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Binomial theorem solved problems pdf

In this section, we give some examples of applying the binomial theorem. Expand \((2x+3)^4\). Solution Using the binomial theorem: \[(a+b)^4 =a^4+4a^3b+6a^2b^2 +4ab^3+ b^4. \] Let \(a =2x\) and \(b=3\). Then \begin{align*} (2x+3)^4 &= (2x)^4+ 4(2x)^3\times3+6(2x)^2\times3^2+ 4(2x)\times3^3+ 3^4\\ &=16x^4+ 96x^3+216x^2+216x+ 81. \end{align*} Expand \((1-x)^{10}\). Solution Using the binomial theorem: \begin{align*} (a+b)^n &= \sum_{r=0}^{n}\dbinom{n}{r}a^{n-r}b^r. \end{align*} Let \(a=1\), \(b=-x\) and \(n = 10\). Then \begin{align*} &(1-x)^{10} = \sum_{r=0}^{10}\dbinom{10}{r}(-x)^r\\ &= 1-10x+45x^2-120x^3+210x^4-252x^5+210x^6-120x^7+45x^8-10x^9+x^{10}. \end{align*} Expand \((2x-3y)^4\) \(\Big(x-\dfrac{2}{x}\Big)^4\). Screencast of exercise 5 The general term in the binomial expansion The general term in the expansion of \((a+b)^n\) is \[\dbinom{n}{r}a^{n-r}b^r, \qquad\text{where}\quad 0 \leq r\leq n. \] For the expansion of \((x-3z^2)^5\), find the general term and find the coefficient of \(x^3z^4\). Solution The general term is \[\dbinom{5}{r}x^{5-r}(-3z^2)^r, \qquad\text{where}\quad 0 \leq r\leq 5. \] To find the coefficient of \(x^3z^4\), we want \(5-r=3\) and \(r=2\). Thus the coefficient of \(x^3z^4\) is \(\dbinom{5}{2}(-3)^2 = 90\). Consider the expression \((a-2b^3)^7\). How many terms are there in the expansion? Find a formula for the general term. Find the constant term in the expansion of \(\Big(x^2 + \dfrac{1}{x^2}\Big)^6\). Solution The general term is \begin{align*} \dbinom{6}{r}\big(x^2\big)^{6-r}\Big(\dfrac{1}{x^2}\Big)^r &= \dbinom{6}{r}x^{12-2r}\Big(\dfrac{1}{x^{2r}}\Big)\\ &=\dbinom{6}{r}x^{12-4r}. \end{align*} This term will be a constant when \(12-4r=0\), that is, when \(r=3\). Hence the constant term in the expansion of \(\Big(x^2 + \dfrac{1}{x^2}\Big)^6\) is \(\dbinom{6}{3}= 20\). Find the constant term in the expansion of \(\Big(x + \dfrac{1}{x^2}\Big)^6\). Screencast of exercise 7 Find the coefficient of \(x^5\) in the expansion of \((1-2x+3x^2)^5\). Solution Bracket \(1-2x\) and expand: \[(1-2x+3x^2)^5=(1-2x)^5+5(1-2x)^4(3x^2)+10(1-2x)^3(3x^2)^2+\dotsb. \] The coefficient of \(x^5\) in \((1-2x)^5\) is \((-2)^5 = -32\). The coefficient of \(x^5\) in \(5(1-2x)^4(3x^2)\) is \(15\tbinom{4}{3}(-2)^3 = -480\). The coefficient of \(x^5\) in \(10(1-2x)^3(3x^2)^2\) is \(90\tbinom{3}{1}(-2) = -540\). The remaining terms do not contain \(x^5\). Therefore the required coefficient is \(-32-480-540=-1052\). The middle term When \(n\) is even, there will be an odd number of terms in the expansion of \((a+b)^n\), and hence there will be a middle term. Let \(n=2m\), for some positive integer \(m\). Then, when the expansion of \((a+b)^n\) is arranged with terms in descending or ascending order, the middle term is \(\dbinom{2m}{m}a^mb^m. \) For example, the middle term of \((a+b)^8\) is \ \dbinom{8}{4}a^4b^4 = 70a^4b^4. \) When \(n\) is odd, there will be two middle terms of \((a+b)^n\). Let \(n=2m+1\), for some positive integer \(m\). Then the middle terms are \(\dbinom{2m+1}{m}a^{m+1}b^m \qquad\text{and}\qquad \dbinom{2m+1}{m+1}a^mb^{m+1}. \) Find the middle term of \((2x-3y)^6\). Screencast of exercise 8 Greatest coefficients When \(n\) is even, we can show that the greatest coefficient of \((1+x)^n\) is the coefficient of the middle term, which is \(\dbinom{n}{\dfrac{n}{2}}.