Arithmetic sequences and series Lesson #24

LC33011 #24

MAT 1375 Precalculus

New York City College of Technology CUNY



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MAT 1375 - Precalculus

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Definition

A sequence is an ordered list of numbers.

 $a_1, a_2, a_3, a_4, a_5, \ldots$

Here a_1 is the first number, a_2 is the second number, a_3 is the third number, etc.

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Examples of sequences:

- 5, 8, 11, 14, 17, 20, 23, ...
- 3, 6, 12, 24, 48, 96, 192, ...
- 1, 4, 9, 16, 25, 36, 49, ...

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- 7, -3.6, $\sqrt{2}$, $\frac{2}{3}$, π , -22, ...

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- $1, 1, 2, 3, 5, 8, 13, 21, 34, \ldots$

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- 1, 1, 2, 3, 5, 8, 13, 21, 34, ...
 (Fibonacci sequence)

Find the first 5 terms of the

sequence:

1 $a_n = 4n + 5$

- **2** $a_n = \sqrt{2n+3}$
- **3** $a_n = n^2$
- **4** $a_n = \frac{n+2}{n+3}$

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- 1, 1, 2, 3, 5, 8, 13, 21, 34, ...
 (Fibonacci sequence)

Find the first 5 terms of the

sequence:

- $a_n = 4n + 5$ $9, 13, 17, 21, 25, \dots$
- $a_n = \sqrt{2n+3}$
- **3** $a_n = n^2$
- **4** $a_n = \frac{n+2}{n+3}$

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Examples of sequences:

- 5, 8, 11, 14, 17, 20, 23, ... (arithmetic sequence) (arithmetic sequence) (arithmetic sequence) (arithmetic sequence) (arithmetic sequence) (b) $a_n = 4n + 5$ $a_1 = 5, a_2 = 8, a_3 = 11$
- 3, 6, 12, 24, 48, 96, 192, ... (geometric sequence)
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- 1, 1, 2, 3, 5, 8, 13, 21, 34, ... (Fibonacci sequence)

Find the first 5 terms of the

sequence:

9, 13, 17, 21, 25, ...

a_n =
$$\sqrt{2n+3}$$

 $\sqrt{5}, \sqrt{7}, 3, \sqrt{11}, \sqrt{13}, \dots$

$$a_n = n^2$$

4
$$a_n = \frac{n+2}{n+3}$$

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- **3**, 6, 12, 24, 48, 96, 192, ... (geometric sequence)
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- 1.1.2.3.5.8.13.21.34... (Fibonacci sequence)

Find the first 5 terms of the sequence:

2
$$a_n = \sqrt{2n+3}$$

 $\sqrt{5}, \sqrt{7}, 3, \sqrt{11}, \sqrt{13}, \dots$

$$a_n = n^2 1, 4, 9, 16, 25, \dots$$

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$$a_n = \frac{n+2}{n+3}$$

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- 1, 1, 2, 3, 5, 8, 13, 21, 34, ...
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 $a_n = 4n + 5$ $9, 13, 17, 21, 25, \dots$ $a_n = \sqrt{2n + 3}$ $\sqrt{5}, \sqrt{7}, 3, \sqrt{11}, \sqrt{13}, \dots$ $a_n = n^2$ $1, 4, 9, 16, 25, \dots$ $a_n = \frac{n+2}{n+3}$ $\frac{3}{4}, \frac{4}{5}, \frac{5}{6}, \frac{6}{7}, \frac{7}{8}, \dots$

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Find the first 5 terms of the sequence:

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- $a_n = \frac{n+2}{n+3}$ $\frac{3}{4}, \frac{4}{5}, \frac{5}{6}, \frac{6}{7}, \frac{7}{8}, \dots$

Find the first 6 terms of the sequence given by the recursive rule.

$$a_1 = 5, \quad a_n = 2 \cdot a_{n-1}$$

 $a_1 = 2, \quad a_n = a_{n-1} + 6$

$$a_1 = 1, a_2 = 1 a_n = a_{n-1} + a_{n-2}$$

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- **a**_n = $\sqrt{2n+3}$ $\sqrt{5}, \sqrt{7}, 3, \sqrt{11}, \sqrt{13}, \dots$
- $a_n = n^2$ $1, 4, 9, 16, 25, \dots$
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Find the first 6 terms of the sequence given by the recursive rule.

