SEMICONDUCTOR PHYSICS

Semiconductors are the material, which have conductivity less than conductors and more than insulators.

For example:- Silicon and Germanium.

TYPES OF SEMICONDUCTOR

1.   **Intrinsic semiconductors:-** These semiconductors   are   the purest and their conductivity is very low.

2.   **Extrinsic semiconductors:-** To increase the   conductivity   some impurity is added to the pure semiconductor, so that the   conductivity increase. This process is known as doping.

These are of two types:-

i)   **N-type semiconductors:-** When pentavalent impurity like phosphorus antimony or bismuth is added to pure semiconductor, one extra electron is added for every doped atom, so that the number of electrons will become more and it is called N-type semiconductors.

ii)   **P-type semiconductors:-** When trivalent impurity like boron, aluminium is added to pure semiconductor, one hole becomes free for every doped atom, so that the number of holes become more and it is called P-type semiconductors.

PN-JUNCTION DIODE

When a P-type semiconductor is brought in contact with the N-type semiconductor, the resulting arrangement is called PN-Junction Diode.

In this, the electrons from N-type move to P-type and holes from P-type to N-type. The region in between P and N type is called depletion layer.

Barrier potential:-

Minority carriers in P-type and N-type semiconductors namely electrons and holes respectively try to move towards the regions where they are in excess and so their number on both sides of depletion layer increases which produces a potential difference between the two sides of depletion layer called potential barrier.

RECTIFIER

A rectifier is mainly a device which converts Alternating Current (AC) to Direct Current (DC)

Two types of rectifier:-

i)   Half wave rectifier.
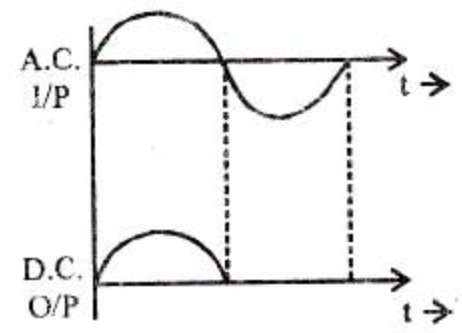
ii)   Full wave rectifier.

HALF WAVE RECTIFIER

The process of removing one-half the input signal to establish a DC Level is called Half Wave Rectification.
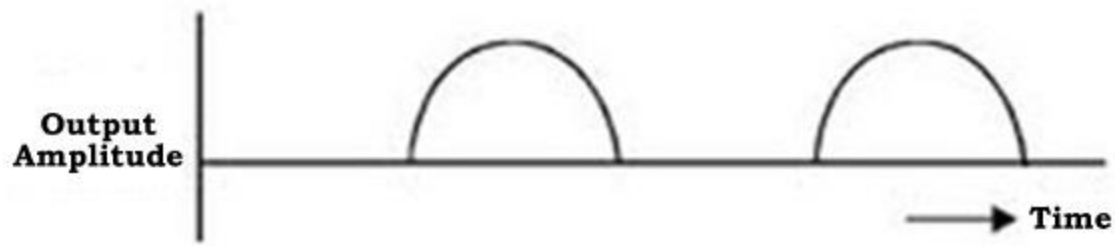
In Half Wave Rectifier only half of the wave i.e. positive half cycle appears at the output and negative half cycle is suppressed.
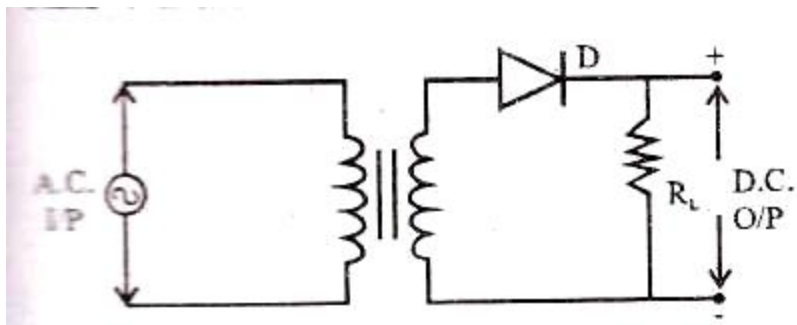
a) **Half wave Rectifier**

