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How to solve graph of polynomial function

Polynomial functions are considered to be the simplest, most commonly used, and most important mathematical functions. These functions are mostly used in real-world models and are considered to be the building blocks of Algebra. Polynomial functions also cover a wide number of other functions. It is essential for one to study and understand polynomial functions due to their extensive applications. In this article, let's learn about the definition of polynomial functions, their types, and graphs with solved examples. What Is a Polynomial Function? In this article, we will be learning about the different aspects of polynomial functions. If we break down the word polynomial into two, we get poly and nomial. Poly means many, and nomial means the term, and hence when they are combined, we can say that polynomials are algebraic expressions with many terms. Let’s go ahead and start with the definition of polynomial functions and their types. Polynomial Function Definition Polynomial functions are expressions that may contain variables of varying degrees, non-zero coefficients, positive exponents, and constants. Constants are whole numbers that occur at the end of a polynomial expression. And, the first term of f(x) is \(a_{n}\)xn, where n is the polynomial’s highest exponent. This is the general form of a polynomial: f(x) = \(a_{n}\)xn + \(a_{n-1}\)xn-1 + ... + \(a_{2}\)x2+ \(a_{1}\)x + \(a_{0}\). This algebraic expression is called a polynomial function in variable x. Here, \(a_{n}\), \(a_{n-1}\), ... \(a_{0}\) are real number constants \(a_{n}\) can’t be equal to zero n is a non-negative integer All the exponents of a polynomial function should be a whole number In the figure, if we break down the general expression, we can identify the various components and common elements a polynomial function is made of. If the constant \(a_n\) is non-zero, we say this is a polynomial function of degree \(n\) and \(a_n\) is the leading coefficient. Degree of a Polynomial Function Degrees are very useful to predict the behavior of polynomials and they also help us to group the polynomials better. The degree of the polynomial function is determined by the highest power of the variable it is raised to. Consider this polynomial function f(x) = -7x3 + 6x2 + 11x – 19, the highest exponent found is 3 from -7x3. This means that the degree of this particular polynomial is 3. The term containing the highest degree is called the polynomial’s leading coefficient, in this case, it’s -7x3. What Are the Types of Polynomial Functions? There is an extensive number of polynomials and polynomial functions that one might encounter in algebra and now we are going to learn how we can classify the most common types of polynomial based on the number of variables used in a polynomial. The three most common polynomials we usually encounter are monomials, binomials, and trinomials. The details of these three types of polynomials are as follows. Monomials are polynomials that contain only one term. Examples: 15x2, 3b, and 12y4 Binomials are polynomials that contain only two terms. Examples: x + y, 4x – 7, and 9x + 2 Trinomials are polynomials that contain only three terms. Examples: x2 – 3 + 5x, z4 + 45 + 3z, and x2 – 12x + 15x Further, the polynomials are also classified in another way based on their degrees along with their examples. The four most common types of polynomials that are used in precalculus and algebra are cubic, quadratic, linear, and quartic. Type of the polynomial Function Degree Example Zero Polynomial Function or constant function 0 Linear Polynomial Function 1 x + 3, 25x + 4, and 8y – 3 Quadratic Polynomial Function 2 5m2 – 12m + 4, 14x2 – 6, and x2 + 4x Cubic Polynomial Function 3 4y3, 15y3 – y2 + 10, and 3a + a3 How Do You Determine a Polynomial Function? In order to determine if a function is polynomial or not, the function needs to be checked against certain conditions for the exponent of the variables. These conditions are as follows: The degree of the variable in the function must only be a positive whole number and should not contain any fractional or negative powers. The variable of the function should not be inside a radical i.e, it should not contain any square roots or cube roots. The variable should not be in the denominator. The below-given table shows an example and some non-examples of polynomial functions: Functions Variable Exponent Constant Terms Polynomial Function or Not? f(b) = 4b2 – 6b + b3 – 15 a 2 in b2 and 3 in b3 -15 4b2, 6b, b3, and 15 Yes f(x) = x2/3+ 2x x 2/3 in x2/3 and 1 in 2x None x2/3 and 2x No f(y) = 1/y3 y -3 in 1/y3 None 1/y3 No Some non-examples of Polynomial Functions: In the polynomial function f(x), the exponent 2/3 of the term x2/3 is not a whole number. In the polynomial function f(y), the variable y is in the denominator. How to Represent Polynomial Function on Graph? It is easier to represent simpler polynomial functions like linear and quadratic but how can we represent