

# ■ UNIT-2

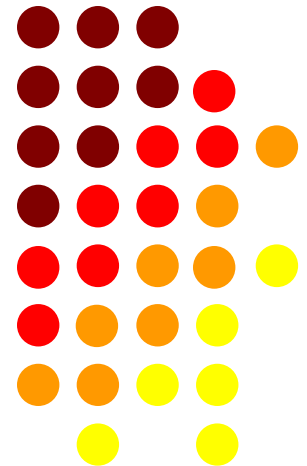
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# Lecture- 9



## Arithmetic Progression(A.P) and its general term



## ARITHMETIC PROGRESSION

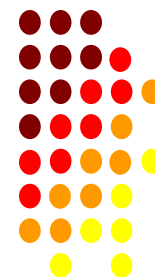
**SEQUENCE** *A succession of numbers arranged in a definite order according to a certain given rule is called a sequence.*

The number occurring at the  $n$ th place of a sequence is called its  $n$ th term or the general term, to be denoted by  $a_n$ .

*A sequence is said to be finite or infinite according as the number of terms in it is finite or infinite respectively.*

*By adding the terms of a sequence, we get a series.*

*A series is said to be finite or infinite according as the number of terms in it is finite or infinite respectively.*



EXAMPLE 1 Write first five terms of the sequence given by the rule  $a_n = (2n + 1)$  and obtain the corresponding series.



SOLUTION We have,  $a_n = (2n + 1)$ .

Putting  $n = 1, 2, 3, 4, 5, \dots$  successively in (i), we get

$$a_1 = (2 \times 1 + 1) = 3; a_2 = (2 \times 2 + 1) = 5; a_3 = (2 \times 3 + 1) = 7;$$

$$a_4 = (2 \times 4 + 1) = 9 \quad \text{and} \quad a_5 = (2 \times 5 + 1) = 11.$$

Hence, the required sequence is  $3, 5, 7, 9, 11, \dots$ .

The corresponding series is  $3 + 5 + 7 + 9 + 11 + \dots$ .



EXAMPLE 2 Write first four terms of the sequence given by  $a_n = \frac{1}{6}(2n - 3)$  and obtain the corresponding series.



EXAMPLE 3 *The Fibonacci sequence is defined by*

$$1 = a_1 = a_2 \text{ and } a_n = a_{n-1} + a_{n-2}, n > 2.$$

*Find  $\frac{a_{n+1}}{a_n}$  for  $n = 1, 2, 3, 4, 5$ .*



## PROGRESSIONS

*Sequences following certain patterns are called progressions.*

### ARITHMETIC PROGRESSION (AP)

*It is a sequence in which each term except the first one differs from its preceding term by a constant.*

*This constant difference is called the common difference of the AP.*

*In an AP we usually denote the first term by  $a$ , the common difference by  $d$  and the  $n$ th term by  $T_n$ .*





Progressions: Sequence following certain patterns are called progressions.

Types of Progressions:

(i) Arithmetic Progression (A.P)

(ii) Geometric Progression (G.P)

(i) Arithmetic Progression (A.P) - It is a sequence in which each term except the first one differs from its preceding term by a constant.



This constant difference is called the common difference of the A.P.

In A.P, first term =  $a$   
common difference =  $d$



General term of an A.P. :-

The  $n^{\text{th}}$  term of an A.P with first term  $a$  and common difference  $d$  is given by

$$T_n = a + (n-1)d$$



EXAMPLE 1 Show that the sequence defined by  $T_n = 3n + 5$  is an AP. Find its common difference.



SOLUTION We have,  $T_n = 3n + 5$ . ... (i)

Replacing  $n$  by  $(n - 1)$  in (i), we get

$$T_{n-1} = 3(n - 1) + 5 \Rightarrow T_{n-1} = 3n + 2. \quad \dots \text{(ii)}$$

Subtracting (ii) from (i), we get

$$(T_n - T_{n-1}) = (3n + 5) - (3n + 2) = 3, \text{ which is constant.}$$

Hence, the given sequence is an AP with common difference 3.



EXAMPLE 2 Show that the sequence  $\log a, \log \left(\frac{a^2}{b}\right), \log \left(\frac{a^3}{b^2}\right), \log \left(\frac{a^4}{b^3}\right), \dots$  forms an AP. Find its common difference.



SOLUTION By symmetry, we find that

$$T_n = \log \left( \frac{a^n}{b^{n-1}} \right) \text{ and } T_{n-1} = \log \left( \frac{a^{n-1}}{b^{n-2}} \right).$$

$$\begin{aligned} \therefore (T_n - T_{n-1}) &= \log \left( \frac{a^n}{b^{n-1}} \right) - \log \left( \frac{a^{n-1}}{b^{n-2}} \right) \\ &= \log \left( \frac{a^n}{b^{n-1}} \times \frac{b^{n-2}}{a^{n-1}} \right) = \log \left( \frac{a}{b} \right) = \text{constant.} \end{aligned}$$

Hence, the given sequence is an AP with common difference  $\log \left( \frac{a}{b} \right)$ .



EXAMPLE 3 Show that the sequence defined by  $T_n = 3n^2 + 2$  is not an AP.





THEOREM 1 *Show that the  $n$ th term of an AP with first term  $a$  and common difference  $d$  is given by  $T_n = a + (n - 1)d$ .*



In an AP with first term =  $a$  and common difference =  $d$ , we have

$$T_n = a + (n - 1)d.$$



## SOME SIMPLE PROPERTIES OF AN AP

- (i) If a constant is added to each term of an AP then the resulting progression is an AP.
- (ii) If a constant is subtracted from each term of an AP then the resulting progression is an AP.
- (iii) If each term of an AP is multiplied by the same nonzero number then the resulting progression is an AP.
- (iv) If each term of an AP is divided by the same nonzero number then the resulting progression is an AP.



EXAMPLE 1 *Show that the progression 7, 12, 17, 22, 27, ... is an AP. Find its general term and the 14th term.*



Sol. We have,  $T_n = 3n + 5 \rightarrow (1)$

So we have  $T_{n-1}$ , by replacing  $n$  by  $(n-1)$  in (1)

we get

$$T_{n-1} = 3(n-1) + 5 = 3n + 2 \rightarrow (2)$$

$$\text{then } T_n - T_{n-1} = (3n + 5) - (3n + 2) = 3$$

which is constant.

Hence the given sequence is an A.P  
with common difference 3.



Q-1 Which term of the A.P: 3, 8, 13 - - - is 248?  
[2011-12, 2018-19]

Sol. In the given A.P,

$$a=3, d=8-3=5$$

So  $n^{\text{th}}$  term of A.P = 248

$$T_n = 248$$

$$a + (n-1)d = 248$$

$$3 + (n-1)5 = 248$$

$$5(n-1) = 248-3$$

$$5(n-1) = 245$$



$$5(n-1) = 248-3$$

$$5(n-1) = 245$$

$$(n-1) = 49$$

$$n = 50$$

So 50<sup>th</sup> term of the given A.P is  
248.



Q-2 Find the  $n^{\text{th}}$  term of an A.P: 5, 8, 11 - -

Sol. In the given A.P,

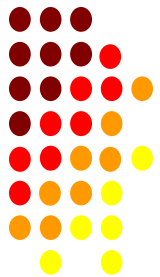
$$a = 5, d = 3$$

[2015-16]

$$\text{So } T_n = 5 + (n-1)3$$

$$= 5 + 3n - 3$$

$$\boxed{T_n = 3n + 2}$$





Q-3 Is 184 a term of the sequence 3, 7, 11, ...?

Sol. In the given A.P.,  
 $a = 3, d = 7 - 3 = 4$   
 $T_n = 184$

[2019-20]

$$a + (n-1)d = 184$$

$$3 + (n-1)4 = 184$$

$$3 + 4n - 4 = 184$$

$$4n - 1 = 184$$

$$4n = 185$$



$$4n - 1 = 184$$

$$4n = 185$$

$$n = 46.25 = 46\frac{1}{4}$$

Since the number of the terms cannot be a fraction, so it follows that 184 is not a term of the given A.P.



Q-4 Which term of the A.P:  
3, 8, 13, ... is 78?

[2020-21]

Sol. In the given A.P,  
 $a = 3, d = 8 - 3 = 5$   
 $T_n = 78$

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$$a + (n-1)d = 78$$

$$3 + (n-1)5 = 78$$

$$3 + 5n - 5 = 78$$

$$5n - 2 = 78$$

$$5n = 80$$

$$n = 16$$

Hence, the 16<sup>th</sup> term of the given AP is  
78.



Q-5 If  $a_n = 5 - 11n$ , find the common difference. [2020-21]

Sol.

$$a_n = 5 - 11n$$

$$a_{n-1} = 5 - 11(n-1)$$

$$= 5 - 11n + 11$$

$$a_{n-1} = 16 - 11n$$



$$a_{n-1} = 16 - 11n$$

So  $d = a_n - a_{n-1} = 16 - 11n - 5 + 11n$

$$d = 11$$

Hence common difference = 11.  
..