b) **Wave forms**

Input Amplitude

Time

Output Amplitude

Time
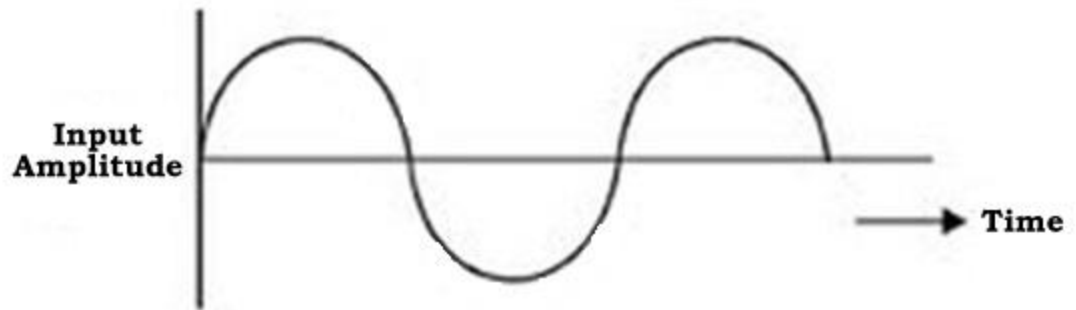
WORKING

The AC supply to be rectified is given through a transformer. The transformer is used to step-up or step-down. During positive half cycle of input AC voltage the terminal A is positive so that diode is forward bias and current appears across R_L.

During negative half cycle polarity changes and diode reverse bias and no current flows.

DISADVANTAGES

i)   The output is low because a.c. supply delivers   power for half cycle only.

ii)   The output contains a lot of ripples.

FULL WAVE RECTIFIER

To overcome the limitation of half wave rectifier, full wave rectifier is used in which output appears for both the half cycle.

