INDEX ACCORDING TO SIMPLE AGGREGATIVE METHOD:

STEP 1: Add the current year prices for various commodities i.e. obtain $\sum p_1$.
STEP 2: Add the base year prices for the same commodities i.e. obtain $\sum p_0$.
STEP 3: Calculate the index as follows:

$$P_{01} = \frac{\sum p_1}{\sum p_0} * 100$$

[Computation of Index Numbers by Simple Aggregative Method when there are two or more commodities]

From the following data, compute a index for the year 2017 taking 2016 as base by simple aggregative method:

Commodity	2016 Price (Rs.)	2017 Price (Rs.)
A	1	5
B	2	4
C	3	3
D	4	2

Commodity	2016 Price (Rs.) (p_0)	2017 Price (Rs.) (p_1)
A	1	5
B	2	4
C	3	3
D	4	2
Total	10	14

Price Index Number:

$$P_{01} = \frac{\sum p_1}{\sum p_0} * 100$$

$$= \frac{14}{10} * 100$$

$$= 140$$

Thus, the prices Index Number of 2017 is 140. It means that there is net increase in the price of commodities in the year 2017 to the extent of 40% as compared to 2016.

Calculate Price Index number for 2015 taking 2011 as base year from the following data by Simple Aggregative Method:

Commodities	Price in 2011	Price in 2015
A	100	140
B	80	120
C	160	180
D	220	240
E	40	40

Commodities	Price in 2011 (p_0)	Price in 2015 (p_1)
A	100	140
B	80	120
C	160	180
D	220	240
E	40	40
Total	600	720

Price Index Number:

$$P_{01} = \frac{\sum p_1}{\sum p_0} * 100$$

$$= \frac{720}{600} * 100$$

$$= 120$$

Thus, the prices Index Number of 2015 is 120. It means that there is net increase in the price of commodities in the year 2015 to the extent of 20% as compared to 2011.

SIMPLE AVERAGE OF PRICE RELATIVES METHOD:

- Under simple average of price relatives method price index is constructed on the basis of price relatives and not on the basis of absolute prices.
- A **Price Relatives** is the ratio of the price of a single commodity in a given period to its price in another period called the base year.

- **Price Relative =** $\frac{p_1}{p_0} * 100$

- p_1 = The commodity price in current year

- p_0 = The commodity price in base year

COMPUTATION OF PRICE INDEX ACCORDING TO SIMPLE AVERAGE OF PRICE RELATIVES METHOD

STEP 1: Calculate Price Relatives for all the items

STEP 2: Calculate the total of Price Relatives i.e. $\sum(\frac{\boldsymbol{p_1}}{\boldsymbol{p_0}} * \mathbf{100})$

STEP 3: Calculate the average of Price Relatives using the following formula:

$$P_{01} = \frac{\sum(\frac{\boldsymbol{p_1}}{\boldsymbol{p_0}} * 100)}{N}$$

Commodity	Base Price	Current Year
A	30	35
B	22	25
C	54	64
D	20	25
E	15	18

Commodity	Base Price (p_0)	Current Year (p_1)	$\frac{p_1}{p_0} * 100$
A	30	35	116.67
B	22	25	113.63
C	54	64	118.51
D	20	25	125
E	15	18	120
			$\sum(\frac{p_1}{p_0} * 100) = 593.8$

$$P_{01} = \frac{\sum(\frac{p_1}{p_0} * 100)}{N}$$

$$= \frac{593.8}{5}$$

$$= 118.76$$

Weighted Aggregative Method:

- In the Weighted Aggregative Indices, weights are assigned to the various items.
- Weights may be assigned in different methods.
- Depending upon the method of assigning weights, a large number of formulae have been devised. Some of them are:

1. Laspeyre’s Method
2. Paasche Method
3. Dorbish and Bowley’s Method
4. Fisher’s ideal Method
5. Marshall-Edgeworth Method
6. Kelly’s Method

Laspeyre's Method

The Laspeyre's Price Index is a weighted aggregate price index where the weights are the base period quantities.

In general, it answers the question, "What would be the value of the base period list of goods when valued at given period prices?"

STEP 1: Multiply the current year prices of various items with base year weights and obtain their total i.e. $\sum p_1 \, q_0$

STEP 2: Multiply the base year prices of various items with the base year weights and obtain their total i.e. $\sum p_0 \, q_0$

STEP 3: Calculate Price Index as follows:

$$P_{01} = \frac{\sum p_1 q_0}{\sum p_0 q_0} * 100$$

From the following data, calculate Laspeyre's Price Index number for the current year.