a polynomial function with a degree greater than two? Let us learn to represent a polynomial expression with a degree of more than two. We can represent all the polynomial functions in the form of a graph. The below-given image shows the graphs of different polynomial functions. An important skill in coördinate geometry consists in recognizing the relationship between equations and their graphs. Linear polynomial functions are also known as first-degree polynomials and they can be represented as y = ax + b. The graph of a linear polynomial function always forms a straight line. The graph of a second-degree or quadratic polynomial function is a curve known as a parabola. It can be represented as y = ax2 + bx + c. A cubic polynomial function of the third degree has the form shown on the right and it can be represented as y = ax3 + bx2 + cx + d. Consider this example: Draw the graph for the quadratic polynomial function f(x) = x2 First, for the polynomial function given here, f(x) = x2, let us complete the table by finding the domain and the range of the function. Let's fill this table by populating the values for the function f(x) by substituting the corresponding values of the variable x. x -4 -3 -2 -1 0 1 2 3 4 f(x) = x2 16 9 4 1 0 1 4 9 16 Let's draw the graph of the function. So, the above-given graph is the graph for the quadratic polynomial function f(x) = x2 How to Solve Polynomial Functions? Polynomial functions are expressions that are constructed with variables and constants. These are certain steps that are to be followed to solve any polynomial function. The basic concept is to equate the given polynomial expression to 0 and solve for x. The main aim of solving a polynomial function is to find the value of x in the polynomial expression For any given function, p(y), its zeros are found by setting the function p(y) to zero. The values of y that represent the set equation are the zeroes of the function p(y). To find the zeros of a function, find the values of y where p(y) = 0. Linear Polynomial Function Consider the below-mentioned polynomial function f(y). Let us solve this function by first putting all the terms on one side and 0 on the other as shown below. 16y - 4 = 0 Simplifying it further, we get: 4y -1 = 0 ⇒ 4y = 1 Thus, y = 1/4 = [-2 ± 2√6]/2 Quadratic Polynomial Function Any quadratic function has the standard form: ax2 + bx + c, where a, b are coefficients and c is the constant. Consider the below-mentioned quadratic polynomial function f(x). Let us solve this function by first putting all the terms on one side and 0 on the other as shown below. x2 + 2x -5. Here a = 1, b = 2 and c = -5 Let us use the quadratic formula to find the quadratic roots, x = [-b ± √(b2 - 4ac)]/2a x = [-2 ± √(22 - 4(1)(-5))]/(2)(1) = [-2 ± √(4 +20)]/2 = [-2 ± √(24)]/2 = [-2 ± 2√6]/2 = -1 ± √6 Hence, -1 ± √6 is the solution for the polynomial function f(x) Cubic Polynomial Function Cubic polynomials can be solved in the same way as quadratic equations. But to make it to a much simpler form, we can use some of these special products: Perfect cube (2 forms): a3 ± 3a2b + 3ab2 ± b3 = (a ± b)3 Difference of the cubes: a3 − b3 = (a − b)(a2 + ab +b2) Sum of the cubes: a3 + b3 = (a + b)(a2 − ab + b2) Let us solve this cubic polynomial function y3 – 2y2 – y + 2. We will start by factorizing the equation: y3 – 2y2 – y + 2 = y2(y – 2) – (y – 2) = (y2 – 1) (y – 2) = (y + 1) (y – 1) (y– 2) y = 1, -1 and 2. Related Articles on Polynomial Functions Check out the following pages related to polynomial functions: Important Notes on Polynomial Functions Here is a list of a few points that should be remembered while studying polynomial functions: Constant functions is another term used to denote zero-degree polynomial functions, and they are represented as y = a First-degree polynomials is another term used to denote linear polynomial functions, and they are represented as y = ax + b The graph of a linear polynomial function always forms a straight line. The degree of the polynomial function is determined by the highest power of the variable it is raised to. Example 1: Solve the Polynomial Function f(x) = 4x - 8 Solution: f(x) = 4x - 8 Let us, set the equation to 0. 4x - 8 = 0 4x = 8 x = 8/4 = 2 The solution for the polynomial function 4x - 8 is 2. Example 2: Find the degree of the polynomial function f(y) = 16y5 + 5y4− 2y7 + y2 Solution: In the given example, the highest exponent found is 7 from -2y7. This means that the degree of this particular polynomial is 7. Check Answer > go to slidego to slide FAQs on Polynomial Functions Polynomial functions are expressions that may contain variables of varying degrees, non-zero coefficients, positive exponents, and constants. For example, f(b) = 4b2 – 6 is a polynomial having a variable 'b' and the degree is 2. What Are the Types of Polynomial Functions? These are the various types of polynomial functions that are classified based on their degrees. Among these, the four most common types of polynomials that are used in precalculus and algebra are cubic, quadratic, linear, and quartic. Zero Polynomial Function or constant function.