$n^{\text{th}}$  term from the end of an A.P. :-

The  $n^{\text{th}}$  term from the end of an A.P with the first term  $a$  and common difference  $d$  and the last term  $l$  is given by

$$T_n = l - (n-1)d$$



# PRACTICE QUESTIONS

1. Write first 4 terms in each of the sequences:

(i)  $a_n = (5n + 2)$       (ii)  $a_n = \frac{(2n - 3)}{4}$       (iii)  $a_n = (-1)^{n-1} \times 2^{n+1}$

2. Find first five terms of the sequence, defined by

$$a_1 = 1, a_n = a_{n-1} + 3 \text{ for } n \geq 2.$$

3. Find first 5 terms of the sequence, defined by

$$a_1 = -1, a_n = \frac{a_{n-1}}{n} \text{ for } n \geq 2.$$

4. Find the 23rd term of the AP  $7, 5, 3, 1, -1, -3, \dots$

5. Find the 20th term of the AP  $\sqrt{2}, 3\sqrt{2}, 5\sqrt{2}, 7\sqrt{2}, \dots$

6. Find the  $n$ th term of the AP  $8, 3, -2, -7, -12, \dots$

7. Find the  $n$ th term of the AP  $1, \frac{5}{6}, \frac{2}{3}, \frac{1}{2}, \dots$





# PRACTICE QUESTIONS

8. Which term of the AP  $9, 14, 19, 24, 29, \dots$  is 379?
9. Which term of the AP  $64, 60, 56, 52, 48, \dots$  is 0?
10. How many terms are there in the AP  $11, 18, 25, 32, 39, \dots, 207$ ?
11. How many terms are there in the AP  $1\frac{5}{6}, 1\frac{1}{6}, \frac{1}{2}, \frac{-1}{6}, \frac{-5}{6}, \dots, -16\frac{1}{6}$ ?



# ANSWERS

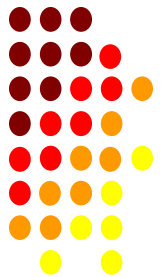
1. (i) 7, 12, 17, 22 (ii)  $\frac{-1}{4}, \frac{1}{4}, \frac{3}{4}, \frac{5}{4}$  (iii) 4, -8, 16, -32      2. 1, 4, 7, 10, 13

3.  $-1, \frac{-1}{2}, \frac{-1}{6}, \frac{-1}{24}, \frac{-1}{120}$     4. -37    5.  $39\sqrt{2}$       6.  $T_n = (13 - 5n)$

7.  $T_n = \frac{1}{6}(7 - n)$     8. 75th      9. 17th      10. 29      11. 28



**THANK YOU**



# Lecture- 10,11



Sum of  $n^{\text{th}}$  terms of a A.P.:- The sum of  $n$  terms of an A.P with first term  $a$  and common difference  $d$  is given by

$$S_n = \frac{n}{2} [2a + (n-1)d]$$

If  $l$  is the last term then:

$$S_n = \frac{n}{2} (a+l)$$



① Find the sum of 23 terms of the AP 5, 9, 13, 17...  
sol. Here  $a=5$ ,  $d=9-5=4$ ,  $n=23$

$$\text{Now, } S_n = \frac{n}{2} [2a + (n-1)d]$$

$$= \frac{23}{2} [2 \times 5 + (23-1) \times 4]$$

$$= \frac{23}{2} \times 98 = 1127 \text{ Ans.}$$



② Find the sum of all odd integers from 1 to 1001.  
Sol. The odd integers from 1 to 1001 are 1, 3, 5, ..., 999, 1001,

This is an A.P. in which  $a = 1$ ,  $d = 3 - 1 = 2$ ,  
 $l = 1001$ , let  $n$  be the number of terms.

$$T_n = a + (n-1)d$$



$$T_n = a + (n-1)d$$

$$1001 = 1 + (n-1) \times 2$$

$$\Rightarrow n = 501$$

Now  $a=1$ ,  $l=1001$  &  $n=501$

$$S_n = \frac{n}{2}(a+l) = \frac{501}{2} \cdot (1+1001) = 501 \times 501 \\ = 251001.$$





Q-3 The third term of an A.P is 7 and the seventh term is 2 more than 3 times the third term. Find the first term, the common difference and the sum of first 20 terms. [2011-12]

Sol.

$$a_3 = T_3 = 7, \quad T_7 = 3T_3 + 2, \quad a = ?$$

$$d = ?$$

$$T_3 = a + (n-1)d = 7$$



Sol.

$$a_3 = T_3 = 7, \quad T_7 = 3T_3 + 2, \quad a = ?$$

$$T_3 = a + (n-1)d = 7$$

$$a + (3-1)d = 7$$

$$a + 2d = 7 \longrightarrow \textcircled{1}$$

$$T_7 = 3T_3 + 2$$

$$a + (7-1)d = 3[a + 2d] + 2$$

$$d = ?$$
$$S_{20} = ?$$



$$T_7 = 3T_3 + 2$$

$$a + (7-1)d = 3[a + 2d] + 2$$

$$a + 6d = 3a + 6d + 2$$

$$\Rightarrow 2a = 2$$

$$\Rightarrow \boxed{a = 1}$$

Use in (1);

$$1 + 2d = 7$$

$$2d = 7 - 1$$

$$2d = 6$$

$$\boxed{d = 3}$$



$$\begin{aligned} S_{20} &= \frac{20}{2} [2 \times 1 + (20-1)3] \\ &= 10 [2 + 19 \times 3] \\ &= 10 [57 + 2] \\ &= 10 \times 59 \end{aligned}$$

$$S_{20} = 590 \text{ Ans}$$





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By ①

$$S_n = \frac{10}{2} [2 + 20] = 110 \text{ Ans}$$



Q.8 Find the sum of  $3+6+9+\dots+30$ .

Sol.

$$a=3, T_n=30$$

[2020-21]

$$T_n = a + (n-1)d = 3 + (n-1) \times 3 = 30$$

$$\Rightarrow n = 10$$

$$\text{So } S_n = \frac{n}{2} [2a + (n-1)d]$$

$$= \frac{10}{2} [6 + (10-1)3] = 5 \times 33$$

$$= 165 \text{ Ans}$$



Q-9. The first term of an A.P is 5, the last term is 45 and the sum is 400. Find the number of terms and the common difference.

Sol. Given

$$a = 5, l = 45, S_n = 400, T_n = 45$$

$$S_n = \frac{n}{2} [a + l] \Rightarrow \frac{n}{2} (50) = 400$$

[2020-21]





$$n = \frac{800}{50} \geq 16$$

So number of terms = 16

Common difference  $d = ?$

$$T_n = a + (n-1)d$$

$$T_{16} = 5 + (16-1)d$$

$$45 = 5 + 15d$$

$$40 = 15d$$

$$\boxed{d = 8/3} \quad \text{Ans}$$



# PRACTICE QUESTIONS

1. Find the sum of 23 terms of the AP  $17, 12, 7, 2, -3, \dots$ .
2. Find the sum of 16 terms of the AP  $6, 5\frac{1}{3}, 4\frac{2}{3}, 4, \dots$ .
3. Find the sum of 25 terms of the AP  $\sqrt{2}, 2\sqrt{2}, 3\sqrt{2}, 4\sqrt{2}, \dots$ .
4. Find the sum of 100 terms of the AP  $0.6, 0.61, 0.62, 0.63, \dots$ .
5. Find the sum of 20 terms of the AP  $(x+y), (x-y), (x-3y), \dots$ .
6. Find the sum of  $n$  terms of the AP  $\frac{x-y}{x+y}, \frac{3x-2y}{x+y}, \frac{5x-3y}{x+y}, \dots$ .
7. Find the sum of the series  $2 + 5 + 8 + 11 + \dots + 191$ .
8. Find the sum of the series  $101 + 99 + 97 + 95 + \dots + 43$ .



# ANSWERS

1.  $-874$       2.  $16$       3.  $325\sqrt{2}$       4.  $109.5$       5.  $20(x-18y)$   
6.  $\frac{n}{2(x+y)} \cdot |n(2x-y) - y|$       7.  $6176$       8.  $2160$



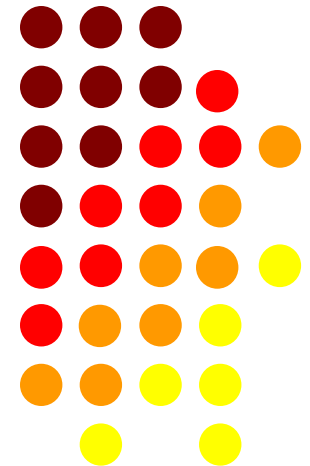
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# Lecture- 12



## Arithmetic Mean



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## ARITHMETIC MEAN

### ARITHMETIC MEAN

If  $a, A, b$  are in AP then we say that  $A$  is the arithmetic mean (AM) between  $a$  and  $b$ .