• $a_1 = 5$, $a_n = 2 \cdot a_{n-1}$ 5, 10, 20, 40, 80, 160 . . . (geometric sequence)

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$$a_1 = 1, a_2 = 1$$

 $a_n = a_{n-1} + a_{n-2}$
 $1, 1, 2, 3, 5, 8 \dots$
(Fibonacci sequence)

Arithmetic sequence

An **arithmetic sequence** is a sequence where each term follows from its previous term by adding a fixed number *d*:



d is called the **common difference**.

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Example

• Find the first 5 terms of the sequence $a_n = 7 + (n-1) \cdot 3$.

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Example

• Find the first 5 terms of the sequence $a_n = 7 + (n-1) \cdot 3$. Answer: 7, 10, 13, 16, 19, ...

This is an arithmetic sequence with first term $a_1 = 7$ and common difference d = 3.

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Solution Find the rule of the arithmetic sequence: 6, 11, 16, 21, 26, 31, ...

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Find the rule of the arithmetic sequence: 6, 11, 16, 21, 26, 31, ...
Answer:

$$a_n=6+(n-1)\cdot 5$$

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Arithmetic sequence

An **arithmetic sequence** is a sequence where each term follows from its previous term by adding a fixed number *d*:

$$\xrightarrow{a_1} \xrightarrow{a_2} \xrightarrow{a_3} \xrightarrow{a_4} \xrightarrow{a_5} \cdots$$

d is called the **common difference**. An arithmetic sequence has the closed form formula:

$$a_n = a_1 + (n-1) \cdot d$$

Example

• Find the first 5 terms of the sequence $a_n = 7 + (n-1) \cdot 3$. Answer: 7, 10, 13, 16, 19, ...

This is an arithmetic sequence with first term $a_1 = 7$ and common difference d = 3.

Find the rule of the arithmetic sequence: 6, 11, 16, 21, 26, 31, ...
Answer:

$$a_n=6+(n-1)\cdot 5$$

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 $a_n = a_1 + (n-1) \cdot d$

Find the closed form formula for the given arithmetic sequence.

- **9** 8, 14, 20, 26, . . .
- 15, 22, 29, 36, . . .
- $3 13, 10, 7, 4, 1, -2, -5, \ldots$
- \bigcirc -19, -11, -3, 5, 13, 21, ...

 $a_n = a_1 + (n-1) \cdot d$

Find the closed form formula for the given arithmetic sequence.

- **3** 8, 14, 20, 26, ... $a_n = 8 + (n-1) \cdot 6$
- 2 15, 22, 29, 36, ...
- $3 13, 10, 7, 4, 1, -2, -5, \ldots$
- $\textcircled{9} -19, -11, -3, 5, 13, 21, \ldots$

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- **3** 8, 14, 20, 26, ... $a_n = 8 + (n-1) \cdot 6$
- 2 $15, 22, 29, 36, \dots$ $a_n = 15 + (n-1) \cdot 7$
- $\textcircled{3} 13, 10, 7, 4, 1, -2, -5, \ldots$
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- 3 $13, 10, 7, 4, 1, -2, -5, \dots$ $a_n = 13 + (n-1) \cdot (-3)$
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Find the closed form formula for the given arithmetic sequence.

- $\begin{array}{l} \bullet & 8, 14, 20, 26, \dots \\ & a_n = 8 + (n-1) \cdot 6 \end{array}$
- 2 $15, 22, 29, 36, \dots$ $a_n = 15 + (n-1) \cdot 7$
- 3 13, 10, 7, 4, 1, $-2, -5, \dots$ $a_n = 13 + (n-1) \cdot (-3)$
- $-19, -11, -3, 5, 13, 21, \dots$ $a_n = -19 + (n-1) \cdot 8$

 $a_n = a_1 + (n-1) \cdot d$

Find the closed form formula for the given arithmetic sequence.

- 8, 14, 20, 26, ... $a_n = 8 + (n-1) \cdot 6$
- (a) $15, 22, 29, 36, \dots$ $a_n = 15 + (n-1) \cdot 7$
- 3 $13, 10, 7, 4, 1, -2, -5, \dots$ $a_n = 13 + (n-1) \cdot (-3)$
- $-19, -11, -3, 5, 13, 21, \dots$ $a_n = -19 + (n-1) \cdot 8$

Find the stated term of the given arithmetic sequence.