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	8
B	2	7	4	7
C	3	8	3	6
D	4	9	2	5

Commodity	p_0	q_0	p_1	q_1	p_1q_0	p_0q_0
A	1	6	5	8	30	6
B	2	7	4	7	28	14
C	3	8	3	6	24	24
D	4	9	2	5	18	36
TOTAL					100	80

$$P_{01} = \frac{\sum p_1q_0}{\sum p_0q_0} * 100$$

$$= \frac{100}{80} * 100$$

$$= 125$$

PAASCHE METHOD:

It is a weighted aggregative price index where the weights are the given period quantities.

In general, it answers the question, “What would be the value of the given period list of goods when valued at base period prices?”

STEP 1: Multiply the current year prices of various items with current year weights and obtain their total i.e. $\sum p_1 q_1$

STEP 2: Multiply the base year prices of various items with current year weights and obtain their total i.e. $\sum p_0 q_1$

STEP 3: Calculate Price Index as follows:

$$P_{01} = \frac{\sum p_1 q_1}{\sum p_0 q_1} * 100$$

From the following data, calculate Paasche Price Index number for the current year.

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	8
B	2	7	4	7
C	3	8	3	6
D	4	9	2	5

Commodity	p_0	q_0	p_1	q_1	p_1q_1	p_0q_1
A	1	6	5	8	40	8
B	2	7	4	7	28	14
C	3	8	3	6	18	18
D	4	9	2	5	10	20
TOTAL					96	60

$$P_{01} = \frac{\sum p_1q_1}{\sum p_0q_1} * 100$$

$$= \frac{96}{60} * 100$$

$$= 160$$

DORBISH AND BOWLEY'S METHOD:

It is a weighted price index which is a arithmetic mean of the Laspeyre's and Paasche's Price Indices.

It is given by the formula:

$$P_{01} = \frac{L + P}{2}$$

Where L = Laspeyre's Index

P = Paasche's Index

From the following data, calculate Dorbish and Bowley's Price Index number for the current year.

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	8
B	2	7	4	7
C	3	8	3	6
D	4	9	2	5

Commodity	p_0	q_0	p_1	q_1	p_1q_0	p_0q_0	p_1q_1	p_0q_1
A	1	6	5	8	30	6	40	8
B	2	7	4	7	28	14	28	14
C	3	8	3	6	24	24	18	18
D	4	9	2	5	18	36	10	20
TOTAL					100	80	96	60

$$P_{01} = \frac{\frac{\sum p_1q_0}{\sum p_0q_0} + \frac{\sum p_1q_1}{\sum p_0q_1}}{2} * 100$$

$$= \frac{\frac{100}{80} + \frac{96}{60}}{2} * 100$$

$$= \frac{1.25+1.6}{2} * 100$$

$$= 142.5$$

FISCHER'S IDEAL INDEX METHOD:

It is weighted price index which is the geometric mean of the Laspeyre's and Paasche's Price Indices.

It is given by the formula:

$$P_{01} = \sqrt{L * P}$$

OR

$$\sqrt{\frac{\sum p_1 q_0}{\sum p_0 q_0} * \frac{\sum p_1 q_1}{\sum p_0 q_1}} * 100$$

From the following data, calculate Fischer's Price Index number for the current year.

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	8
B	2	7	4	7
C	3	8	3	6
D	4	9	2	5

Commodity	p_0	q_0	p_1	q_1	p_1q_0	p_0q_0	p_1q_1	p_0q_1
A	1	6	5	8	30	6	40	8
B	2	7	4	7	28	14	28	14
C	3	8	3	6	24	24	18	18
D	4	9	2	5	18	36	10	20
TOTAL					100	80	96	60

$$P_{01} = \sqrt{\frac{\sum p_1q_0}{\sum p_0q_0} * \frac{\sum p_1q_1}{\sum p_0q_1}} * 100$$

$$= \sqrt{\frac{100}{80} * \frac{96}{60}} * 100$$

$$= \sqrt{9600/4800} * 100$$

$$= \sqrt{2} * 100$$

$$= 141.42$$

MARSHALL EDGEWORTH'S METHOD:

It is a weighted aggregative price index which also takes into consideration both the current year as well as base year prices and quantities.

It is given by the formula:

$$= \frac{\sum(q_0+q_1)\,P_1}{\sum(q_0+q_1)\,P_0} * 100$$

$$= \frac{\sum q_0\,P_1+\sum q_1\,P_1}{\sum q_0\,P_0+\sum q_1\,P_0} * 100$$

From the following data, calculate Marshall Edgeworth's Price Index number for the current year.