### INSERTION OF A SINGLE ARITHMETIC MEAN BETWEEN $a$ AND $b$

Let  $a$  and  $b$  be two given numbers and let  $A$  be the arithmetic mean between  $a$  and  $b$ . Then,

$a, A, b$  are in AP

$$\Rightarrow A - a = b - A$$

$$\Rightarrow 2A = a + b \Rightarrow A = \frac{a+b}{2}.$$

Hence, the arithmetic mean between  $a$  and  $b$  is  $\frac{a+b}{2}$ .



EXAMPLE 1 Find the arithmetic mean between

- (i) 14 and -6,                      (ii)  $(a - b)$  and  $(a + b)$ .

SOLUTION (i) Arithmetic mean between 14 and -6

$$= \frac{14 + (-6)}{2} = \frac{8}{2} = 4.$$

(ii) Arithmetic mean between  $(a - b)$  and  $(a + b)$

$$= \frac{(a - b) + (a + b)}{2} = \frac{2a}{2} = a.$$



Q-2 Insert six arithmetic means between 15 and -13.

Sol. Let  $A_1, A_2, A_3, A_4, A_5, A_6$  be the six arithmetic means between 15 and -13 then





So 15,  $A_1, A_2, A_3, A_4, A_5, A_6, -13$  are in A.P

$$\text{So } d = \frac{(-13 - 15)}{(6 + 1)} = -4$$

$$\text{So } A_1 = (15 + d) = 15 - 4 = 11, \quad A_2 = \frac{(15 + 2d)}{2} = 7$$

$$A_3 = (15 + 3d) = 15 - 12 = 3$$

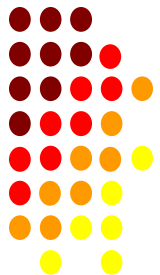
$$A_4 = (15 + 4d) = 15 - 16 = -1$$

$$A_5 = (15 + 5d) = 15 - 20 = -5$$

$$A_6 = (15 + 6d) = 15 - 24 = -9$$



Hence the required six AMs between 15 and  
-13 is  
11, 7, 3, -1, -5, -9.



Some more question related to A.P.

- ① If  $a, b, c$  are in A.P, show that  
(i)  $(b+c), (c+a)$  and  $(a+b)$  are in A.P

Sol. Since  $a, b, c$  are in A.P we have

$$2b = a + c \rightarrow \text{①}$$

- (i)  $(b+c), (c+a), (a+b)$  will be in A.P if

$$(c+a) - (b+c) = (a+b) - (c+a)$$

So if  $a - b = b - c$



So if  $a - b = b - c$

$$2b = a + c$$

which is true by (i)

Hence  $(b+c), (c+a), (a+b)$  are in A.P.



# PRACTICE QUESTIONS

1. Find the arithmetic mean between  
(i) 9 and 19,           (ii) 15 and  $-7$ ,           (iii)  $-16$  and  $-8$ .
2. Insert four arithmetic means between 4 and 29.
3. Insert three arithmetic means between 23 and 7.
4. Insert six arithmetic means between 11 and  $-10$ .
5. There are  $n$  arithmetic means between 9 and 27. If the ratio of the last mean to the first mean is  $2 : 1$ , find the value of  $n$ .
6. Insert arithmetic means between 16 and 65 such that the 5th AM is 51. Find the number of arithmetic means.
7. Insert five numbers between 11 and 29 such that the resulting sequence is an AP.



# ANSWERS

1. (i) 14 (ii) 4 (iii) -12    2. 9, 14, 19, 24    3. 19, 15, 11    4. 8, 5, 2, -1, -4, -7

5.  $n = 5$

6. six

7. 14, 17, 20, 23, 26



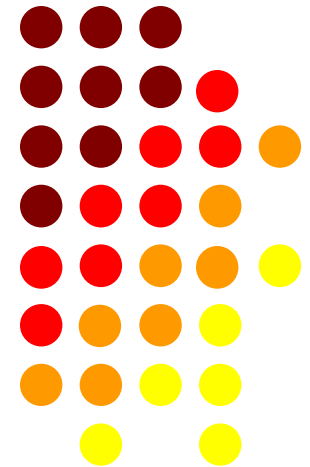
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# Lecture- 12



## Geometric Progression(G.P) and its general term





## GEOMETRICAL PROGRESSION (GP)

A sequence  $a_1, a_2, a_3, \dots, a_n$  is called a geometrical progression, if each term is nonzero and  $\frac{a_{k+1}}{a_k} = r$  (constant) for all  $k \geq 1$ .

The constant ratio is called its *common ratio*.

A geometrical progression is abbreviated as GP.

In a GP we usually denote the *first term* by  $a$ , the *common ratio* by  $r$  and the *nth term* by  $T_n$ .

The *nth term* of a GP is called its general term.



# GENERAL TERM OF A GP

## REMEMBER

In a GP with first term =  $a$  and common ratio =  $r$ , we have

$$n\text{th term, } T_n = ar^{n-1}.$$



**Example** Find the  $10^{\text{th}}$  and  $n^{\text{th}}$  terms of the GP. 5, 25, 125, ...



**Solution** Here  $a = 5$  and  $r = 5$ . Thus,  $a_{10} = 5(5)^{10-1} = 5(5)^9 = 5^{10}$   
and  $a_n = ar^{n-1} = 5(5)^{n-1} = 5^n$ .



**Example** Which term of the G.P., 2,8,32, ... up to  $n$  terms is 131072?

**Solution** Let 131072 be the  $n^{\text{th}}$  term of the given G.P. Here  $a = 2$  and  $r = 4$ .

Therefore  $131072 = a_n = 2(4)^{n-1}$  or  $65536 = 4^{n-1}$

This gives  $4^8 = 4^{n-1}$ .

So that  $n - 1 = 8$ , i.e.,  $n = 9$ . Hence, 131072 is the 9<sup>th</sup> term of the G.P.



**Example** In a G.P., the 3<sup>rd</sup> term is 24 and the 6<sup>th</sup> term is 192. Find the 10<sup>th</sup> term.



**Solution** Here,  $a_3 = ar^2 = 24$  ... (1)

and  $a_6 = ar^5 = 192$  ... (2)

Dividing (2) by (1), we get  $r = 2$ . Substituting  $r = 2$  in (1), we get  $a = 6$ .

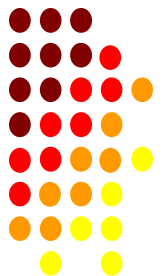
Hence  $a_{10} = 6 (2)^9 = 3072$ .



EXAMPLE Show that the progression 6, 18, 54, 162, ... is a GP. Write down its first term and the common ratio.

SOLUTION We have  $\frac{18}{6} = \frac{54}{18} = \frac{162}{54} = 3$  (constant).

So, the given progression is a GP in which the first term = 6 and the common ratio = 3.





EXAMPLE . Show that the progression  $-16, 4, -1, \frac{1}{4}, \dots$  is a GP. Write down its first term and the common ratio.

SOLUTION We have  $\frac{4}{-16} = \frac{-1}{4} = \frac{(1/4)}{-1} = \frac{-1}{4}$  (constant).

So, the given progression is a GP in which  $a = -16$  and  $r = \frac{-1}{4}$ .



EXAMPLE Find the 10th term and the general term of the progression

$$\frac{1}{4}, \frac{-1}{2}, 1, -2, 4, \dots$$

SOLUTION In the given progression, we have

$$\begin{aligned} \left(\frac{-1}{2}\right) \div \frac{1}{4} &= \left(\frac{-1}{2} \times 4\right) = -2, & 1 \div \left(\frac{-1}{2}\right) &= 1 \times (-2) = -2, \\ (-2) \div 1 &= -2 \text{ and } 4 \div (-2) &= -2. \end{aligned}$$

So, the given progression is a GP in which  $a = \frac{1}{4}$  and  $r = -2$ .



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$\therefore$  the 10th term,  $T_{10} = ar^{(10-1)} = ar^9 = \frac{1}{4} \times (-2)^9 = \frac{-512}{4} = -128$ .

The general term,  $T_n = ar^{(n-1)} = \frac{1}{4} \times (-2)^{(n-1)} = (-1)^{(n-1)} \times 2^{(n-3)}$ .

EXAMPLE Show that the progression

$$1, \frac{(\sqrt{2}-1)}{2\sqrt{3}}, \frac{(3-2\sqrt{2})}{12}, \frac{(5\sqrt{2}-7)}{24\sqrt{3}}, \dots$$

is a GP. Find its 5th term.