(F(x) = k) Linear Polynomial Function.(f(x) = ax + b) Quadratic Polynomial Function.(f(x) = ax2 + bx + c) Cubic Polynomial Function.(f(x) = ax3 + bx2 + cx + d) Quartic Polynomial Function. (f(x) = ax4 + bx3 + cx2+ dx + e) How Do You Write a Polynomial Function? This is how a polynomial function is written f(x) = \(a_{n}\)xn + \(a_{n-1}\)xn-1 + ... + \(a_{2}\)x2+ \(a_{1}\)x + \(a_{0}\). This algebraic expression is called a polynomial function in variable x. The first term of f(x) is \(a_{n}\)xn, where n is the polynomial’s highest exponent. Here, \(a_{n}\), \(a_{n-1}\), ... \(a_{0}\) are real number constants \(a_{n}\) can’t be equal to zero n is a non-negative integer All the exponents of a polynomial function should be a whole number How to Find the Degree of Polynomial Functions? The degree of the polynomial function is determined by the highest power of the variable it is raised to. Consider the polynomial function f(y) = -4y3 + 6y4 + 11y – 10, the highest exponent found is 4 from the term 6y4. Hence the degree of this particular polynomial is 4. How to Find the Number of Roots of a Polynomial Function? To find the number of roots of a polynomial function, we first need to find the highest-degree term of the polynomial which is the containing the highest exponent. The highest exponent is equal to the number of roots the polynomial function will have. If the highest exponent of the given polynomial function is 2, then the function will have two roots; if the highest exponent of the function is 3, then it'll have three roots; and so on. Consider the example of a polynomial function f(u) = u6 - 5u2 +2. Here, the highest exponent of the given polynomial function is 6, and hence it'll have six roots. What Are Not Polynomial Functions? Is 0 a Polynomial Function? For any function to be considered as a polynomial function, the function needs to follow all these conditions. These conditions are as follows: The degree of the variable in the function must only be a positive whole number and should not contain any fractional or negative powers. The variable of the function should not be inside a radical i.e, it should not contain any square roots or cube roots. The variable should not be in the denominator. Any function that does not follow any of the conditions listed above cannot be considered a polynomial function. Example: The function f(a) = 2a - 6a-2 is not a polynomial function since the degree of the variable a is -2 which is a negative integer. The function f(y) = 0 is also a polynomial, but its degree is not defined. What Are the Examples of Polynomial Functions? Here are a few examples of polynomial functions: Zero Polynomial Function or constant function. Eg: y = 1 Linear Polynomial Function. Eg: 5y + 10 Quadratic Polynomial Function. Eg: 14x2 + 2x – 6 Cubic Polynomial Function. Eg: 4y3 + 5y2 + 2 Quartic Polynomial Function. Eg: 3y4 + 5 A polynomial looks like this: example of a polynomial "Solving" means finding the "roots" ... ... a "root" (or "zero") is where the function is equal to zero: In between the roots the function is either entirely above, or entirely below, the x-axis Let's check: when x = −2, then x2 − 4 = (−2)2 − 4 = 4 − 4 = 0 when x = 2, then x2 − 4 = 22 − 4 = 4 − 4 = 0 How do we solve polynomials? That depends on the Degree! Degree The first step in solving a polynomial is to find its degree. The Degree of a Polynomial with one variable is ... ... the largest exponent of that variable. When we know the degree we can also give the polynomial a name: Degree Name Example Graph Looks Like 0 Constant 7 1 Linear 4x+3 2 Quadratic x2−3x+2 3 Cubic 2x3−5x2 4 Quartic x4+3x−2 ... etc ... ... How To Solve So now we know the degree, how to solve? Read how to solve Linear Polynomials (Degree 1) using simple algebra. Read how to solve Quadratic Polynomials (Degree 2) with a little work, It can be hard to solve Cubic (degree 3) and Quartic (degree 4) equations, And beyond that it can be impossible to solve polynomials directly. So what do we do with ones we can't solve? Try to solve them a piece at a time! If we find one root, we can then reduce the polynomial by one degree (example later) and this may be enough to solve the whole polynomial. Here are some main ways to find roots. 1. Basic Algebra We may be able to solve using basic algebra: 2x+1 is a linear polynomial: The graph of y = 2x+1 is a straight line It is linear so there is one root. Use Algebra to solve: A "root" is when y is zero: 2x+1 = 0 Subtract 1 from both sides: 2x = −1 Divide both sides by 2: x = −1/2 And that is the solution: x = −1/2 (You can also see this on the graph) We can also solve Quadratic Polynomials using basic algebra (read that page for an explanation). 