\) When \(n\) is odd, there are two greatest coefficients, which are the coefficients of the two middle terms \(\dbinom{n}{\dfrac{1}{2}(n-1)} \qquad\text{and}\qquad \dbinom{n}{\dfrac{1}{2}(n+1)}.\) In general, finding the greatest coefficients for an expansion can be undertaken in a systematic fashion, as shown in the following example. Find the greatest coefficient in the expansion of \((1+ 3x)^{21}\). Solution The general term of this expansion is \(\dbinom{21}{k}(3x)^k\), and its coefficient is \(c_k = \dbinom{21}{k}3^k\). The next coefficient is \(c_{k+1}= \dbinom{21}{k+1}3^{k+1}\). We have \begin{align*} \dfrac{c_{k+1}}{c_k}&=\dfrac{\tbinom{21}{k+1}3^{k+1}}{\tbinom{21}{k}3^k}\\ &=\dfrac{21!}{(20-k)!(k+1)!} \times \dfrac{(21-k)!k!}{21!} \times 3\\ &=\dfrac{63-3k}{k+1}. \end{align*} To find where the coefficients are increasing, we solve \(c_{k+1}>c_k\), that is, \(\dfrac{c_{k+1}}{c_k} >1\). From above, \(\dfrac{63-3k}{k+1}>1\), which is equivalent to \(kc_k\) for \(k=0,1,2,\dots,14,15\). The sequence of coefficients is increasing from \(c_0\) to \(c_{16}\) and decreasing from \(c_{16}\) to \(c_{21}\). Hence \(c_{16}\) is the largest coefficient: \[c_{16}=\dbinom{21}{16}3^{16} = 875\, 957\, 725\, 629. \] Find the greatest coefficient of \((2x+3y)^{15}\). Next page - Content - Proof of the binomial theorem by mathematical induction Binomial expression is an algebraic expression with two terms only, e.g. 4x2+9. When such terms are needed to expand to any large power or index say n, then it requires a method to solve it.Therefore, a theorem called Binomial Theorem is introduced which is an efficient way to expand or to multiply a binomial expression. Binomial Theorem is defined as the formula using which any power of a binomial expression can be expanded in the form of a series.Binomial theoremBinomial Theorem is used to solve binomial expressions in a simple way. It gives an expression to calculate the expansion of (a+b)n for any positive integer n. The Binomial theorem is stated as:(a + b)n = nC0 an + nC1 an-1 b1 + nC2 an-2 b2 + …. + nCr an-r br + …. + nCn bnNow, as it is understood that what is a binomial expression and the purpose of the binomial theorem, so try to expand (a+b)n for large values of n (e.g. n = 10. 11, 12,…) using the above statement as:(a + b)10 = a10 + 10a9b + 45a8b2 + 120a7b3 + 210a6b4 + 252a5b5 + 210a4b6+120a3b7+ 45a2b8+ 10ab9+ b10(a + b)11 = a11 + 11a10b + 55a9b2 + 165a8b3 + 330a7b4 + 462a6b5 + 462a5b6 + 330a4b7 + 165a3b8 + 55a2b9 + 11ab10 + b11(a + b)12 = a12 + 12a11b + 66a10b2 + 220a9b3 + 495a8b4 + 792a7b5 + 924a6b6 + 792a5b7 + 495a4b8 + 220a3b9 + 66a2b10 + 12ab11 + b12and so on.In case of the expansion of smaller powers, it is difficult to calculate the coefficients of the binomial expansion using the same statement. This drawback of the binomial theorem is resolved by Pascal's Triangle.The Pascal Triangle is an alternative method of the calculation of coefficients that come in binomial expansions, using a diagram rather than algebraic methods.In the diagram shown below, it is noticed that each number in the triangle is the sum of the two directly above it. This pattern continues indefinitely to obtain coefficients of any index of the binomial expression.When we observe the pattern of the coefficients of the expansion (a + b)n, The Pascal's triangle for the pattern of the coefficients of the expansion (a + b)7 is shown in