SOLUTION In the given progression, we have

$$\frac{T_2}{T_1} = \left[ \frac{(\sqrt{2}-1)}{2\sqrt{3}} \times \frac{1}{1} \right] = \frac{(\sqrt{2}-1)}{2\sqrt{3}}, \quad \frac{T_3}{T_2} = \frac{(3-2\sqrt{2})}{12} \times \frac{2\sqrt{3}}{(\sqrt{2}-1)} = \frac{(\sqrt{2}-1)}{2\sqrt{3}},$$

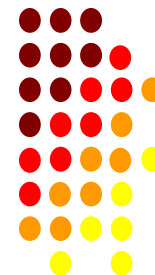
$$\frac{T_4}{T_3} = \frac{(5\sqrt{2}-7)}{24\sqrt{3}} \times \frac{12}{(3-2\sqrt{2})} = \frac{(\sqrt{2}-1)}{2\sqrt{3}}.$$

$$\therefore \frac{T_2}{T_1} = \frac{T_3}{T_2} = \frac{T_4}{T_3} = \dots = \frac{(\sqrt{2}-1)}{2\sqrt{3}} \text{ (constant).}$$

So, the given progression is a GP in which  $a = 1$  and  $r = \frac{(\sqrt{2}-1)}{2\sqrt{3}}$ .

$$\begin{aligned} \therefore \text{the 5th term, } T_5 &= ar^{(5-1)} = ar^4 = 1 \times \left( \frac{\sqrt{2}-1}{2\sqrt{3}} \right)^4 \\ &= \frac{(\sqrt{2}-1)^4}{144} = \frac{(3-2\sqrt{2})^2}{144} \\ &= \frac{(17-12\sqrt{2})}{144}. \end{aligned}$$

$$\text{Hence, } T_5 = \frac{(17-12\sqrt{2})}{144}.$$



EXAMPLE The 4th, 7th and 10th terms of a GP are  $a$ ,  $b$ ,  $c$  respectively. Prove that  $b^2 = ac$ .

SOLUTION Let  $A$  be the first term and  $r$  be the common ratio of the given GP.  
Then,

$$a = Ar^{(4-1)} = Ar^3; b = Ar^{(7-1)} = Ar^6 \text{ and } c = Ar^{(10-1)} = Ar^9.$$

$$\therefore ac = (Ar^3) \times (Ar^9) = A^2 r^{12} = (Ar^6)^2 = b^2.$$

Hence,  $b^2 = ac$ .



EXAMPLE If  $a, b, c$  are three consecutive terms of an AP and  $x, y, z$  are three consecutive terms of a GP, then prove that

$$x^{(b-c)} \cdot y^{(c-a)} \cdot z^{(a-b)} = 1.$$

SOLUTION It is given that  $a, b, c$  are in AP. Let  $d$  be the common difference of this AP. Then,

$$(b-c) = -(c-b) = -d, \quad (c-a) = \{(c-b) + (b-a)\} = 2d$$

and  $(a-b) = -(b-a) = -d.$

Also,  $x, y, z$  are in GP. So,  $y = \sqrt{xz}.$

$$\begin{aligned} \therefore x^{(b-c)} \cdot y^{(c-a)} \cdot z^{(a-b)} &= x^{-d} \times (\sqrt{xz})^{2d} \times z^{-d} \\ &= x^{-d} \times (xz)^d \times z^{-d} \\ &= x^{-d} \times (xz)^d \times z^{-d} \\ &= x^{-d} \times x^d \times z^d \times z^{-d} = x^{(-d+d)} \times z^{(-d+d)} = (x^0 \times z^0) = 1. \end{aligned}$$

Hence,  $x^{(b-c)} \cdot y^{(c-a)} \cdot z^{(a-b)} = 1.$



EXAMPLE If  $a, b, c$  are in GP and  $a^{1/x} = b^{1/y} = c^{1/z}$ , prove that  $x, y, z$  are in AP.

SOLUTION Since  $a, b, c$  are in GP, we have

$$b^2 = ac.$$

Let  $a^{1/x} = b^{1/y} = c^{1/z} = k$  (say).

Then,  $a = k^x, b = k^y$  and  $c = k^z$ .

Putting these values in (i), we get

$$(k^y)^2 = (k^x) \times (k^z) \Rightarrow k^{2y} = k^{(x+z)}$$

$$\therefore 2y = x + z.$$

Hence,  $x, y, z$  are in AP.



$n^{\text{th}}$  term from the end of a G.P.  $\div$

The  $n^{\text{th}}$  term from the end of a G.P. with the first term  $a$ , the common ratio  $r$  and the last term  $l$  is given by

$$\frac{l}{r^{n-1}}$$





EXAMPLE

Show that the progression

$$1, \frac{(\sqrt{2}-1)}{2\sqrt{3}}, \frac{(3-2\sqrt{2})}{12}, \frac{(5\sqrt{2}-7)}{24\sqrt{3}}, \dots$$

is a GP. Find its 5th term.



**SOLUTION** In the given progression, we have

$$\frac{T_2}{T_1} = \left[ \frac{(\sqrt{2}-1)}{2\sqrt{3}} \times \frac{1}{1} \right] = \frac{(\sqrt{2}-1)}{2\sqrt{3}}, \frac{T_3}{T_2} = \frac{(3-2\sqrt{2})}{12} \times \frac{2\sqrt{3}}{(\sqrt{2}-1)} = \frac{(\sqrt{2}-1)}{2\sqrt{3}},$$

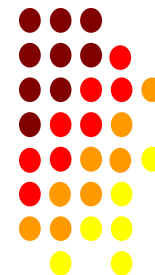
$$\frac{T_4}{T_3} = \frac{(5\sqrt{2}-7)}{24\sqrt{3}} \times \frac{12}{(3-2\sqrt{2})} = \frac{(\sqrt{2}-1)}{2\sqrt{3}}.$$

$$\therefore \frac{T_2}{T_1} = \frac{T_3}{T_2} = \frac{T_4}{T_3} = \dots = \frac{(\sqrt{2}-1)}{2\sqrt{3}} \text{ (constant).}$$

So, the given progression is a GP in which  $a = 1$  and  $r = \frac{(\sqrt{2}-1)}{2\sqrt{3}}$ .

$$\begin{aligned} \therefore \text{the 5th term, } T_5 &= ar^{(5-1)} = ar^4 = 1 \times \left[ \frac{(\sqrt{2}-1)}{2\sqrt{3}} \right]^4 \\ &= \frac{(\sqrt{2}-1)^4}{144} = \frac{(3-2\sqrt{2})^2}{144} \\ &= \frac{(17-12\sqrt{2})}{144}. \end{aligned}$$

$$\text{Hence, } T_5 = \frac{(17-12\sqrt{2})}{144}.$$



# PRACTICE QUESTIONS

1. Find the 6th and  $n$ th terms of the GP  $2, 6, 18, 54, \dots$
2. Find the 17th and  $n$ th terms of the GP  $2, 2\sqrt{2}, 4, 8\sqrt{2}, \dots$
3. Find the 7th and  $n$ th terms of the GP  $0.4, 0.8, 1.6, \dots$
4. Find the 10th and  $n$ th terms of the GP  $\frac{-3}{4}, \frac{1}{2}, \frac{-1}{3}, \frac{2}{9}, \dots$
5. Which term of the GP  $3, 6, 12, 24, \dots$  is 3072?
6. Which term of the GP  $\frac{1}{4}, \frac{-1}{2}, 1, \dots$  is  $-128$ ?
7. Which term of the GP  $\sqrt{3}, 3, 3\sqrt{3}, \dots$  is 729?



# PRACTICE QUESTIONS

8. In a GP, the ratio of the sum of first three terms is to that of first six terms is  $125 : 152$ . Find the common ratio.
9. Find the sum of the geometric series  $3 + 6 + 12 + \dots + 1536$ .



# ANSWERS

1.  $486, 2 \times 3^{(n-1)}$     2.  $512, (\sqrt{2})^{(n+1)}$     3.  $25.6, \frac{2^n}{5}$     4.  $\frac{128}{6561}, \frac{-3}{4} \times \left(\frac{-2}{3}\right)^{(n-1)}$

5. 11th

6. 10th

7. 12th



# ANSWERS

8.  $r = \frac{r\omega}{\omega}$

9. 3069

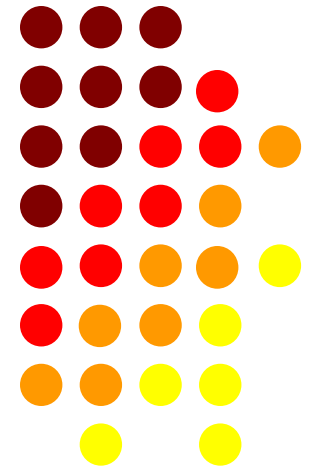


■ ***THANK YOU***



# Lecture- 13

**Sum of n terms of Geometric  
Progression(G.P) and its Infinite  
term**





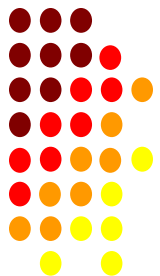
## SUM OF $n$ TERMS OF A GP

THEOREM *Prove that the sum of  $n$  terms of a GP with the first term  $a$  and the common ratio  $r$  is given by*

$$S_n = \begin{cases} na, & \text{when } r = 1; \\ \frac{a(1-r^n)}{(1-r)}, & \text{when } r < 1; \\ \frac{a(r^n-1)}{(r-1)}, & \text{when } r > 1. \end{cases}$$



EXAMPLE 1 Find the sum of 8 terms of the GP 3, 6, 12, 24, ... .