2. By experience, or simply guesswork. It is always a good idea to see if we can do simple factoring: This is cubic ... but wait ... we can factor out "x": x3+2x2−x = x(x2+2x−1) Now we have one root (x=0) and what is left is quadratic, which we can solve exactly. Or we may notice a familiar pattern: Again this is cubic ... but it is also the "difference of two cubes": x3−8 = x3−23 And so we can turn it into this: x3−8 = (x−2)(x2+2x+4) There is a root at x=2, because: (2−2)(22+2×2+4) = (0)(22+2×2+4) And we can then solve the quadratic x2+2x+4 and we are done 3. Graphically. Graph the polynomial and see where it crosses the x-axis. We can enter the polynomial into the Function Grapher, and then zoom in to find where it crosses the x-axis. Graphing is a good way to find approximate answers, and we may also get lucky and discover an exact answer. Caution: before you jump in and graph it, you should really know How Polynomials Behave, so you find all the possible answers! Factors This is useful to know: When a polynomial is factored like this: f(x) = (x−a)(x−b)(x−c)... Then a, b, c, etc are the roots! So Linear Factors and Roots are related, know one and we can find the other. (Read The Factor Theorem for more details.) We see "(x−3)", and that means that 3 is a root (or "zero") of the function. Sure? Well, let us put "3" in place of x: f(x) = (33+2·32)(3−3) f(3) = (33+2·32)(0) Yes! f(3)=0, so 3 is a root. How to Check Found a root? Check it! Simply put the root in place of "x": the polynomial should be equal to zero. The polynomial is degree 3, and could be difficult to solve. So let us plot it first: The curve crosses the x-axis at three points, and one of them might be at 2. We can check easily, just put "2" in place of "x": f(2) = 2(2)3−(2)2−7(2)+2 = 16−4−14+2 = 0 Yes! f(2)=0, so we have found a root! How about where it crosses near −1.8: f(−1.8) = 2(−1.8)3−(−1.8)2−7(−1.8)+2 = −11.664−3.24+12.6+2 = −0.304 No, it isn't equal to zero, so −1.8 will not be a root (but it may be close!) But we did discover one root, and we can use that to simplify the polynomial, like this So, f(2)=0 is a root ... that means we also know a factor: (x−2) must be a factor of 2x3−x2−7x+2 Next, divide 2x3−x2−7x+2 by (x−2) using Polynomial Long Division to find: 2x3−x2−7x+2 = (x−2)(2x2+3x−1) So now we can solve 2x2+3x−1 as a Quadratic Equation and we will know all the roots. That last example showed how useful it is to find just one root. Remember: If we find one root, we can then reduce the polynomial by one degree and this may be enough to solve the whole polynomial. How Far Left or Right When trying to find roots, how far left and right of zero should we go? There is a way to tell, and there are a few calculations to do, but it is all simple arithmetic. Read Bounds on Zeros for all the details. Have We Got All The Roots? There is an easy way to know how many roots there are. The Fundamental Theorem of Algebra says: A polynomial of degree n ... ... has n roots (zeros) but we may need to use complex numbers So: number of roots = the degree of polynomial. The degree is 3 (because the largest exponent is 3), and so: There are 3 roots. But Some Roots May Be Complex Yes, indeed, some roots may be complex numbers (ie have an imaginary part), and so will not show up as a simple "crossing of the x-axis" on a graph. But there is an interesting fact: Complex Roots always come in pairs! So we either get no complex roots, or 2 complex roots, or 4, etc... Never an odd number. Which means we automatically know this: Degree Roots Possible Combinations 1 1 1 Real Root 2 2 2 Real Roots, or 2 Complex Roots 3 3 3 Real Roots, or 1 Real and 2 Complex Roots 4 4 4 Real Roots, or 2 Real and 2 Complex Roots, or 4 Complex Roots etc etc! Positive or Negative Roots? There is also a special way to tell how many of the roots are negative or positive called the Rule of Signs that you may like to read about. Multiplicity of a Root Sometimes a factor appears more than once. We call that Multiplicity: Multiplicity is how often a certain root is part of the factoring. This could be written out in a more lengthy way like this: f(x) = (x−5)(x−5)(x−5)(x+7)(x−1)(x−1) (x−5) is used 3 times, so the root "5" has a multiplicity of 3, likewise (x+7) appears once and (x−1) appears twice. So: the root +5 has a multiplicity of 3 the root −7 has a multiplicity of 1 (a "simple" root) the root +1 has a multiplicity of 2 Q: Why is this useful? A: It makes the graph behave in a special way! When we see a factor like (x-r)n, "n" is the multiplicity, and even multiplicity just touches the axis at "r" (and otherwise stays one side of the x-axis) odd multiplicity crosses the axis at "r" (changes from one side of the x-axis to the other) We can see it on this graph: (x−2) has even multiplicity, so it just touches the axis at x=2 (x−4) has odd multiplicity, so it crosses the axis at x=4 Like this: Summary We can directly solve polynomials of Degree 1 (linear) and 2 (quadratic) For Degree 3 and up, graphs can be helpful It is also helpful to: Know how far left or right the roots may be Know how many roots (the same as its degree) Estimate how many may be complex, positive or negative Multiplicity is how often a certain root is part of the factoring. Copyright © 2017 MathsIsFun.com

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