the figure below:Thus, from the above diagram the expansion of small powers of n (e.g. n=0, 1, 2, 3, 4, 5, 6, 7) can be calculated as:(a + b)0 = 1(a + b)1 = a + b(a + b)2 = a2 + 2ab +b2(a + b)3 = a3 + 3a2b + 3ab2 + b3(a + b)4 = a4 + 4a3b + 6a2b2 + 4ab3 + b4(a + b)5 = a5 + 5a4b + 10a3b2 + 10a2b3 + 5ab4 + b5(a + b)6 = a6 + 6a5b + 15a4b2 + 20a3b3 + 15a2b4 + 6ab5 + b6(a + b)7 = a7 + 7a6b + 21a5b2 + 35a4b3 + 35a3b4 + 21a2b5 + 7ab6 + b7In this way the expansion from (a + b)0 to (a + b)7 are obtained by the application of Pascal's Triangle. But finding (a + b)15 is really a long process using Pascal's triangle. So, here is where the binomial theorem comes into the picture.When the coefficients are observed closely thorem become as follows:(a+b)1 = 1C0a + 1C1b(a+b)2 = 2C0a2 + 2C1ab + 2C2b2(a+b)3 = 3C0a3 + 3C1a2b + 3C2ab2 + 3C3b3So from the above pattern, the expansion of (a + b)n becomes as follows:(a + b)n = nC0an + nC1an-1b1 + nC2an-2b2 + …. + nCran-rbr + …. + nCnbnThe above statement is called Binomial Theorem.Binomial Theorem FormulaThe formula obtained by the Binomial Theorem is called the Binomial Theorem Formula, this formula can directly applied to a binomial equation (let it contains terms as x and y) raised to any power n is given as:Some examples on the above formula are as follows:(x+y)2=x2+2xy+y2(x+y)3=x3+3x2y+3xy2+y3Properties of the Binomial TheoremThe Binomial expansion or Binomial theorem is an important part of Arithmetic Mean. It is neither too easy nor too tough because it can be directly applied in a question. Some of the important properties of a Binomial expansion (a+b)n are stated as:There are (n+1) terms in an expansion of a binomial expression with index n i.e. one more than the power (index) of the binomial expression. e.g, The number of terms presents in the expansion of (a+b)n is equal to (n+1).The expansion of (a+b)n has first term is equal to an while the last one is equal to bn.Such that the sum of the indices of each a and b is equal to n only.When a = b or a+b = n only, then nCa = nCb.The coefficient of each term equidistant from the beginning and the end are equal. Such coefficients are called as the binomial coefficients and nCr = nCr-1 where r is 0,1,2,…,n.Sample Problems on Binomial TheoremLet's try some sample problems on the binomial theorem.Problem 1: Expand the binomial expression (2x + 3y)2.Solution:(2x)2 + 2(2x)(3y) + (3y)2= 4x2 + 12xy + 9y2Problem 2: Expand the following (1 – x + x2)4Solution:Put 1 – x = y.Then,(1 – x + x2)4 = (y + x2)4= 4C0y4(x2)0 + 4C1y3(x2)1 + 4C2y2(x2)2 +4C3y(x2)3 +4C4(x2)4= y4 + 4y3x2 + 6y2x4 + 4yx6 + x8= (1 – x)4 + 4(1 – x)3x2 + 6(1 – x)2x4 + 4(1 – x)x6 + x8= 1 – 4x + 10x2 – 16x3 + 19x4 – 16x5 + 10x6– 4x7 + x8Problem 3: Find the 4th term from the end in the expansion of ((x3/2) – (2/x2))8.Solution:Since rth term from the end in the expansion of (a + b)n is(n – r + 2)th term from the beginning.Therefore, 4th term from the end is 8 – 4 + 2,i.e., 6th term from the beginning, which is given byT6 = 8C5(x3/2)3(-2/x2)5= 8C3(x9/8)(64/x10)= 672/x6Problem 4: Find the middle term (terms) in the expansion of ((p/x) + (x/p))9Solution:Since the power of binomial is odd. Therefore, we have two middle termswhich are 5th and 6th terms. These are given byT5 = 9C4(p/x)5(x/p)4= 9C4(p/x)= 126(p/x)T6 = 9C5(p/x)4(x/p)5= 9C5(x/p)= 126(x/p) binomial theorem solved problems pdf

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