- 500th term of 8, 12, 16, 20, 24, ...
- **2** 444th term of 4,7,10,13,16,...
- **3** 57th term of $5, -1, -7, -13, -20, \ldots$
- \bigcirc 1234th term of $-5, -7, -9, -11, -13, \ldots$

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 $a_n = a_1 + (n-1) \cdot d$

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- 8, 14, 20, 26, ... $a_n = 8 + (n-1) \cdot 6$
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- 3 $13, 10, 7, 4, 1, -2, -5, \dots$ $a_n = 13 + (n-1) \cdot (-3)$
- $-19, -11, -3, 5, 13, 21, \dots$ $a_n = -19 + (n-1) \cdot 8$

Find the stated term of the given arithmetic sequence.

- 500th term of 8,12,16,20,24,... $a_n = 8 + (n-1) \cdot 4$ $\Rightarrow a_{500} = 8 + 499 \cdot 4 = 2004$
- **2** 444th term of 4,7,10,13,16,...
- **③** 57th term of $5, -1, -7, -13, -20, \ldots$
- \bigcirc 1234th term of $-5, -7, -9, -11, -13, \ldots$

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 $a_n = a_1 + (n-1) \cdot d$

Find the closed form formula for the given arithmetic sequence.

- 8, 14, 20, 26, ... $a_n = 8 + (n-1) \cdot 6$
- 2 $15, 22, 29, 36, \dots$ $a_n = 15 + (n-1) \cdot 7$
- $\begin{array}{l} \bullet \quad 13, 10, 7, 4, 1, -2, -5, \ldots \\ a_n = 13 + (n-1) \cdot (-3) \end{array}$
- $-19, -11, -3, 5, 13, 21, \dots$ $a_n = -19 + (n-1) \cdot 8$

Find the stated term of the given arithmetic sequence.

- 500th term of 8,12,16,20,24,... $a_n = 8 + (n-1) \cdot 4$ $\Rightarrow a_{500} = 8 + 499 \cdot 4 = 2004$
- ② 444th term of 4,7,10,13,16,... $a_n = 4 + (n-1) \cdot 3$ ⇒ $a_{444} = 4 + 443 \cdot 3 = 1333$
- **③** 57th term of 5, -1, -7, -13, -20, ... $a_n = 5 + (n - 1) \cdot (-6)$ ⇒ $a_{57} = 5 + 56 \cdot (-6) = -331$
- 1234th term of $-5, -7, -9, -11, -13, \dots$ $a_n = -5 + (n-1) \cdot (-2)$ $\Rightarrow a_{1234} = -5 + 1233 \cdot (-2) = -2471$

Definition

A series is a sum of terms in a sequence. We use the following \sum "sigma" notation:

$$\sum_{n=1}^{p} a_n = a_1 + \dots + a_p$$

More generally:

$$\sum_{n=m}^{p} a_n = a_m + \cdots + a_p.$$

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$$\sum_{n=1}^{4} (2n+3) =$$

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$$\sum_{n=1}^{5} (n^2 + 2n) =$$

$$\sum_{n=1}^{6} (9-n) = \sum_{n=1}^{4} \frac{2}{n+3} =$$

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= 5+7+9+11
= 32

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$$\begin{array}{l}
\bullet \quad \sum_{n=1}^{5} (9-n) = \\
= 8+7+6+5+4+3 \\
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$$= (1+2) + (4+4) + (9+6) + (16+8) + (25+10) =$$

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$$\sum_{n=1}^{4} \frac{2}{n+3} =$$

$$= \frac{2}{4} + \frac{2}{5} + \frac{2}{6} + \frac{2}{7} = \frac{1}{2} + \frac{2}{5} + \frac{1}{3} + \frac{2}{7} =$$

$$= \frac{105+84+70+60}{2\cdot5\cdot3\cdot7} = \frac{319}{210}$$

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Find the sum of the first 100 terms of $2, 4, 6, 8, 10, 12, \ldots$

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Answer: Use the "Gauss trick" (Carl Friedrich Gauss, 1777-1855):

2	+4	+6	 +196	+198	+200
200	+198	+196	 +6	+4	+2
202	+202	+202	 +202	+202	+202

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Therefore:
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Arithmetic series

For any arithmetic sequence $a_n = a_1 + (n-1) \cdot d$ the sum of the first p terms is

$$\sum_{n=1}^p a_n = \frac{p}{2} \cdot (a_1 + a_p)$$

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Arithmetic series For $a_n = a_1 + (n - 1) \cdot d$: $\sum_{n=1}^{p} a_n = \frac{p}{2} \cdot (a_1 + a_p)$

• Find $\sum_{n=1}^{300} (7 + (n-1) \cdot 5)$

Find the sum of the given arithmetic sequence. Sum the first 97 terms of 11, 15, 19, 23, ...