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	8
B	2	7	4	7
C	3	8	3	6
D	4	9	2	5

Commodity	p_0	q_0	p_1	q_1	p_1q_0	p_0q_0	p_1q_1	p_0q_1
A	1	6	5	8	30	6	40	8
B	2	7	4	7	28	14	28	14
C	3	8	3	6	24	24	18	18
D	4	9	2	5	18	36	10	20
TOTAL					100	80	96	60

$$P_{01} = = \frac{\sum q_0 P_1 + \sum q_1 P_1}{\sum q_0 P_0 + \sum q_1 P_0} * 100$$

$$== \frac{100+96}{80+60} * 100$$

$$= \frac{196}{140} * 100$$

$$= 140$$

KELLY'S METHOD:

It is a weighted aggregative price index which uses fixed weights.

Weights are the quantities which may relate to any period (not necessarily the base year or current year) or which may be an average of the quantities of two or three or more years.

It is given by the formula:

(a) If fixed quantities are given as weights:

$$P_{01} = \frac{\sum p_1 q}{\sum p_0 q} * 100$$

(b) If average of the quantities of two years is used as weights:

$$P_{01} = \frac{\sum p_1 q}{\sum p_0 q} * 100 \quad (\text{where } q = \frac{q_0 + q_1}{2})$$

From the following data, calculate Kelly's Price Index number for the current year.

Commodity	Quantity (Kg.)	Base Year Price	Current Year Price
A	10	1	5
B	9	2	4
C	8	3	3
D	7	4	2

Commodity	q	p_0	p_1	p_1q	p_0q
A	10	1	5	50	10
B	9	2	4	36	18
C	8	3	3	24	24
D	7	4	2	14	28
TOTAL				124	80

$$P_{01} = \frac{\sum p_1 q}{\sum p_0 q} * 100$$

$$= \frac{124}{80} * 100$$

$$= 155$$

From the following data, calculate Kelly's Price Index number for the current year.

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	14
B	2	7	4	11
C	3	8	3	8
D	4	9	2	5

Commodity	q_0	q_1	q $(\frac{q_0+q_1}{2})$	p_0	p_1	p_1q	p_0q
A	6	14	10	1	5	50	10
B	7	11	9	2	4	36	18
C	8	8	8	3	3	24	24
D	9	5	7	4	2	14	28
TOTAL						124	80

$$P_{01} = \frac{\sum p_1 q}{\sum p_0 q} * 100$$

$$= \frac{124}{80} * 100$$

$$= 155$$

Weighted Average of Relatives Method:

- Under this method price index is constructed on the basis of price relatives and not on the basis of absolute prices.
- A Price Index is obtained by taking the average of all weighted price relatives.

COMPUTATION OF WEIGHTED AVERAGE OF RELATIVES METHOD:

STEP 1: Calculate Price Relatives (P) for each of the items as follows:

$$\textbf{Price Relative} = \frac{p_1}{p_0} * 100$$

STEP 2: Calculate Value Weights (V) by multiplying the base year prices (p_0) of various items with the base year quantities (q_0) and obtain their total i.e. $\sum V = \sum p_0 \, q_0$

STEP 3: Multiply the Price Relatives (P) by the value weights (W) assigned and obtain their total i.e. $\sum PV$

STEP 4: Calculate the Price Index as follows:

$$P_{01} = \frac{\sum PV}{\sum V}$$

Where P = Price Relatives

V = Value Weights i.e. $\sum p_0 \, q_0$

From the following data, compute an index for the year 2017 taking 2016 as base by weighted average of price relatives method:

Commodity	Base Year		Current Year	
	Price	Quantity	Price	Quantity
A	1	6	5	14
B	2	7	4	11
C	3	8	3	8
D	4	9	2	5

Commodity	q_0	q_1	p_0	p_1	$V= p_0q_0$	Price Relatives (P)	PV
A	6	14	1	5	6	500	3000
B	7	11	2	4	14	200	2800
C	8	8	3	3	24	100	2400
D	9	5	4	2	36	50	1800
TOTAL					80		10000

$$P_{01} = \frac{\sum PV}{\sum V}$$

$$= \frac{10000}{80}$$

$$= 125$$

QUANTITY OR VOLUME INDEX NUMBERS:

Quantity Index Numbers measure change in quantities which may represent the physical volume of production, employment etc.

Prices are used a s weights

Quantity indices are obtained by changing p to q and q to p in the various formulae discussed earlier.