Arithmetic sequence problem solving pdf

In this explainer, we will learn how to solve real-world applications of arithmetic sequences, where we will find the common difference, th term explicit formula, and order and value of a specific sequence term.We begin by defining what we mean by an arithmetic sequence.An arithmetic sequence is a sequence that has a fixed, or common, difference between any two successive terms.An arithmetic sequence of index has a general, or th, term of =+(−1), where is the first term and is the common difference.For example, the sequence 5,8,11,14,... is arithmetic as it has a fixed difference of 3 between successive terms. In this sequence, =3 and the first term =5.Often, arithmetic sequences appear in real-world problems and we can apply what we know about arithmetic sequences to solve these. In the first example, we will find the value of a specific term in the sequence given the first term and the common difference.Fady's exercise plan lasts for 6 minutes on the first day and increases by 4 minutes each day. For how long will Fady exercise on the eighteenth day?Answer We notice that as Fady's exercise plan increases by a fixed amount each day, it forms an arithmetic sequence. An arithmetic sequence is a sequence with a common difference between successive terms.An arithmetic sequence of index has an th term of =+(−1), where is the first term and is the common difference.The first term in the sequence is the number of minutes Fady exercises for on the first day, so =6. The common difference is the number of minutes by which Fady increases his exercise time each day, so =4.We can substitute these values into the th term formula =+(−1) to find the general term of this sequence: =6+(−1)×4=6+4−4=4+2.We could then use the th term to find any specific term in the sequence. To find the number of minutes that Fady exercises for on the eighteenth day, we calculate the 18th term, . Substituting =18 into the equation =4+2 and simplifying give =4(18)+2=72+2=74.Therefore, we can give the answer that the length of time that Fady exercises for on the eighteenth day is 74 minutes.In the next example, we will see how the arithmetic sequence formula can be applied to a decreasing sequence.A doctor prescribed 15 pills for his patient to be taken in the first week. Given that the patient should decrease the dosage by 3 pills every week, find the week in which he will stop taking the medicine completely.Answer In this question, a patient has begun taking medication with 15 pills in the first week. As the number of pills decreases each week by the same number, we can consider this a decreasing arithmetic sequence.An arithmetic sequence of index has a general term of =+(−1), where is the first term and is the common difference.In this case, the first term is 15, so =15. As the common difference decreases each week, the difference will be a negative value, so =−3. We substitute these values into =+(−1) to find the th term of this sequence. This gives =15+(−1)×(−3).Simplifying, we have =15+[−3(−1)]=15−3+3=18−3.To find the week in which the patient stops their medicine, we need to find the week in which =0. Thus, we solve to find the value of in the equation 0=18−3.Adding 3 to both sides and then dividing through by 3 give 0=18−33=18=6.As is the number of weeks, we can answer the question that the patient stops taking their medication in the sixth week.As a check of our answer, we could list the values in the sequence until we get a term of 0. The sequence would be 15,12,9,6,3,0.↑↑↑↑↑↑123456WeekWeekWeekWeekWeekWeekThis confirms that the patient would stop taking their medication, taking 0 pills, in the sixth week.In the following example, we will see how we can use the th term of a sequence to find the common difference.The population of a city was 57 of a million in 2010 and 5 million in 2016. The population growth can be described as an arithmetic sequence. Find its common difference, which represents the annual growth of the population.Answer We are given that the population growth of this city forms an arithmetic sequence. We recall that an arithmetic sequence is one that has a common difference between terms. In order to find the common difference here, we can use the formula for the th term of the sequence.An arithmetic sequence of index has an th term of =+(−1), where is the first term and is the common difference.The first term in this sequence, in millions, is 57. We are not told the term number that is 5 million, but we can calculate this given that the sequence starts in 2010 and is 5 million in 2016. Although a simple calculation would determine that 2016−2010=6years, since we also need to include both 2010 and 2016, the term that is 5 million is actually the seventh term. YearTermNumber20102011201220132014201520161234567Using a sequence in which the terms represent millions of the population, we can substitute =57 and =7 into the formula =+(−1) to write an equation in terms of for the 7th term, giving us =57+(7−1)=57+6.We know that =5 (million), so we can write the equation 5=57+6.Simplifying by subtracting 57 and then dividing both sides by 6 give 5−57=6307=63042=57=.Therefore, the common difference is 57, and, as this figure is in millions, we can give the answer that the annual population growth is 57 of a million.We will now outline another key formula for arithmetic sequences, finding the sum of the first terms of a sequence.The sum of the first terms of an arithmetic sequence can be calculated using the formula S=2(2+(−1)), where is the first term and is the common difference.In the next example, we will see how we can apply this formula to find the sum of the first terms of an arithmetic sequence.A runner is preparing himself for a long-distance race. He covered 6 km on the first day and then increased the distance by 0.5 kilometres every day. Find the total distance he covered in 14 days.Answer In this question, the runner is increasing his distance by a fixed amount each day. This means that we can represent the distances run each day as an arithmetic sequence. We need to find the total, or sum, of the distances covered in 14 days. Therefore, we can use the formula to find the sum of the first terms of an arithmetic sequence. This can be written as S=2(2+(−1)), where is the first term and is the common difference.Here, the first term of the sequence is the distance covered by the runner on the first day, so =6. The common difference =0.5. We need to