Input AC signal

+ve

0

-ve

AC input

Centre tap

A

B

D_1

During positive half cycle

R_L

DC output

D_2

During negative half cycle

Output DC signal
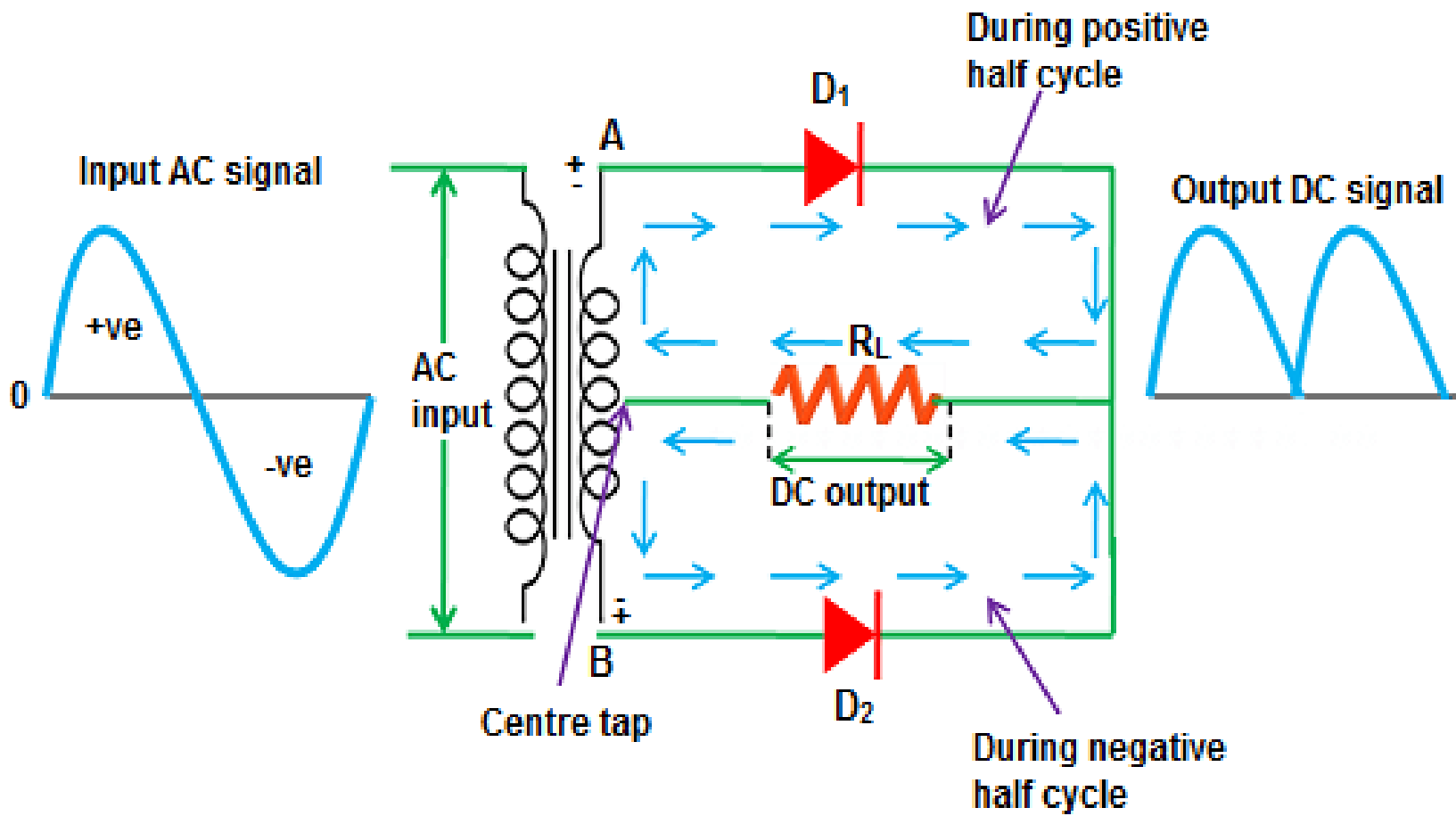
WORKING

When AC is switched on, the ends A and B become +ve and –ve during +ve half cycle, so that diode D_1 being forward biased and current will appears across the R_L. During –ve half cycle B is +ve and A is –ve, so that diode D_2 being forward biased and current will appears through R_L. Hence, both the half cycles are utilized for the output.

ADVANTAGES

The output and efficiency is high, because AC supply delivers power during both the half cycles.

POLYMERS AND PLASTICS

POLYMERS :

Polymers are the substances with very high molecular masses and each molecule of which consists of a large number of simple molecules joined by covalent bond.

MONOMER :

The repeating unit present in a polymer is known as **Monomer**

POLYMERISATION:

the process by which monomers are converted into polymers is called

TYPES OF POLYMERS

There are mainly two types of polymers

– Natural : cotton, silk, wood, leather…

– Synthetic : plastics, nylon, latex…

FOR EXAMPLE, POLYTHENE IS OBTAINED FROM A LARGE NUMBER OF ETHENE MOLECULES BY POLYMERISATION.

$$n\ (CH_2 = CH_2) \xrightarrow[\text{high pressure}]{O_2} \left(CH_2 - CH \right)_n$$

(Monomer)

Polythene
(Polymer)
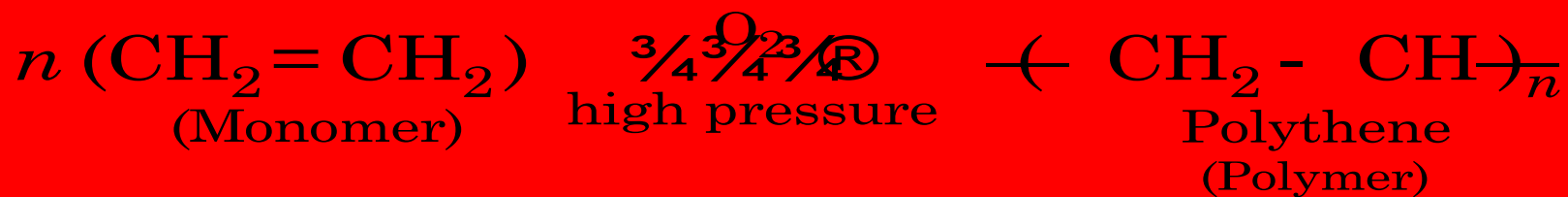
THERMOPLASTICS

- Thermoplastics soften when heated and can be moulded into required shapes when in this state. They will harden again on cooling. By heating and cooling, they can be softened and heated over and over again.

THERMOSETTING PLASTICS

- Will only mould once.

- Strong primary bonds are connected by strong covalent bonds.

- Cross-link process (curing) formed by heat and pressure.

- Non-reversible structure cannot be softened by heating.

