

NCERT SOLUTIONS

CLASS - 11th



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Exercise 8.1

Q1 Expand the expression $(1 - 2x)^5$

Answer.

$$\begin{aligned}(1 - 2x)^5 &= {}^5C_0(1)^5 - {}^5C_1(1)^4(2x) + {}^5C_2(1)^3(2x)^2 - {}^5C_3(1)^2(2x)^3 + {}^5C_4(1)^1(2x)^4 - {}^5C_5(2x)^5 \\&= 1 - 5(2x) + 10(4x^2) - 10(8x^3) + 5(16x^4) - (32x^5) \\&= 1 - 10x + 40x^2 - 80x^3 + 80x^4 - 32x^5\end{aligned}$$

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Q2 Expand the expression $\left(\frac{2}{x} - \frac{x}{2}\right)^5$

Answer.

$$\begin{aligned}\left(\frac{2}{x} - \frac{x}{2}\right)^5 &= {}^5C_0\left(\frac{2}{x}\right)^5 - {}^5C_1\left(\frac{2}{x}\right)^4\left(\frac{x}{2}\right) + {}^5C_2\left(\frac{2}{x}\right)^3\left(\frac{x}{2}\right)^2 \\&\quad - {}^5C_3\left(\frac{2}{x}\right)^2\left(\frac{x}{2}\right)^3 + {}^5C_4\left(\frac{2}{x}\right)\left(\frac{x}{2}\right)^4 - {}^5C_5\left(\frac{x}{2}\right)^5 \\&= \frac{32}{x^5} - 5\left(\frac{16}{x^4}\right)\left(\frac{x}{2}\right) + 10\left(\frac{8}{x^3}\right)\left(\frac{x^2}{4}\right) - 10\left(\frac{4}{x^2}\right) + 5\left(\frac{2}{x}\right)\left(\frac{x^4}{16}\right) - \frac{x^5}{32} \\&= \frac{32}{x^5} - \frac{40}{x^3} + \frac{20}{x} - 5x + \frac{5}{8}x^3 - \frac{x^5}{32}\end{aligned}$$

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Q3 Expand the expression $(2x - 3)^6$

Answer. By using Binomial theorem, the expression $(2x - 3)^6$ can be expressed as

$$\begin{aligned}(2x - 3)^6 &= {}^6C_0(2x)^6 - {}^6C_1(2x)^5(3) + {}^6C_2(2x)^4(3)^2 - {}^6C_3(2x)^3(3)^3 \\&\quad + {}^6C_4(2x)^2(3)^4 - {}^6C_5(2x)(3)^5 + {}^6C_6(3)^6 \\&= 64x^6 - 6(32x^5)(3) + 15(16x^4)(9) - 20(8x^3)(27) \\&\quad + 15(4x^2)(81) - 6(2x)(243) + 729 \\&= 64x^6 - 576x^5 + 2160x^4 - 4320x^3 + 4860x^2 - 2916x + 729\end{aligned}$$

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Q4 Expand the expression $\left(\frac{x}{3} + \frac{1}{x}\right)^5$

Answer. By using Binomial Theorem, the expression $\left(\frac{x}{3} + \frac{1}{x}\right)^5$ can be expand as

$$\begin{aligned} \left(\frac{x}{3} + \frac{1}{x}\right)^5 &= {}^5C_0 \left(\frac{x}{3}\right)^5 + {}^5C_1 \left(\frac{x}{3}\right)^4 \left(\frac{1}{x}\right) + {}^5C_2 \left(\frac{x}{3}\right)^3 \left(\frac{1}{x}\right)^2 \\ &= \frac{x^5}{243} + 5 \left(\frac{x^4}{81}\right) \left(\frac{1}{x}\right) + 10 \left(\frac{x^3}{27}\right) \left(\frac{1}{x^2}\right) + 10 \left(\frac{x^2}{9}\right) \left(\frac{1}{x^3}\right) + 5 \left(\frac{x}{3}\right) \left(\frac{1}{x^4}\right) + \frac{1}{x^5} \\ &= \frac{x^5}{243} + \frac{5x^3}{81} + \frac{10x}{27} + \frac{10}{9x} + \frac{5}{3x^3} + \frac{1}{x^5} \end{aligned}$$