2 Sum the first 234 terms of
$$-17, -5, 7, 19, ...$$

2 Find
$$\sum_{n=1}^{555} (-3n+9)$$

Arithmetic series

For

$$a_n = a_1 + (n-1) \cdot d$$
:
 $\sum_{n=1}^p a_n = \frac{p}{2} \cdot (a_1 + a_p)$

Find the sum of the given arithmetic sequence. Sum the first 97 terms of 11, 15, 19, 23,...

• Find
$$\sum_{n=1}^{\infty} (7 + (n-1) \cdot 5)$$

 $p = 300, \quad a_1 = 7,$
 $a_{300} = 7 + 299 \cdot 5 = 1502$

Sum the first 234 terms of $-17, -5, 7, 19, \ldots$

 \bigcirc Sum the first 500 terms of 18, 13, 8, 3, $-2, \ldots$

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2 Find
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300

Arithmetic series

For

$$a_n=a_1+(n-1)\cdot d:$$

$$\boxed{\sum_{n=1}^p a_n=rac{p}{2}\cdot(a_1+a_p)}$$

1 Find $\sum_{n=1}^{\infty} (7 + (n-1) \cdot 5)$

 $=\frac{300}{2} \cdot (7+1502) = 226,350$

 $p = 300, \quad a_1 = 7, \\ a_{300} = 7 + 299 \cdot 5 = 1502 \\ \Rightarrow \sum_{n=0}^{300} (7 + (n-1) \cdot 5)$

2 Find $\sum_{n=1}^{555} (-3n+9)$

Find the sum of the given arithmetic sequence.

Sum the first 97 terms of 11, 15, 19, 23, ...

2 Sum the first 234 terms of $-17, -5, 7, 19, \ldots$

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Find
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 $p = 555, \quad a_1 = 6,$
 $a_{555} = -3 \cdot 555 + 9 = -1656$

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Arithmetic series

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p = 300. $a_1 = 7$. $a_{300} = 7 + 299 \cdot 5 = 1502$ $\Rightarrow \sum^{300} (7 + (n-1) \cdot 5)$

c . .

Sum the first 97 terms of 11, 15, 19, 23, ... We need $\sum_{n=1}^{97} a_n$ for $a_n = 11 + (n-1) \cdot 4$. $p = 97, a_1 = 11, a_{97} = 11 + 96 \cdot 4 = 395$

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- Sum the first 500 terms of 18, 13, 8, 3, -2, ...We need $\sum_{n=1}^{500} a_n$ for $a_n = 18 + (n-1) \cdot (-5)$. $p = 500, a_1 = 18, a_{500} = 18 + 499 \cdot (-5) = -2,477$

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24. Arithmetic sequences and series

7/8

For
$$a_n = a_1 + (n-1) \cdot d$$
:
$$\sum_{n=1}^p a_n = \frac{p}{2} \cdot (a_1 + a_p)$$

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- Sum the first 234 terms of −17, −5, 7, 19, ...
 We need ∑_{n=1}²³⁴ a_n for a_n = −17 + (n − 1) · 12.
 p = 234, a₁ = −17, a₂₃₄ = −17 + 233 · 12 = 2,779
 ⇒ ∑_{n=1}²³⁴ a_n = ²³⁴/₂ · (−17 + 2779) = 323, 154
- Sum the first 500 terms of 18, 13, 8, 3, -2, ... We need $\sum_{n=1}^{500} a_n$ for $a_n = 18 + (n-1) \cdot (-5)$. $p = 500, a_1 = 18, a_{500} = 18 + 499 \cdot (-5) = -2,477$ $\Rightarrow \sum_{n=1}^{500} a_n = \frac{500}{2} \cdot (18 + (-2,477)) = -614,750$

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MAT 1375 - Precalculus

24. Arithmetic sequences and series 8/8

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