- Phenol formaldehyde. Hard and brittle, 'Bakelite' has been used for electrical fittings and saucepan handles.
- Urea formaldehyde. Good electrical and thermal properties and used for electrical fittings and door handles.

METHODS FOR MAKING POLYMERS

ADDITION POLYMERIZATION AND CONDENSATION POLYMERIZATION

Addition polymerization:

monomers react to form a polymer without net loss of atoms.

Most common form: free radical chain reaction of ethylenes

$$n\ CH_2=\underset{\underset{Cl}{|}}{\overset{\overset{H}{|}}{C}} \longrightarrow \left[CH_2-\underset{\underset{Cl}{|}}{\overset{\overset{H}{|}}{C}} \right]_n$$

n monomers   one polymer molecule
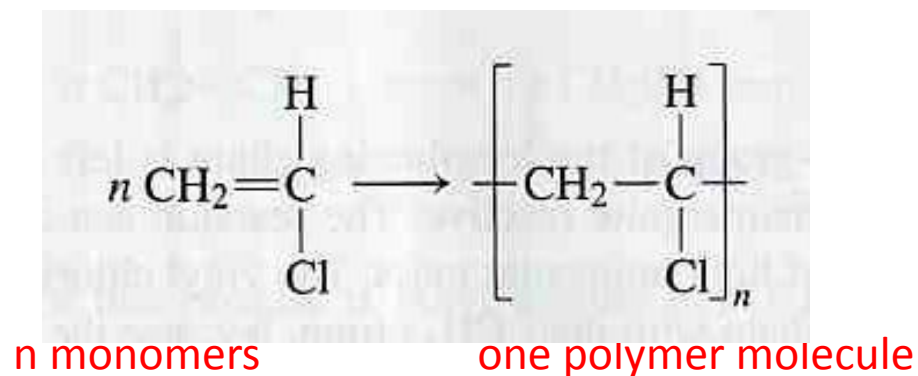
Two main synthetic approaches

- *Addition* polymerization
    - Simply adding monomers together – synthetic plastics

- *Condensation* polymerization
    - Combination by exclusion of a small molecule (usually water) – extensively used by nature

Condensation polymerization

Condensation polymerization: the polymer grows from monomers by splitting off a small molecule such as water or carbon dioxide.

Example: Nylon-66

. NYLON-66:-

It is prepared by condensation polymerization of hexamethylenediamine and Adipic acid.
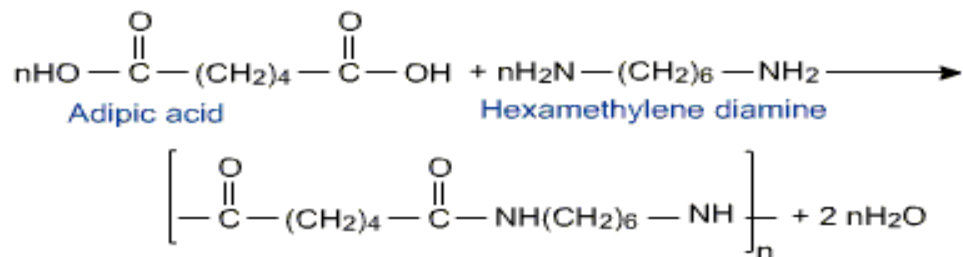
The fibres of Nylon-66 have very high tensile strength. They are quite tough and resistant to abrasion.

Uses:

It is used in making bristles of toothbrush, socks, sheets, ropes, etc and also in textile industries

Uses of Polymers

- Polymers are incorporated into nearly every aspect of daily life
  - Entertainment
  - Sports
  - Clothes
  - Hobbies/Toys
  - Household products
  - Automotive

IN DAILY LIFE:

Polymers are the backbone of the modern civilization. The polymers are commonly used in our day to day life example cars, bikes, scooters, furniture, clothing, medical equipments, plastic ware, etc. The article of common use such as radio, televisions, mobiles, sun glasses, bottles, buckets, packaging containers, toys, electrical switches, kitchen wares (bowl, mugs, saucers, plates, trays, etc) and other decorative articles are made up of polymers.

STATISTICS

Definations: Statistics ; Measure of central tendency

- <u>Defination of statistics</u>: statistics may be defined as the science of collection, organization, analysis and interpretation of numerical data.

- <u>Measures of Central Tendency</u>: An average is called a measure of central tendency, because it tends to lie centrally with the values of the variable arranged according to magnitude.