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Q5 Expand the expression $\left(x + \frac{1}{x}\right)^6$

Answer.

$$\begin{aligned} \left(x + \frac{1}{x}\right)^6 &= {}^6C_0(x)^6 + {}^6C_1(x)^5 \left(\frac{1}{x}\right) + {}^6C_2(x)^4 \left(\frac{1}{x}\right)^2 \\ &+ {}^6C_3(x)^3 \left(\frac{1}{x}\right)^3 + {}^6C_4(x)^2 \left(\frac{1}{x}\right)^4 + {}^6C_5(x) \left(\frac{1}{x}\right)^5 + {}^6C_6 \left(\frac{1}{x}\right)^6 \\ &= x^6 + 6x^5 \left(\frac{1}{x}\right) + 15x^4 \left(\frac{1}{x^2}\right) + 20x^3 \left(\frac{1}{x^3}\right) + 15x^2 \left(\frac{1}{x^4}\right) + 6x \left(\frac{1}{x^5}\right) + \frac{1}{x^6} \\ &= x^6 + 6x^4 + 15x^2 + 20 + \frac{15}{x^2} + \frac{6}{x^4} + \frac{1}{x^6} \end{aligned}$$

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Q6 Using binomial theorem, evaluate $(96)^3$

Answer.

96 can be expressed as the sum or difference of two numbers whose powers are easier to calculate and then, binomial theorem can be applied.

It can be written that, $96 = 100 - 4$

$$\begin{aligned} \therefore (96)^3 &= (100 - 4)^3 \\ &= {}^3C_0(100)^3 - {}^3C_1(100)^2(4) + {}^3C_2(100)(4)^2 - {}^3C_3(4)^3 \\ &= (100)^3 - 3(100)^2(4) + 3(100)(4)^2 - (4)^3 \\ &= 1000000 - 120000 + 4800 - 64 \\ &= 884736 \end{aligned}$$

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Q7 Using binomial theorem, evaluate $(102)^5$

Answer.

102 can be expressed as the sum or difference of two numbers whose powers are easier to calculate and then, Binomial Theorem can be applied.

It can be written that, $102 = 100 + 2$

$$\begin{aligned} \therefore (102)^5 &= (100 + 2)^5 \\ &= {}^5C_0(100)^5 + {}^5C_1(100)^4(2) + {}^5C_2(100)^3(2)^2 + {}^5C_3(100)^2(2)^3 \\ &+ {}^5C_4(100)(2)^4 + {}^5C_5(2)^5 \\ &= (100)^5 + 5(100)^4(2) + 10(100)^3(2)^2 + 10(100)^2(2)^3 + 5(100)(2)^4 + (2)^5 \\ &= 1000000000 + 1000000000 + 400000000 + 800000 + 80000 + 32 \\ &= 11040808032 \end{aligned}$$

Q8 Using binomial theorem, evaluate $(101)^4$

Answer.

101 can be expressed as the sum or difference of two numbers whose powers are easier to calculate and then, Binomial Theorem can be applied.

It can be written that, $101 = 100 + 1$

$$\begin{aligned}\therefore (101)^4 &= (100 + 1)^4 \\ &= {}^4C_0(100)^4 + {}^4C_1(100)^3(1) + {}^4C_2(100)^2(1)^2 + {}^4C_3(100)(1)^3 + {}^4C_4(1)^4 \\ &= (100)^4 + 4(100)^3 + 6(100)^2 + 4(100) + (1)^4 \\ &= 100000000 + 400000 + 60000 + 400 + 1 \\ &= 104060401\end{aligned}$$

Q9 Using binomial theorem, evaluate $(99)^5$

Answer.