SOLUTION Here  $a = 3, r = 2 > 1$  and  $n = 8$ .

Using the formula,  $S_n = \frac{a(r^n - 1)}{(r - 1)}$ , we get

$$S_8 = \frac{3 \times (2^8 - 1)}{(2 - 1)} = 3 \times (256 - 1) = 3 \times 255 = 765.$$



EXAMPLE 2 Find the sum of the geometric series  $1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \dots$  to 12 terms.

SOLUTION Here  $a = 1$ ,  $r = \frac{1}{2} < 1$  and  $n = 12$ .

Using the formula,  $S_n = \frac{a(1-r^n)}{(1-r)}$ , we get

$$S_{12} = \frac{1 \times \left\{ 1 - \left( \frac{1}{2} \right)^{12} \right\}}{\left( 1 - \frac{1}{2} \right)} = \frac{\left( 1 - \frac{1}{2^{12}} \right)}{\left( \frac{1}{2} \right)} = \frac{(2^{12} - 1)}{2^{11}} = \frac{4095}{2048}.$$



EXAMPLE Find the sum of the series  $2 + 6 + 18 + 54 + \dots + 4374$ .

SOLUTION Clearly, the given series is a geometric series in which  $a = 2$ ,  $r = 3 > 1$  and  $l = 4374$ .

$$\therefore \text{the required sum} = \frac{(lr - a)}{(r - 1)} = \frac{(4374 \times 3 - 2)}{(3 - 1)} = \frac{13120}{2} = 6560.$$

Hence, the sum of the given series is 6560.



EXAMPLE 5 In a GP, it is being given that  $T_1 = 3$ ,  $T_n = 96$  and  $S_n = 189$ . Find the value of  $n$ .

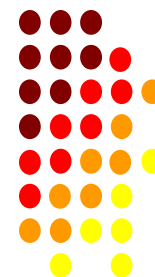
SOLUTION Here,  $a = 3$ ,  $l = 96$  and  $S_n = 189$ .

Let the common ratio of the given GP be  $r$ .

$$\begin{aligned} \text{Then, } S_n &= \frac{(lr - a)}{(r - 1)} \Rightarrow \frac{(96r - 3)}{(r - 1)} = 189 \\ &\Rightarrow (96r - 3) = (189r - 189) \\ &\Rightarrow 93r = 186 \Rightarrow r = 2. \end{aligned}$$

$$\begin{aligned} \text{Now, } l &= ar^{n-1} \Rightarrow 3 \times 2^{n-1} = 96 \\ &\Rightarrow 2^{n-1} = 32 = 2^5 \Rightarrow n - 1 = 5 \Rightarrow n = 6. \end{aligned}$$

Hence,  $n = 6$ .



EXAMPLE | Sum the series  $5 + 55 + 555 + \dots$  to  $n$  terms.

SOLUTION We have

$$\begin{aligned} & 5 + 55 + 555 + \dots \text{ to } n \text{ terms} \\ &= 5 \times \{1 + 11 + 111 + \dots \text{ to } n \text{ terms}\} \\ &= \frac{5}{9} \times \{9 + 99 + 999 + \dots \text{ to } n \text{ terms}\} \\ &= \frac{5}{9} \times \{(10 - 1) + (10^2 - 1) + (10^3 - 1) + \dots \text{ to } n \text{ terms}\} \\ &= \frac{5}{9} \times \{(10 + 10^2 + 10^3 + \dots \text{ to } n \text{ terms}) - n\} \\ &= \frac{5}{9} \times \left\{ \frac{10 \times (10^n - 1)}{(10 - 1)} - n \right\} = \frac{5}{81} \times (10^{n+1} - 9n - 10). \end{aligned}$$

Hence, the required sum is  $\frac{5}{81} \times (10^{n+1} - 9n - 10)$ .



EXAMPLE . Sum the series  $.4 + .44 + .444 + \dots$  to  $n$  terms.

SOLUTION We have

$$\begin{aligned} &.4 + .44 + .444 + \dots \text{ to } n \text{ terms} \\ &= 4 \times \{.1 + .11 + .111 + \dots \text{ to } n \text{ terms}\} \\ &= \frac{4}{9} \times \{.9 + .99 + .999 + \dots \text{ to } n \text{ terms}\} \\ &= \frac{4}{9} \times \{(1 - .1) + (1 - .01) + (1 - .001) + \dots \text{ to } n \text{ terms}\} \end{aligned}$$





$$= \frac{4}{9} \times \{(1 + 1 + \dots \text{ to } n \text{ terms}) - (.1 + .01 + .001 + \dots \text{ to } n \text{ terms})\}$$

$$= \frac{4}{9} \times \left[ n - \frac{.1 \times \{1 - (.1)^n\}}{(1 - .1)} \right] \quad \left\{ \because S_n = \frac{a(1 - r^n)}{(1 - r)} \right\}$$

$$= \frac{4}{9} \times \left[ n - \frac{\frac{1}{10} \cdot \left[ 1 - \frac{1}{(10)^n} \right]}{\left( 1 - \frac{1}{10} \right)} \right]$$

$$= \frac{4}{9} \times \left[ n - \frac{(10^n - 1)}{9 \cdot 10^n} \right] = \frac{4}{9} \times \left[ n - \frac{1}{9} \left[ 1 - \frac{1}{10^n} \right] \right]$$

$$= \frac{4}{81} \times \left[ 9n - \left[ 1 - \frac{1}{10^n} \right] \right] = \frac{4}{81} \times \left[ 9n - 1 + \frac{1}{10^n} \right].$$

Hence, the required sum is  $\frac{4}{81} \times \left( 9n - 1 + \frac{1}{10^n} \right)$ .



**SUMMARY**

Sum of an infinite GP with the first term  $a$  and the common ratio  $r$ , where  $|r| < 1$ , is given by  $S = \frac{a}{(1-r)}$ .



**EXAMPLE 1** Find the sum of the infinite geometric series  $\left(1 + \frac{1}{3} + \frac{1}{9} + \frac{1}{27} + \dots \infty\right)$ .

**SOLUTION** In the given infinite geometric series, we have

$$a = 1 \text{ and } r = \frac{1}{3} \text{ such that } |r| = \frac{1}{3} < 1.$$

Hence, the sum of the given infinite series is

$$S = \frac{a}{(1-r)} = \frac{1}{\left(1-\frac{1}{3}\right)} = \frac{1}{\left(\frac{2}{3}\right)} = \frac{3}{2}.$$

Hence, the required sum is  $\frac{3}{2}$ .



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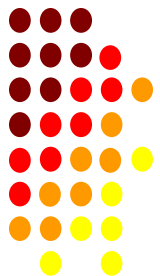
EXAMPLE 2 Find the sum of the infinite geometric series  $\left(1 - \frac{1}{3} + \frac{1}{3^2} - \frac{1}{3^3} + \dots \infty\right)$ .

SOLUTION The given series is an infinite geometric series in which

$$a = 1, r = -\frac{1}{3} \text{ and } |r| = \frac{1}{3} < 1.$$

Hence, the sum of the given infinite geometric series is

$$S = \frac{a}{(1-r)} = \frac{1}{\left(1 + \frac{1}{3}\right)} = \frac{1}{\left(\frac{4}{3}\right)} = \frac{3}{4}.$$



EXAMPLE Find the sum of the infinite geometric series

$$(\sqrt{2} + 1) + 1 + (\sqrt{2} - 1) + \dots \infty.$$

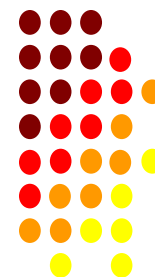
SOLUTION We have

$$\frac{1}{(\sqrt{2} + 1)} = \frac{1}{(\sqrt{2} + 1)} \times \frac{(\sqrt{2} - 1)}{(\sqrt{2} - 1)} = \frac{(\sqrt{2} - 1)}{1}.$$

So, the given series is an infinite geometric series in which  $a = (\sqrt{2} + 1)$  and  $r = (\sqrt{2} - 1) < 1$ .

Hence, the sum of the given infinite geometric series is

$$\begin{aligned} S &= \frac{a}{(1-r)} = \frac{(\sqrt{2} + 1)}{[1 - (\sqrt{2} - 1)]} = \frac{(\sqrt{2} + 1)}{(2 - \sqrt{2})} \times \frac{(2 + \sqrt{2})}{(2 + \sqrt{2})} \\ &= \frac{4 + 3\sqrt{2}}{(4 - 2)} = \frac{(4 + 3\sqrt{2})}{2}. \end{aligned}$$



EXAMPLE Prove that  $6^{1/2} \cdot 6^{1/4} \cdot 6^{1/8} \cdot \dots \infty = 6$ .