Arithmetic Mean(A.M.):

The arithmetic mean of an individual series is defined as the quotient of the sum of all the values of the variable by the total number of items.

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

Example 1

Example : The blood pressure of seven middle aged men were as follows:

151, 124, 132, 170, 146, 124 and 113.

$$\bar{x} = \frac{(151+124+132+170+146+124+113)}{7}$$

The mean is $= 137.14$

In case of discrete frequency distribution A.M. is calculated as:

A.M. $(\overline{X}) = \sum(f_i \ x_i) / \sum f_i$

OR $\sum(f \ x) / \sum f$

Where f_i is the frequency of x_i $(1 \leq I \leq n)$

Example2

Calculate the A.M. for the following data:

Income (in rs.):	500	520	550	600	800 1000
No. of emp:	4 10	6	5	3	2

Sol.

S.no.	Income in rs. (x_i)	No. of employees (f_i)	(f_i x_i)
1.	500	4	2000
2.	520	10	5200
3.	550	6	3300
4.	600	5	3000
5.	800	3	2400
6.	1000	2	2000
		$\sum f = 30$	$\sum(f_i x_i) = 17900$

Mean $= \sum(f_i x_i) / \sum f_i = 17900/30 = 596.67$

For Grouped or continuous frequency distribution, Arithmatic mean is calculated as:

Arithmatic Mean = $A + \dfrac{\sum f_i u_i}{\sum f_i} * h$

This method is called ***STEP DEVIATION METHOD***

EXAMPLE 3

Calculate the Arithmetic mean of the marks scored by the students of a class in a class test from the following data :

Marks	Number of students	Mid Point (x_i)	ui= (xi – A)/h	fiui
0-10	12	5	-2	-24
10-20	18	15	-1	-18
20-30	27	A = 25	0	0
30-40	20	35	1	20
40-50	17	45	2	34
50-60	6	55	3	18
Total	100			30

By step Deviation method, Arithmatic mean = A+(∑fi ui / ∑fi) * h
= 25 + (30/100)*10 = 28

Median :

The median of a statistical series is defined as the size of the middle most item (or the A.M. of two middle most items), provided the items are in the order of magnitude.

For an individual series, to find median we proceed as follow:

(a) Arrange the observations in ascending or descending order of magnitude.

(b) If n is odd; then median = $(n+1/2)^{th}$ observation.

If n is even; them median = A.M. of $(n/2)^{th \ \&}$ $(n/2) + 1^{th}$ observation.

Example 1:

Find the median of the values:

31   38   27   28   36   25   35   40

Sol: We arrange the values in ascending order

25   27   28   31   35   36   38   40

n = 8 (even);

Median = A.M. of $(8/2)^{th}$ & $(8/2) + 1^{th}$ observations

= (31+35)/2 = 33

In case of discrete frequency distribution Median is calculated as:

- Step I: Find the cumulative frequency (C.F.).

- Step 2: Find N/2 where N= $\sum f_i$

- Step 3: See the C.F. just greater than N/2.

- Step 4: The value of x corresponding to C.F. just greater than N/2 is median.

Example 2:

Calculate the Median of the following frequency distribution :

x	f	c.f.
1	8	8
2	10	18
3	11	29
4	16	45
5	20	65
6	25	90
7	15	105
8	9	114
9	6	120
	N = 120	

Here N is 120; N/2 is 60; C.F. just greater than N/2 is 65; So corresponding value of x '5' is median.

- Step I: Find the cumulative frequency (C.F.).
- Step 2: Find N/2 where N= $\sum f_i$
- Step 3: The class corresponding to C.F. just greater than N/2 is median class and the value of the median is calculated by formula:

Median = l + ((N/2-F)/f) *h

Where l= lower limit of median class

F = C.F. of class preceding the median class

f is the frequency of median class

h is the width of median class.

Example 3

Calculate the median from the following distribution:

Class	Freuency	Cumative frequency
5-10	5	5
10-15	6	11 (F)
15-20 (Median class)	15 (f)	26 (C.F. just greater than N/2)
20-25	10	36
25-30	5	41
30-35	4	45
35-40	2	47
40-45	2	49
	N= 49	
Here N = 49	N/2 = 24.5	C.F. just greater than N/2 is 26
Corresponding class 15-20 is median class		Median = l +((N/2-F)/f) *h
Median = 15 + (24.5-11)/15 * 5 = 19.5		

MODE

- The mode of a distribution of the variable is that value of the variable for which the frequency is maximum.

