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Recursive Forms:

[To see these examples with "explicit forms" (instead of "recursive") go to Sequences as Functions - Explicit]

Certain sequences (not all) can be defined (expressed) in a "recursive" form.

In a recursive formula, each term is defined as a function of its preceding term(s).

[Each term is found by doing something to the term(s) immediately in front of that term.]

A recursive formula designates the starting term, a_1 , and the n^{th} term of the sequence, a_n , as an expression containing the previous term (the term before it), a_{n-1} .

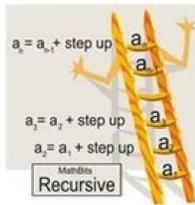
The process of recursion can be thought of as climbing a ladder. To get to the third rung, you must step on the second rung. Each rung on the ladder depends upon stepping on the rung below it. You start on the first rung of the ladder, a_1 .

From the first rung, you move to the second rung, a_2 .

$$a_2 = a_1 + \text{"step up"}$$

From the second rung, you move to the third rung, a_3 .

$$a_3 = a_2 + \text{"step up"}$$



If you are on the n^{th} rung, you must have stepped on the $(n-1)^{\text{th}}$ rung. $a_n = a_{n-1} + \text{"step up"}$

Notation: Recursive forms work with the term(s) immediately in front of the term being examined. The table at the right shows that there are many options as to how this relationship may be expressed in notations.

Given Term	Term in front of Given Term
a_4	a_3
a_n	a_{n-1}
a_{n+1}	a_n
a_{n+4}	a_{n+3}
$f(6)$	$f(5)$
$f(n)$	$f(n-1)$
$f(n+1)$	$f(n)$

A recursive formula is written with two parts: a statement of the first term along with a statement of the formula relating successive terms.

The statements below are all naming the same sequence:

$$\left. \begin{array}{l} a_1 = 1; a_n = a_{n-1} + 4 \\ a_1 = 1; a_{n+1} = a_n + 4 \\ f(1) = 1; f(n) = f(n-1) + 4 \\ f(1) = 1; f(n+1) = f(n) + 4 \end{array} \right\} \begin{array}{l} \text{Be aware} \\ \text{of various} \\ \text{options!} \end{array}$$

Given a term in an arithmetic sequence and the common difference find the recursive formula and the three terms in the sequence after the last one given.

23) $a_n = -1.4, d = 0.6$ 24) $a_n = -44, d = -2$

$a_{22} = -1.4 + .6 = -.8$
 $a_{23} = -.8 + .6 = -.2$
 $a_{24} = -.2 + .6 = .4$

$a_n = a_{n-1} + .6$ for $n \geq 2$

$a_{21} = a_1 + 20(.6)$
 $-1.4 = a_1 + 12$
 -12

In the next example, we will find the next three terms of an arithmetic sequence.

Example 2: Finding Consecutive Terms of an Arithmetic Sequence

Write the next 3 terms in the arithmetic sequence 12, 19, 26, 33, _____

Answer

In this example, we need to find the next 3 terms of a given arithmetic sequence. Recall that an arithmetic sequence is a sequence in which the difference between any two consecutive terms is always the same. The difference between any two consecutive terms of an arithmetic sequence is called the common difference. To find the next term in the arithmetic sequence, we can add the common difference to the previous term. Let's begin by finding the common difference.

To find the common difference, we can find the difference of any two consecutive terms. For instance, the difference between the first two terms is given by

$$19 - 12 = 7.$$

This tells us that the common difference of this arithmetic sequence is equal to 7. We can verify this by checking whether the next term can be obtained by adding 7 to the previous term:

$$19 + 7 = 26,$$

$$26 + 7 = 33.$$

We can see that adding 7 to the second term produces the third term, and adding 7 to the third term produces the fourth term. This verifies that 7 is the common difference.

We can find the fourth, fifth, and sixth term of this sequence by consecutively adding 7 to the previous term. We will use the notation a_n to represent the n^{th} term of this sequence. We can compute

$$a_4 = 33 + 7 = 40,$$

$$a_5 = 40 + 7 = 47,$$

$$a_6 = 47 + 7 = 54.$$

This tells us that the next 3 terms in the arithmetic sequence are

$$40, 47, 54.$$

The common difference of the arithmetic sequence in the previous example is positive, and we can see that each term of the sequence is larger than the previous term. This tells us that this sequence is increasing.

Evaluation of a Composition of Functions

$$f(x) = x^3 \quad g(x) = x^2 - 2$$

$$f \circ g(2) = ? \quad g(2) = 2^2 - 2 = 4 - 2 = 2$$

$$f \circ g(2) = f(g(2)) = f(2) = 2^3 = 8.$$

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