99 can be written as the sum or difference of two numbers whose powers are easier to calculate and then, Binomial Theorem can be applied.

It can be written that, $99 = 100 - 1$

$$\begin{aligned}\therefore (99)^5 &= (100 - 1)^5 \\ &= {}^5C_0(100)^5 - {}^5C_1(100)^4(1) + {}^5C_2(100)^3(1)^2 - {}^5C_3(100)^2(1)^3 \\ &\quad + {}^5C_4(100)(1)^4 - {}^5C_5(1)^5 \\ &= (100)^5 - 5(100)^4 + 10(100)^3 - 10(100)^2 + 5(100) - 1 \\ &= 1000000000 - 500000000 + 10000000 - 100000 + 500 - 1 \\ &= 10010000500 - 500100001 \\ &= 9509900499\end{aligned}$$

Q10 Using Binomial Theorem, indicate which number is larger $(1.1)^{10000}$ or 1000

Answer.

By splitting 1.1 and then applying Binomial Theorem, the first few terms of $(1.1)^{10000}$ can be obtained as

$$\begin{aligned}(1.1)^{10000} &= (1 + 0.1)^{10000} \\ &= (1 + 0.1)^{10000} C_1(1.1) + \text{Other positive terms} \\ &= 1 + 10000 \times 1.1 + \text{Other positive terms} \\ &= 1 + 11000 + \text{Other positive terms} \\ &> 1000 \\ (1.1)^{10000} &> 1000\end{aligned}$$

Q11 Find $(a + b)^4 - (a - b)^4$. Hence, evaluate $(\sqrt{3} + \sqrt{2})^4 - (\sqrt{3} - \sqrt{2})^4$

Answer. Using Binomial Theorem, the expression $(a + b)^4$ and $(a - b)^4$, can be expanded as

$$(a + b)^4 = {}^4C_0 a^4 + {}^4C_1 a^3 b + {}^4C_2 a^2 b^2 + {}^4C_3 a b^3 + {}^4C_4 b^4$$

$$(a - b)^4 = {}^4C_0 a^4 - {}^4C_1 a^3 b + {}^4C_2 a^2 b^2 - {}^4C_3 a b^3 + {}^4C_4 b^4$$

$$\therefore (a + b)^4 - (a - b)^4 = {}^4C_0 a^4 + {}^4C_1 a^3 b + {}^4C_2 a^2 b^2 + {}^4C_3 a b^3 + {}^4C_4 b^4 - [{}^4C_0 a^4 - {}^4C_1 a^3 b + {}^4C_2 a^2 b^2 - {}^4C_3 a b^3 + {}^4C_4 b^4]$$

$$= 2 ({}^4C_1 a^3 b + {}^4C_3 a b^3) = 2 (4a^3 b + 4ab^3)$$

$$= 8ab (a^2 + b^2)$$

By putting $a = \sqrt{3}$ and $b = \sqrt{2}$, we obtain

$$\begin{aligned} (\sqrt{3} + \sqrt{2})^4 - (\sqrt{3} - \sqrt{2})^4 &= 8(\sqrt{3})(\sqrt{2}) \{(\sqrt{3})^2 + (\sqrt{2})^2\} \\ &= 8(\sqrt{6})\{3 + 2\} = 40\sqrt{6} \end{aligned}$$

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Q12 Find $(x + 1)^6 + (x - 1)^6$. Hence or otherwise evaluate $(\sqrt{2} + 1)^6 + (\sqrt{2} - 1)^6$

Answer.