- <u>In case of an individual series</u>, mode is calculated as by counting the number of times the various values repeat themselves and the value which occurs maximum no. of times is the modal value.

In case of discrete frequency distribution mode is calculated as:

For discrete frequency distribution, generally mode is calculated by finding the value for which frequency is maximum.

Example 2

Find the mode of the following distribution:

Size in inches	No of shirts sold
30	8
32	17
34	30
36	35
38	18
40	7
42	3

35 shirts of size 36 have the maximum sale. So mode of distribution is "36".

For grouped or continuous frequency distribution mode is calculates as:

To find the mode of continuous frequency distribution, we follow the following steps:

STEP 1: Determine the class of maximum frequency, this class is modal class.

STEP 2: Determine the value of mode by applying the formula:

Mode $= l + (f\text{-}f_1 / f\text{-}f_1\text{-}f_2) * h$

Where l is the lower limit of modal class

f is the frequency of modal class

h is the width of modal class

f_1 is the frequency of class preceding the modal class

f_2 is the frequency of class following the modal class

Example 3

Calculate the mode from the following data:

Rent (in Rs.)	No. of houses
20-40	6
40-60	9
60-80	11
80-100	14 (f_1)
100-120 (Modal class)	20 (f)
120-140	15 (f_2)
140-160	10
Highest frequency is 20	Hence Modal class is 100-120
Mode = l + (f-f_1 / f-f_1-f_2) * h	
Here l= 100; h= 20; f= 20; f_1 = 14; f_2 = 15	
Mode = 100 + (20-14)/(2*20-14-15) *20 = 110.91	

Measures of dispersion

- <u>Mean Deviation</u>: It is defined as the A.M. of the absolute deviations of all the values taken from any central value.

- <u>Standard Deviation</u>: The standard deviation of a statistical data is defined as the positive square root of the A.M. of the squared deviations of items from the A.M. of the series under consideration.

Mean Deviation ($\bar{x}$) = $\sum \dfrac{\left| x_i - \bar{x} \right|}{n}$

Mean Deviation (Median) = $\sum \dfrac{\left| x_i - \text{Median} \right|}{n}$

Cofficient of Mean Deviation (x) = $\dfrac{\text{M.D.}(X)}{\bar{x}}$

Cofficient of Mean Deviation (Median) = M.D.(Medain)/Median

Example 1

Calculate the mean deviation about mean and its coefficient for the following data:
21 23 25 28 30 32 46 38 48 46

S.No.	Xi	$x_i - \bar{x}$	$\lvert x_i - \bar{x} \rvert$
1	21	-12.7	12.7
2	23	-10.7	10.7
3	25	-8.7	8.7
4	28	-5.7	5.7
5	30	-3.7	3.7
6	32	-1.7	1.7
7	46	12.3	12.3
8	38	4.3	4.3
9	48	14.3	14.3
10	46	12.3	12.3
Mean = 337/10 =33.7	M.D. = 86.4/10 = 8.64	Coeff. = 8.64/33.7 = 26	$\sum \lvert x_i - \bar{x} \rvert = 86.4$

For frequency distribution & Grouped Data M.D. is calculated as:

$$\text{Mean Deviation } (\bar{x}) = \frac{\sum f_i \left| x_i - \bar{x} \right|}{n}$$

$$\text{Mean Deviation } (\text{Median}) = \frac{\sum f_i \left| x_i - \text{Median} \right|}{N}$$

Example 2

Calculate the mean deviation about mean and its coefficient for the following frequency distribution:

X	f	fx	X-$\bar{x}$	$\lvert x - \bar{x} \rvert$	f$\lvert x - \bar{x} \rvert$
5	8	40	-4	4	32
7	6	42	-2	2	12
9	2	18	0	0	0
10	2	20	1	1	2
12	2	24	3	3	6
15	6	90	6	6	36
	N = 26	$\sum$f x = 234			$\sum$f $\lvert x - \bar{x} \rvert$ =88
Mean = 234/26=9		M.D. = 88/26= 3.38		Coefficient of M.D. = 3.38/9= 0.38	

For Individual series & frequency distribution Standard Deviation is calculated as:

S.D.(Individual series) $= \sqrt{\sum_{i=1}^{i=n}(x\,i - \mathrm{x})^2 \,/\mathrm{n}}$

Where x_i are the values of variable under consideration.