find the sum of the first 14 terms, so =14. We can substitute these values into the formula S=2(2+(−1)), giving S=142(2(6)+(14−1)×(0.5)).We can simplify this equation to give S=7(12+13(0.5))=7(12+6.5)=7(18.5)=129.5.Therefore, the total distance covered by the runner in 14 days is 129.5 km.We will now see an example of how we can find an th term in an arithmetic sequence, given the sum of the terms up to .Ramy saves £1 on the first day, £2 on the second day, £3 on the third day, and so on, saving an extra £1 each day. On which day will he have saved over £100 in total?Answer We note that the terms in this sequence of Ramy's savings increase by a fixed amount, £1, each day. This sequence forms an arithmetic sequence. We are asked to find the day on which Ramy will have saved over £100 in total. Note, we are not asked which term has the value £100. Rather, £100 is the total of all the daily savings. We can use the formula for the sum of the first terms of an arithmetic sequence: S=2(2+(−1)), where is the first term and is the common difference.As Ramy begins by saving £1 on the first day, =1. The difference =1, since his money saved on each day increases by £1. We can calculate the sum of the th terms by substituting these values into the formula S=2(2+(−1)), which gives S=2(2(1)+(−1)(1)).We then simplify, giving S=2(2+(−1))=2(1+)=+2.Now, we need to find the value of such that S≥100. Thus, we can write +2≥100.We multiply both sides of the inequality by 2 and subtract 200 from both sides, giving +≥200+−200≥0.Now, we have a quadratic in , which we can solve to find the value of . We note that +−200=0 cannot be factored, so we use another method of solving. The quadratic formula allows us to solve a quadratic ax+bx+c=0, where a≠0, by x=−b±√b−4ac2a.We can solve +−200=0 for by substituting the values a=1, b=1, and c=−200. This gives us =−1±√1−4(1)(−200)2(1).Simplifying, we have =−1±√1+8002=−1±√8012.We can then use a calculator to solve the two values of : =−1+√8012=−1−√8012=13.65...=−14.65...orLooking at these results, as is a term in the sequence, it cannot be a negative value, so we can exclude the value =−14.65.... As =13.65... is not an integer, this tells us that there is no th term in the sequence for which S is exactly 100. The th term for which the sum of the first terms is greater than 100 must be the first integer after 13.65...—that is, the 14th term.As a check, we can find the sum of all the terms up to the 13th and the 14th terms. Therefore, to find the sum of the terms up to =13 with the same values =1 and =1, we can substitute these into our simplified equation, S=+2, and simplify, giving S=13+132=169+132=1822=91.To find the sum of the terms up to =14, we have S=14+142=196+142=2102=105.On day 13, Ramy will have saved a total of £91, and on day 14, he will have saved £105. Therefore, we can give the answer that the day on which he will have saved over £100 is day 14.In the final example, we will see how we can find the first term in an arithmetic sequence given another term and the sum of the th terms.A company wants to distribute 14 500 LE among the top 5 sales representatives as a bonus. The bonus for the last-place representative is 1 300 LE, and the difference in bonus is constant among the representatives. Find the bonus of the representative in the first place.Answer In this question, we have an example of a decreasing sequence. The first-place employee gets the largest bonus, and the last-place employee gets the smallest bonus. We are told that there are 5 employees, and, as the difference in bonus is a fixed amount, we can model this as an arithmetic sequence.We recall that the th term of an arithmetic sequence is given by =+(−1), where is the first term and is the common difference.As there are 5 employees, the last-place employee has the amount of money in position number 5. Therefore, for =5, we can write in terms of and as =+(5−1)=+4.We are given that the term value for the 5th employee is 1 300 LE, so, substituting =1300 into this equation, we have 1300=+4.We cannot solve this single equation with two unknown values, so we use the additional information given to us regarding the total of all the bonuses. We can use the formula for the sum of the first terms of an arithmetic sequence: S=2(2+(−1)), where is the first term and is the common difference.We can write the sum of the first 5 terms in terms of and for =5 as follows: S=52(2+(5−1)).Simplifying this gives S=52(2+4)=5(2+4)2=5+10.The sum of the 5 terms in this sequence is the total bonus amount awarded, so we can write that S=14500. Substituting this into the equation above, we have 14500=5+10.We now have two equations with two unknowns, which we can solve simultaneously using elimination or substitution: 1300=+4,14500=5+10.(1)(2)We can rearrange equation (1) to make the subject, which gives =1300−4.Substituting this value for into equation (2), we can write this equation as 14500=5(1300−4)+10.We then expand the parentheses and simplify to give 14500=6500−20+1014500=6500−10.Adding 10 to both sides and then subtracting 14 500 give 14500+10=650010=6500−1450010=−8000.Then, dividing through by 10, we have =−800.The difference, , is a negative value, as we would expect from a decreasing sequence, and means that the employees' bonuses decrease by 800 LE.We can substitute =−800 into equation (1) or (2) to find the value of . Substituting into equation (1) and simplifying give 1300=+4(−800)1300=−3200.Adding 3 200 to both sides, we have 4500=.Now, we have calculated that the first term in the sequence, , is 4 500. This means that we can answer the question that the bonus of the representative in first place is 4 500 LE.As a check, we can create the sequence of the 5 employees' bonuses, with a first term of 4 500 and a common difference of −800. The sequence would be as follows.The last-place employee did get a bonus of 1 300 LE, and the sum of all terms, 4500+3700+2900+2100+1300, is 14 500. Therefore, we have confirmed our answer of 4 500 LE.We can now summarize the key points.An arithmetic sequence is a sequence that has a fixed, or common, difference between any two successive terms.An arithmetic sequence of index has a general, or th, term of =+(−1), where is the first term and is the common difference.The sum of the first terms of an arithmetic sequence can be calculated using the formula S=2(2+(−1)), where is the first term and is the common difference.

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