SOLUTION We observe here that  $\left(\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \dots \infty\right)$  is an infinite geometric series in which  $a = \frac{1}{2}$  and  $r = \left(\frac{1}{4} \times \frac{2}{1}\right) = \frac{1}{2}$  such that  $|r| < 1$ .

So, this sum is given by

$$S = \frac{\left(\frac{1}{2}\right)}{\left(1 - \frac{1}{2}\right)} = \frac{\left(\frac{1}{2}\right)}{\left(\frac{1}{2}\right)} = 1. \quad \dots (i)$$

$$\therefore 6^{1/2} \cdot 6^{1/4} \cdot 6^{1/8} \cdot \dots \infty = 6^{\left(\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \dots \infty\right)} = 6^1 = 6 \quad [\text{using (i)}].$$

Hence,  $6^{1/2} \cdot 6^{1/4} \cdot 6^{1/8} \cdot \dots \infty = 6$ .



# PRACTICE QUESTIONS

1. Find the sum of the GP:

- (i)  $1 + 3 + 9 + 27 + \dots$  to 7 terms
- (ii)  $1 + \sqrt{3} + 3 + 3\sqrt{3} + \dots$  to 10 terms
- (iii)  $0.15 + 0.015 + 0.0015 + \dots$  to 6 terms
- (iv)  $1 - \frac{1}{2} + \frac{1}{4} - \frac{1}{8} + \dots$  to 9 terms
- (v)  $\sqrt{2} + \frac{1}{\sqrt{2}} + \frac{1}{2\sqrt{2}} + \dots$  to 8 terms
- (vi)  $\frac{2}{9} - \frac{1}{3} + \frac{1}{2} - \frac{3}{4} + \dots$  to 6 terms

2. Find the sum of the GP:

- (i)  $\sqrt{7} + \sqrt{21} + 3\sqrt{7} + \dots$  to  $n$  terms
- (ii)  $1 - \frac{1}{3} + \frac{1}{3^2} - \frac{1}{3^3} + \dots$  to  $n$  terms
- (iii)  $1 - a + a^2 - a^3 + \dots$  to  $n$  terms ( $a \neq 1$ )



# PRACTICE QUESTIONS

- 1 Find the sum of the series:
- (i)  $8 + 88 + 888 + \dots$  to  $n$  terms
  - (ii)  $3 + 33 + 333 + \dots$  to  $n$  terms
  - (iii)  $0.7 + 0.77 + 0.777 + \dots$  to  $n$  terms





# ANSWERS

1. (i) 1093                      (ii)  $121(\sqrt{3} + 1)$                       (iii)  $\frac{333333}{2000000}$                       (iv)  $\frac{171}{256}$   
 (v)  $\frac{255\sqrt{2}}{128}$                       (vi)  $\frac{-133}{144}$

2. (i)  $\frac{\sqrt{7}}{2}(\sqrt{3} + 1)(3^{n/2} - 1)$                       (ii)  $\frac{3^n - (-1)^n}{4 \times 3^{(n-1)}}$                       (iii)  $\frac{1 - (-a)^n}{(1+a)}$



# ANSWERS

$$(i) \frac{8}{81} [10^{(n+1)} - 10 - 9n]$$

$$(ii) \frac{1}{27} [10^{(n+1)} - 10 - 9n]$$

$$(iii) \frac{7}{81} \left( 9n - 1 + \frac{1}{10^n} \right)$$



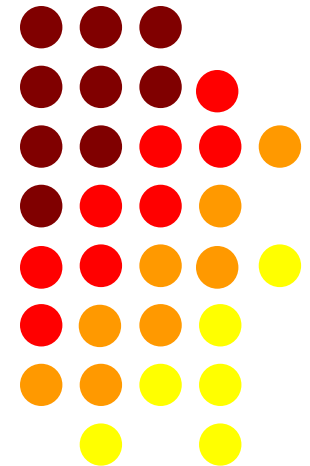
■ ***THANK YOU***



# Lecture- 14



## Sum to n terms of Special Series



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## SUM OF FIRST $n$ NATURAL NUMBERS

THEOREM 1 *Prove that*  $(1 + 2 + 3 + \dots + n) = \frac{1}{2}n(n + 1)$



Some Special Series :-

$$\textcircled{1} (1+2+3+\dots+n) = \frac{n(n+1)}{2}$$

$$\sum_{n=1}^n n = \frac{1}{2}n(n+1)$$

$$\textcircled{2} (1^2+2^2+3^2+\dots+n^2) = \frac{n}{6}(n+1)(2n+1)$$

$$\sum_{n=1}^n n^2 = \frac{n}{6}(n+1)(2n+1)$$



$$\textcircled{3} \quad (1^3 + 2^3 + 3^3 + \dots + n^3) = \left[ \frac{n}{2} (n+1) \right]^2$$
$$\sum_{n=1}^n n^3 = \left( \frac{n}{2} \right)^2 (n+1)^2$$



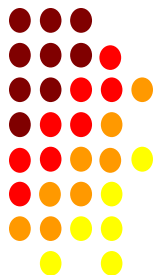
EXAMPLE 1 If  $S_1$ ,  $S_2$  and  $S_3$  are the sums of first  $n$  natural numbers, their squares and their cubes respectively then show that  $9S_2^2 = S_3(1 + 8S_1)$ .

SOLUTION We have

$$S_1 = (1 + 2 + 3 + \dots + n) \Rightarrow S_1 = \frac{1}{2}n(n+1);$$

$$S_2 = (1^2 + 2^2 + 3^2 + \dots + n^2) \Rightarrow S_2 = \frac{1}{6}n(n+1)(2n+1);$$

$$\text{and } S_3 = (1^3 + 2^3 + 3^3 + \dots + n^3) \Rightarrow S_3 = \frac{1}{4}n^2(n+1)^2.$$





$$\therefore 9S_2^2 = 9 \times \frac{1}{36} \cdot n^2(n+1)^2(2n+1)^2 = \frac{1}{4}n^2(n+1)^2(2n+1)^2.$$

$$\begin{aligned} \text{And, } S_3(1+8S_1) &= \frac{1}{4}n^2(n+1)^2 \cdot \left\{1 + 8 \cdot \frac{1}{2}n(n+1)\right\} \\ &= \frac{1}{4}n^2(n+1)^2(4n^2+4n+1) = \frac{1}{4}n^2(n+1)^2(2n+1)^2. \end{aligned}$$

$$\text{Hence, } 9S_2^2 = S_3(1+8S_1).$$



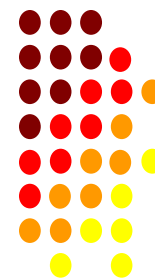
EXAMPLE Find the sum to  $n$  terms of the series whose  $n$ th term is  $(2n - 1)^2$ .

SOLUTION We have,  $T_k = (2k - 1)^2 = (4k^2 - 4k + 1)$ .

$\therefore$  sum to  $n$  terms is given by

$$\begin{aligned}
 S_n &= \sum_{k=1}^n T_k \\
 &= \sum_{k=1}^n (4k^2 - 4k + 1) = 4 \cdot \sum_{k=1}^n k^2 - 4 \cdot \sum_{k=1}^n k + n \\
 & \qquad \qquad \qquad [\because 1 + 1 + \dots n \text{ times} = n] \\
 &= 4 \cdot \frac{1}{6} n(n+1)(2n+1) - 4 \cdot \frac{1}{2} n(n+1) + n \\
 &= \frac{2}{3} n(n+1)(2n+1) - 2n(n+1) + n \\
 &= \frac{1}{3} \cdot \{2n(n+1)(2n+1) - 6n(n+1) + 3n\} \\
 &= \frac{1}{3} [n(n+1)\{2(2n+1) - 6\} + 3n] = \frac{1}{3} \cdot [4n(n+1)(n-1) + 3n] \\
 &= \frac{1}{3} (4n^3 - n) = \frac{1}{3} n(4n^2 - 1).
 \end{aligned}$$

Hence, the required sum is  $\frac{1}{3} n(4n^2 - 1)$ .



EXAMPLE Find the sum of the series  $1^2 + 3^2 + 5^2 + \dots$  to  $n$  terms.

SOLUTION We have

$$\begin{aligned} T_k &= k\text{th term of } (1^2 + 3^2 + 5^2 + \dots) \\ &= \{1 + (k-1) \times 2\}^2 = (2k-1)^2 = (4k^2 - 4k + 1). \end{aligned}$$

$$\begin{aligned} \therefore S_n &= \sum_{k=1}^n T_k \\ &= \sum_{k=1}^n (4k^2 - 4k + 1) \\ &= 4 \sum_{k=1}^n k^2 - 4 \sum_{k=1}^n k + (1 + 1 + \dots \text{ } n \text{ times}) \\ &= 4 \cdot \frac{1}{6} n(n+1)(2n+1) - 4 \cdot \frac{1}{2} n(n+1) + n \\ &= \frac{n}{3} \cdot \{2(n+1)(2n+1) - 6(n+1) + 3\} = \frac{n}{3} (4n^2 - 1). \end{aligned}$$

Hence, the required sum is  $\frac{n}{3} (4n^2 - 1)$ .