S.D. (For Discrete Frequency distribution):

$$\sqrt{\sum_{i=1}^{i=n} f\,i\,(x\,i - \mathrm{x}\,)^2 \,/\mathrm{N}}$$

Where N is the sum of all the frequencies.

Example 1

Find the S.D. and C.V. for the following data:
4,6,10,12,18

S.No.	x	x- $\bar{x}$	$(x – \bar{x})2$
1	4	-6	36
2	6	-4	16
3	10	0	0
4	12	2	4
5	18	8	x64

Mean = ∑x / n	**Mean = 50/5 = 10**

S.D. = $\sqrt{\sum_{i=1}^{i=n}(x\,i - mean)^2 / n}$ **S.D. = √120/5 = 4.899**

C.V. = (4.899/10) * 100 = 48.99 %

Example 2

Calculate the S.D. and C.V. for the following

X	f	fx	X - $\bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
5	12	60	-23	529	6348
15	18	270	-13	169	3042
25	27	675	-3	9	243
35	20	700	7	49	980
45	17	765	17	289	4913
55	6	330	27	729	4374
	$\sum f = 100$	$\sum fx = 2800$			$\sum f(x - \bar{x})^2 = 19900$

Mean = 2800/100 = 28

S.D. = $\sqrt{\sum_{i=1}^{i=n} fi\,(xi - \bar{x})^2 / N}$ S.D. = √ 19900/100 = 14.11

C.V. = S.D. / Mean * 100 = 50.39%

For Grouped data S.D. is calculated as:

$$S.D. = \sqrt{\sum f_i \, (u_i)^2 \, / N - (\sum f_i u_i / N)^2} \, / N * h$$

Where $u_i = x_i - A$ and N is the sum of frequency.

$\qquad\qquad\qquad h$

Example 3

Find the S.D. & C.V. for the following data:

class	f	x	U = x-A/h	fu	u²	fu²
0-5	20	2.5	-4	-80	16	320
5-10	24	7.5	-3	-72	9	216
10-15	32	12.5	-2	-64	4	128
15-20	28	17.5	-1	-28	1	28
20-25	20	22.5	0	0	0	0
25-30	16	27.5	1	16	1	16
30-35	34	32.5	2	68	4	136
35-40	10	37.5	3	30	9	90
40-45	16	42.5	4	64	16	256
	$\sum$f=200			$\sum$fu = -66		$\sum$fu² = 1190

Mean $= A + \sum fu/\sum f * h = 20.85$ **S.D.** $= \sqrt{\sum f_i (u_i)^2 /N - (\sum f_i u_i /N)^2} /N * h = 12.1$

C.V. = C.V. = S.D. / Mean * 100 = 58.03%

OTHER FORMULAS (S.D.)

- <u>Cofficient of S.D.</u> = S.D./Mean

- <u>Cofficient of variation</u> = (S.D./Mean) *100

- <u>Variance</u> = Square of S.D.

Rank Correlation Coefficient:

Rank Coorelation Coefficient is given by the   formula:

$$r = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

Where n is no. of items

d is the difference of ranks.

Example 1

Find the coefficient of rank correlation for the following data:

x	y	R1	R2	d=R1-R2	d²
56	15	3	2	1	1
58	12	4	1	3	9
62	16	5	3	2	4
72	17	7	4	3	9
54	19	2	5	-3	9
52	20	1	6	-5	25
71	21	6	7	-1	1
90	22	9	8	1	1
81	23	8	9	-1	1
92	24	10	10	0	0
					$\sum d^2 = 60$
r = 1 – (6* 60)/10(100-1) = 0.64					

Example 2

Seven Competitors in a music competition are ranked by the judges x & y in the following order. What is the degree of agreement between the judges. Also find the coefficient of correlation.

S.No.	Competitors	R1	R2	d = R1-R2	d²
1	A	2	1	1	1
2	B	1	3	-2	4
3	C	4	2	2	4
4	D	3	4	-1	1
5	E	5	5	0	0
6	F	7	6	1	1
7	G	6	7	-1	1
					$\sum d^2 = 12$

r = 1-(72/7*48) = .7857 (Agreement between the judges is high)