Using Binomial Theorem, the expressions, $(x + 1)^6$ and $(x - 1)^6$, can be expanded as

$$(x + 1)^6 = {}^6C_0 x^6 + {}^6C_1 x^5 + {}^6C_2 x^4 + {}^6C_3 x^3 + {}^6C_4 x^2 + {}^6C_5 x + {}^6C_6$$

$$(x - 1)^6 = {}^6C_0 x^6 - {}^6C_1 x^5 + {}^6C_2 x^4 - {}^6C_3 x^3 + {}^6C_4 x^2 - {}^6C_5 x + {}^6C_6$$

$$\begin{aligned} \therefore (x + 1)^6 + (x - 1)^6 &= 2 [{}^6C_0 x^6 + {}^6C_2 x^4 + {}^6C_4 x^2 + {}^6C_6] \\ &= 2 [x^6 + 15x^4 + 15x^2 + 1] \end{aligned}$$

By putting $x = \sqrt{2}$, we obtain

$$\begin{aligned} (\sqrt{2} + 1)^6 + (\sqrt{2} - 1)^6 &= 2 [(\sqrt{2})^6 + 15(\sqrt{2})^4 + 15(\sqrt{2})^2 + 1] \\ &= 2(8 + 15 \times 4 + 15 \times 2 + 1) \\ &= 2(8 + 60 + 30 + 1) \\ &= 2(99) = 198 \end{aligned}$$

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Q13 Show that $9^{n+1} - 8n - 9$ is divisible by 64, whenever n

Answer.

In order to show that $9^{n+1} - 8n - 9$ is divisible by 64, it has to be proved that,

$$9^{n+1} - 8n - 9 = 64k, \text{ where } k \text{ is some natural number}$$

By Binomial Theorem,

$$(1 + a)^m = {}^mC_0 + {}^mC_1 a + {}^mC_2 a^2 + \dots + {}^mC_m a^m$$

For $a = 8$ and $m = n + 1$, we obtain

$$(1 + 8)^{n+1} = {}^{n+1}C_0 + {}^{n+1}C_1 (8) + {}^{n+1}C_2 (8)^2 + \dots + {}^{n+1}C_{n+1} (8)^{n+1}$$

$$\Rightarrow 9^{n+1} = 1 + (n + 1)(8) + 8^2 [{}^{n+1}C_2 + {}^{n+1}C_3 \times 8 + \dots + {}^{n+1}C_{n+1} (8)^{n-1}]$$

$$\Rightarrow 9^{n+1} = 9 + 8n + 64 [{}^{n+1}C_2 + {}^{n+1}C_3 \times 8 + \dots + {}^{n+1}C_{n+1} (8)^{n-1}]$$

$$\Rightarrow 9^{n+1} - 8n - 9 = 64k, \text{ where } k = {}^{n+1}C_2 + {}^{n+1}C_3 \times 8 + \dots + {}^{n+1}C_{n+1} (8)^{n-1} \text{ is a natural number}$$

Thus, $9^{n+1} - 8n - 9$ is divisible by 64, whenever n is a positive integer.

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Q14 Prove that $\sum_{r=0}^n 3^r C_r = 4^n$

Answer. By Binomial Theorem,

$$\sum_{i=0}^n C_i a^{n-i} b^i = (a+b)^n$$

By putting $b = 3$ and $a = 1$ in the above equation, we obtain

$$\sum_{r=0}^n C_r (1)^{n-r} (3)^r = (1+3)^n$$

$$\Rightarrow \sum_{r=0}^n 3^r C_r = 4^n$$

Hence, proved.

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Exercise 8.2

Q1 Find the coefficient of $x^5 \ln(x+3)^8$

Answer.

It is known that $(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by

$$T_{r+1} = {}^n C_r a^{n-r} b^r$$

Assuming that x^5 occurs in the $(r+1)^{\text{th}}$ term of the expansion $(x+3)^8$, we obtain

$$T_{r+1} = {}^8 C_r (x)^{8-r} (3)^r$$

Comparing the indices of x in x^5 and in T_{r+1} , we obtain

$$r = 3$$

Thus, the coefficient of x^5 is ${}^8 C_3 (3)^3 = \frac{8!}{3!5!} \times 3^3 = \frac{8 \cdot 7 \cdot 6 \cdot 5!}{3 \cdot 2 \cdot 5!} \cdot 3^3 = 1512$

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Q2 Find the coefficient of $a^5 b^7 \ln(a-2b)^{12}$

Answer.