EXAMPLE Find the sum of  $n$  terms of the series

$$\frac{1}{(2 \times 5)} + \frac{1}{(5 \times 8)} + \frac{1}{(8 \times 11)} + \dots$$



SOLUTION We have

$$\begin{aligned}
 T_k &= \frac{1}{(\text{kth term of } 2, 5, 8, \dots) \times (\text{kth term of } 5, 8, 11, \dots)} \\
 &= \frac{1}{\{2 + (k-1) \times 3\} \times \{5 + (k-1) \times 3\}} \\
 &= \frac{1}{(3k-1)(3k+2)} = \frac{1}{3} \left\{ \frac{1}{(3k-1)} - \frac{1}{(3k+2)} \right\}.
 \end{aligned}$$

$$\therefore T_k = \frac{1}{3} \left\{ \frac{1}{(3k-1)} - \frac{1}{(3k+2)} \right\}. \quad \dots \text{ (i)}$$

Putting  $k = 1, 2, 3, \dots, n$  successively in (i), we get

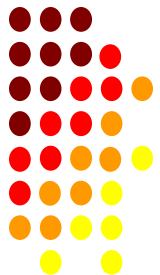
$$T_1 = \frac{1}{3} \left( \frac{1}{2} - \frac{1}{5} \right)$$

$$T_2 = \frac{1}{3} \left( \frac{1}{5} - \frac{1}{8} \right)$$

$$T_3 = \frac{1}{3} \left( \frac{1}{8} - \frac{1}{11} \right)$$

... ..

$$T_n = \frac{1}{3} \left\{ \frac{1}{(3n-1)} - \frac{1}{(3n+2)} \right\}.$$



$$T_3 = \frac{1}{3} \left( \frac{1}{8} - \frac{1}{11} \right)$$

.... ..  
.... ..

$$T_n = \frac{1}{3} \left\{ \frac{1}{(3n-1)} - \frac{1}{(3n+2)} \right\}.$$

Adding columnwise, we get

$$\begin{aligned} S_n &= (T_1 + T_2 + T_3 + \dots + T_n) \\ &= \frac{1}{3} \left( \frac{1}{2} - \frac{1}{3n+2} \right) = \frac{n}{2(3n+2)}. \end{aligned}$$



# PRACTICE QUESTIONS

**QUES-01**

$$1 \times 2^2 + 3 \times 3^2 + 5 \times 4^2 + \dots \text{ to } n \text{ terms}$$

**QUES-02**

$$3 \times 1^2 + 5 \times 2^2 + 7 \times 3^2 + \dots \text{ to } n \text{ terms}$$

**QUES-03**

$$\frac{1}{(1 \times 2)} + \frac{1}{(2 \times 3)} + \frac{1}{(3 \times 4)} + \dots \text{ to } n \text{ terms}$$

**QUES-04**

$$\frac{1}{(1 \times 3)} + \frac{1}{(3 \times 5)} + \frac{1}{(5 \times 7)} + \dots + \frac{1}{(2n-1)(2n+1)}$$



# ANSWERS

**ANS-01**

$$\frac{n}{2}(n^3 + 4n^2 + 4n - 1)$$

**ANS-02**

$$\frac{n(n+1)(3n^2 + 5n + 1)}{6}$$

**ANS-03**

$$\frac{n}{(n+1)}$$

**ANS-04**

$$\frac{n}{(2n+1)}$$





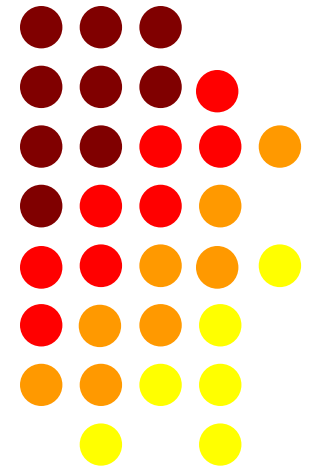
**THANK YOU**



# Lecture-15,16



## Relation between A.M. and G.M



Relation between A.M and G.M:-

IF  $A$  and  $G$  are respectively the arithmetic and geometric means between two distinct positive numbers  $a$  and  $b$  then

$$A > G$$



Q-1 Find two positive numbers whose difference is 12 and whose A.M exceed the G.M by 2. [2011-12]



Sol. Let the positive numbers be  $a$  &  $b$

Given as  $a - b = 12 \rightarrow$  ①

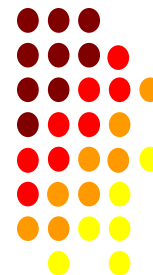
$$\text{A.M of } a \text{ \& } b = \text{G.M of } a \text{ \& } b + 2$$

$$\frac{a+b}{2} = \sqrt{ab} + 2$$

$$\frac{a+b}{2} - 2 = \sqrt{ab}$$

$$\frac{a+b-4}{2} = \sqrt{ab}$$

By ①



$$\frac{a+b-4}{2} = \sqrt{ab}$$

By ①

$$\frac{12+b+b-4}{2} = \sqrt{(12+b) \cdot b}$$

$$a = 12+b$$

$$\frac{8+2b}{2} = \sqrt{12b+b^2}$$

$$4+b = \sqrt{12b+b^2}$$

$$(4+b)^2 = 12b+b^2$$



$$16 + \cancel{b^2} + 8b = 12b + \cancel{b^2}$$

$$\Rightarrow 16 = 4b$$

$$\Rightarrow b = 4$$

$$\text{By } \textcircled{1} \quad a = 12 + b = 12 + 4 = 16 \text{ Ans}$$



EXAMPLE Find two positive numbers  $a$  and  $b$  whose AM and GM are 34 and 16 respectively.

SOLUTION We have

$$\frac{a+b}{2} = 34 \text{ and } \sqrt{ab} = 16$$

$$\Rightarrow a + b = 68 \text{ and } ab = 256$$

$$\Rightarrow (a - b) = \sqrt{(a + b)^2 - 4ab} = \sqrt{(68)^2 - 4 \times 256} = \sqrt{3600} = \pm 60$$

$$\Rightarrow a + b = 68 \text{ and } a - b = \pm 60$$

$$\Rightarrow (a + b = 68, a - b = 60) \text{ or } (a + b = 68, a - b = -60)$$

$$\Rightarrow (a = 64, b = 4) \text{ or } (a = 4, b = 64)$$

Hence, the required numbers are  $(a = 64, b = 4)$  or  $(a = 4, b = 64)$ .





Some Special Series :-

$$\textcircled{1} (1+2+3+\dots+n) = \frac{n(n+1)}{2}$$

$$\sum_{n=1}^n n = \frac{1}{2}n(n+1)$$

$$\textcircled{2} (1^2+2^2+3^2+\dots+n^2) = \frac{n}{6}(n+1)(2n+1)$$

$$\sum_{n=1}^n n^2 = \frac{n}{6}(n+1)(2n+1)$$



$$\textcircled{3} \quad (1^3 + 2^3 + 3^3 + \dots + n^3) = \left[ \frac{n}{2} (n+1) \right]^2$$
$$\sum_{n=1}^n n^3 = \left( \frac{n}{2} \right)^2 (n+1)^2$$



EXAMPLE 1 *If  $S_1$ ,  $S_2$  and  $S_3$  are the sums of first  $n$  natural numbers, their squares and their cubes respectively then show that  $9S_2^2 = S_3(1 + 8S_1)$ .*

SOLUTION We have

$$S_1 = (1 + 2 + 3 + \dots + n) \Rightarrow S_1 = \frac{1}{2}n(n+1);$$

$$S_2 = (1^2 + 2^2 + 3^2 + \dots + n^2) \Rightarrow S_2 = \frac{1}{6}n(n+1)(2n+1);$$

$$\text{and } S_3 = (1^3 + 2^3 + 3^3 + \dots + n^3) \Rightarrow S_3 = \frac{1}{4}n^2(n+1)^2.$$



$$\therefore 9S_2^2 = 9 \times \frac{1}{36} \cdot n^2(n+1)^2(2n+1)^2 = \frac{1}{4}n^2(n+1)^2(2n+1)^2.$$

$$\begin{aligned} \text{And, } S_3(1+8S_1) &= \frac{1}{4}n^2(n+1)^2 \cdot \left\{1 + 8 \cdot \frac{1}{2}n(n+1)\right\} \\ &= \frac{1}{4}n^2(n+1)^2(4n^2+4n+1) = \frac{1}{4}n^2(n+1)^2(2n+1)^2. \end{aligned}$$

$$\text{Hence, } 9S_2^2 = S_3(1+8S_1).$$



EXAMPLE

Sum the series  $3 \cdot 8 + 6 \cdot 11 + 9 \cdot 14 + \dots$  to  $n$  terms.