It is known that $(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by

$$T_{r+1} = {}^n C_r a^{n-r} b^r$$

$a^5 b^7$ occurs in the $(r+1)^{\text{th}}$ term of the expansion $(a-2b)^{12}$,

$$T_{r+1} = {}^{12} C_r (a)^{12-r} (-2b)^r = {}^{12} C_r (-2)^r (a)^{12-r} (b)^r$$

Thus the coefficient of $a^5 b^7$ is

$${}^{12} C_7 (-2)^7 = -\frac{12!}{7!5!} \cdot 2^7 = -\frac{12 \cdot 11 \cdot 10 \cdot 9 \cdot 8 \cdot 7!}{5 \cdot 4 \cdot 3 \cdot 2 \cdot 7!} \cdot 2^7 = -(792)(128) = -101376$$

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Q3 Write the general term in the expansion of $(x^2 - y)^6$

Answer.

It is known that the general term T_{r+1} {which is the $(r+1)^{\text{th}}$ term} in the binomial expansion of $(a+b)^n$ is given by $T_{r+1} = {}^n C_r a^{n-r} b^r$

Thus, the general term in the expansion of $(x^2 - y^6)$ is

$$T_{r+1} = {}^6C_r (x^2)^{6-r} (-y)^r = (-1)^r C_r \cdot x^{12-2r} y^r$$

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Q4 Write the general term in the expansion of $(x^2 - yx)^{12}$, $x \neq 0$

Answer.

It is known that the general term T_{r+1} { which is the $(r+1)^{\text{th}}$ term } in the binomial expansion of $(a+b)^n$ is given by $T_{r+1} = {}^nC_r a^{n-r} b^r$

Thus the general term of expansion of $(x^2 - yx)^{12}$ is

$$T_{r+1} = {}^{12}C_r (x^2)^{12-r} (-yx)^r = (-1)^r {}^{12}C_r \cdot x^{24-2r} \cdot y^r \cdot x^r = (-1)^r C_r \cdot x^{24-r} \cdot y^r$$

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Q5 Find the 4th term in the expansion of $(x - 2y)^{12}$

Answer.

It is known that $(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by

$$T_{r+1} = {}^nC_r a^{n-r} b^r$$

Thus, the 4th term in the expansion of $(x - 2y)^{12}$ is

$$T_4 = T_{4-1+1} = {}^{12}C_3 (x)^{12-3} (-2y)^3 = (-1)^3 \cdot \frac{12!}{3!9!} \cdot x^9 \cdot (2)^3 \cdot y^3 = -\frac{12 \cdot 11 \cdot 10}{3 \cdot 2} \cdot (2)^3 x^9 y^3 = -1760 x^9 y^3$$

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Q6 Find the 13th term in the expansion of $\left(9x - \frac{1}{3\sqrt{x}}\right)^{18}$, $x \neq 0$

Answer.

$(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$

$$\begin{aligned} T_{13} &= T_{12+1} = {}^{18}C_{12} (9x)^{18-12} \left(-\frac{1}{3\sqrt{x}}\right)^{12} \\ &= (-1)^{12} \frac{18!}{12!6!} (9)^6 (x)^6 \left(\frac{1}{3}\right)^{12} \left(\frac{1}{\sqrt{x}}\right)^{12} \\ &= \frac{18 \cdot 17 \cdot 16 \cdot 15 \cdot 14 \cdot 13 \cdot 12!}{12!6 \cdot 5 \cdot 4 \cdot 3 \cdot 2} \cdot x^6 \cdot \left(\frac{1}{x^6}\right) \cdot 3^{12} \left(\frac{1}{3^{12}}\right) \\ &= 18564 \end{aligned}$$