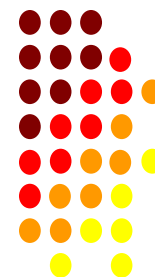
SOLUTION

We have

$$\begin{aligned} T_k &= (\text{kth term of } 3, 6, 9, \dots) \times (\text{kth term of } 8, 11, 14, \dots) \\ &= \{3 + (k-1) \times 3\} \times \{8 + (k-1) \times 3\} = 3k(3k+5) \\ &= (9k^2 + 15k). \end{aligned}$$

$$\begin{aligned} \therefore S_n &= \sum_{k=1}^n T_k \\ &= \sum_{k=1}^n (9k^2 + 15k) = 9 \left( \sum_{k=1}^n k^2 \right) + 15 \left( \sum_{k=1}^n k \right) \\ &= 9 \cdot \left\{ \frac{1}{6} n(n+1)(2n+1) \right\} + 15 \cdot \left\{ \frac{1}{2} n(n+1) \right\} \\ &= \frac{3}{2} n(n+1) \{(2n+1) + 5\} = 3n(n+1)(n+3). \end{aligned}$$

Hence, the required sum is  $3n(n+1)(n+3)$ .



EXAMPLE Find the sum to  $n$  terms of the series whose  $n$ th term is  $(2n - 1)^2$ .

SOLUTION We have,  $T_k = (2k - 1)^2 = (4k^2 - 4k + 1)$ .

$\therefore$  sum to  $n$  terms is given by

$$\begin{aligned}
 S_n &= \sum_{k=1}^n T_k \\
 &= \sum_{k=1}^n (4k^2 - 4k + 1) = 4 \cdot \sum_{k=1}^n k^2 - 4 \cdot \sum_{k=1}^n k + n \\
 &\qquad\qquad\qquad [\because 1 + 1 + \dots n \text{ times} = n] \\
 &= 4 \cdot \frac{1}{6} n(n+1)(2n+1) - 4 \cdot \frac{1}{2} n(n+1) + n \\
 &= \frac{2}{3} n(n+1)(2n+1) - 2n(n+1) + n \\
 &= \frac{1}{3} \cdot \{2n(n+1)(2n+1) - 6n(n+1) + 3n\} \\
 &= \frac{1}{3} [n(n+1)\{2(2n+1) - 6\} + 3n] = \frac{1}{3} \cdot [4n(n+1)(n-1) + 3n] \\
 &= \frac{1}{3} (4n^3 - n) = \frac{1}{3} n(4n^2 - 1).
 \end{aligned}$$

Hence, the required sum is  $\frac{1}{3} n(4n^2 - 1)$ .



EXAMPLE Sum the series  $1 \cdot 2 \cdot 3 + 2 \cdot 3 \cdot 4 + 3 \cdot 4 \cdot 5 + \dots$  to  $n$  terms.

SOLUTION We have

$$\begin{aligned} T_k &= (\text{kth term of } 1, 2, 3, \dots) \times (\text{kth term of } 2, 3, 4, \dots) \\ &\quad \times (\text{kth term of } 3, 4, 5, \dots) \\ &= \{1 + (k-1) \times 1\} + \{2 + (k-1) \times 1\} \times \{3 + (k-1) \times 1\} \\ &= k(k+1)(k+2) = (k^3 + 3k^2 + 2k). \end{aligned}$$

$$\therefore S_n = \sum_{k=1}^n T_k$$



$$\begin{aligned}\therefore S_n &= \sum_{k=1}^n T_k \\ &= \sum_{k=1}^n (k^3 + 3k^2 + 2k) = \sum_{k=1}^n k^3 + 3 \sum_{k=1}^n k^2 + 2 \sum_{k=1}^n k \\ &= \frac{1}{4}n^2(n+1)^2 + 3 \cdot \frac{1}{6}n(n+1)(2n+1) + 2 \cdot \frac{1}{2}n(n+1) \\ &\quad \left\{ \because \sum_{k=1}^n k^3 = \left[ \frac{1}{2}n(n+1) \right]^2, \sum_{k=1}^n k^2 = \frac{1}{6}n(n+1)(2n+1), \right. \\ &\quad \left. \sum_{k=1}^n k = \frac{1}{2}n(n+1) \right\} \\ &= \frac{1}{4}n(n+1) \{n(n+1) + 2(2n+1) + 4\}\end{aligned}$$





$$= \frac{1}{4}n(n+1)(n^2+5n+6) = \frac{1}{4}n(n+1)(n+2)(n+3).$$

Hence, the required sum is  $\frac{1}{4}n(n+1)(n+2)(n+3)$ .



EXAMPLE Find the sum of the series  $1^2 + 3^2 + 5^2 + \dots$  to  $n$  terms.

SOLUTION We have

$$\begin{aligned} T_k &= k\text{th term of } (1^2 + 3^2 + 5^2 + \dots) \\ &= \{1 + (k-1) \times 2\}^2 = (2k-1)^2 = (4k^2 - 4k + 1). \end{aligned}$$

$$\begin{aligned} \therefore S_n &= \sum_{k=1}^n T_k \\ &= \sum_{k=1}^n (4k^2 - 4k + 1) \\ &= 4 \sum_{k=1}^n k^2 - 4 \sum_{k=1}^n k + (1 + 1 + \dots \text{ } n \text{ times}) \\ &= 4 \cdot \frac{1}{6} n(n+1)(2n+1) - 4 \cdot \frac{1}{2} n(n+1) + n \\ &= \frac{n}{3} \cdot \{2(n+1)(2n+1) - 6(n+1) + 3\} = \frac{n}{3} (4n^2 - 1). \end{aligned}$$

Hence, the required sum is  $\frac{n}{3} (4n^2 - 1)$ .



EXAMPLE Find the sum of  $n$  terms of the series

$$\frac{1}{(2 \times 5)} + \frac{1}{(5 \times 8)} + \frac{1}{(8 \times 11)} + \dots$$



SOLUTION We have

$$\begin{aligned}
 T_k &= \frac{1}{(\text{kth term of } 2, 5, 8, \dots) \times (\text{kth term of } 5, 8, 11, \dots)} \\
 &= \frac{1}{\{2 + (k-1) \times 3\} \times \{5 + (k-1) \times 3\}} \\
 &= \frac{1}{(3k-1)(3k+2)} = \frac{1}{3} \left\{ \frac{1}{(3k-1)} - \frac{1}{(3k+2)} \right\}.
 \end{aligned}$$

$$\therefore T_k = \frac{1}{3} \left\{ \frac{1}{(3k-1)} - \frac{1}{(3k+2)} \right\}. \quad \dots \text{ (i)}$$

Putting  $k = 1, 2, 3, \dots, n$  successively in (i), we get

$$\begin{aligned}
 T_1 &= \frac{1}{3} \left( \frac{1}{2} - \frac{1}{5} \right) \\
 T_2 &= \frac{1}{3} \left( \frac{1}{5} - \frac{1}{8} \right) \\
 T_3 &= \frac{1}{3} \left( \frac{1}{8} - \frac{1}{11} \right) \\
 \dots & \quad \dots \quad \dots \quad \dots \\
 \dots & \quad \dots \quad \dots \quad \dots \\
 T_n &= \frac{1}{3} \left\{ \frac{1}{(3n-1)} - \frac{1}{(3n+2)} \right\}.
 \end{aligned}$$



$$T_3 = \frac{1}{3} \left( \frac{1}{8} - \frac{1}{11} \right)$$

.... ..  
.... ..

$$T_n = \frac{1}{3} \left\{ \frac{1}{(3n-1)} - \frac{1}{(3n+2)} \right\}.$$

Adding columnwise, we get

$$\begin{aligned} S_n &= (T_1 + T_2 + T_3 + \dots + T_n) \\ &= \frac{1}{3} \left( \frac{1}{2} - \frac{1}{3n+2} \right) = \frac{n}{2(3n+2)}. \end{aligned}$$



# PRACTICE QUESTIONS

**QUES-01**

$$1 \times 2^2 + 3 \times 3^2 + 5 \times 4^2 + \dots \text{ to } n \text{ terms}$$

**QUES-02**

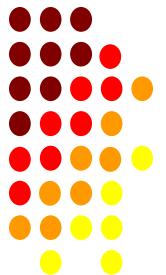
$$3 \times 1^2 + 5 \times 2^2 + 7 \times 3^2 + \dots \text{ to } n \text{ terms}$$

**QUES-03**

$$\frac{1}{(1 \times 2)} + \frac{1}{(2 \times 3)} + \frac{1}{(3 \times 4)} + \dots \text{ to } n \text{ terms}$$

**QUES-04**

$$\frac{1}{(1 \times 3)} + \frac{1}{(3 \times 5)} + \frac{1}{(5 \times 7)} + \dots + \frac{1}{(2n-1)(2n+1)}$$



# ANSWERS

**ANS-01**

$$\frac{n}{2}(n^3 + 4n^2 + 4n - 1)$$

**ANS-02**

$$\frac{n(n+1)(3n^2 + 5n + 1)}{6}$$

**ANS-03**

$$\frac{n}{(n+1)}$$

**ANS-04**

$$\frac{n}{(2n+1)}$$



**THANK YOU**