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Q7 Find the middle terms in the expansions of $\left(3 - \frac{x^3}{6}\right)^7$

Answer. It is known that in the expansion of $(a+b)^n$, if n is odd then there are two middle terms, namely

$$\left(\frac{n+1}{2}\right)^{\text{th}} \text{ term and } \left(\frac{n+1}{2} + 1\right)^{\text{th}} \text{ Term}$$

$$\begin{aligned}
T_4 &= T_{3+1} = {}^7C_3(3)^{1-3} \left(-\frac{x^3}{6}\right)^3 = (-1)^3 \frac{7!}{3!4!} \cdot 3^4 \cdot \frac{x^9}{6^3} \\
&= -\frac{7 \cdot 6 \cdot 5 \cdot 4!}{3 \cdot 2 \cdot 4!} \cdot 3^4 \cdot \frac{1}{2^3 \cdot 3^3} \cdot x^9 = -\frac{105}{8}x^9 \\
T_5 &= T_{4,1} = {}^7C_4(3)^{7-4} \left(-\frac{x^3}{6}\right)^4 = (-1)^4 \frac{7!}{4!3!} (3)^3 \cdot \frac{x^{12}}{6^4} \\
&= \frac{7 \cdot 6 \cdot 5 \cdot 4!}{4! \cdot 3 \cdot 2} \cdot \frac{3^3}{2^4 \cdot 3^4} \cdot x^{12} = \frac{35}{48}x^{12} \\
\left(3 - \frac{x^3}{6}\right)^7 &\text{ are } -\frac{105}{8}x^9 \text{ and } \frac{35}{48}x^{12}
\end{aligned}$$

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Q8 Find the middle terms in the expansion of $\left(\frac{x}{3} + 9y\right)^{10}$

Answer.

It is known that in the expansion $(a + b)^n$, if n is even, then the middle term is $\left(\frac{n}{2} + 1\right)^{\text{th}}$ term.

$$\begin{aligned}
T_6 &= T_{5+1} = {}^{10}C_5 \left(\frac{x}{3}\right)^{10-5} (9y)^5 = \frac{10!}{5!5!} \cdot \frac{x^5}{3^5} \cdot 9^5 \cdot y^5 \\
&= \frac{10 \cdot 9 \cdot 8 \cdot 7 \cdot 6 \cdot 5!}{5 \cdot 4 \cdot 3 \cdot 2 \cdot 5!} \cdot \frac{1}{3^5} \cdot 3^5 \cdot x^5 y^5 \\
&= 252 \times 3^5 \cdot x^5 \cdot y^5 = 61236x^5y^5
\end{aligned}$$

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Q9 In the expansion of $(1 + a)^{m+n}$, prove that coefficients of a^m and a^n

Answer.

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by

$$T_{r+1} = {}^nC_r a^{n-r} b^r$$

Assuming that a^m occurs in the $(r + 1)^{\text{th}}$ term of the expansion $(1 + a)^{m+n}$, we obtain

$$T_{r+1} = {}^{m+n}C_r (1)^{m+n-r} (a)^r = {}^{m+n}C_r a^r$$

Therefore, the coefficient of a^m is

$$m + n C_m = \frac{(m+n)!}{m!(m+n-m)!} = \frac{(m+n)!}{m!n!}$$

Assuming that a^n occurs in the $(k + 1)^{\text{th}}$ term of the expansion $(1 + a)^{m+n}$, we obtain

$$T_{k+1} = {}^{m+n}C_k (1)^{m+n-k} (a)^k = {}^{m+n}C_k (a)^k$$

Therefore, the coefficient of a^n is

$$m + n C_n = \frac{(m+n)!}{n!(m+n-n)!} = \frac{(m+n)!}{n!m!}$$

Thus, from (1) and (2), it can be observed that the coefficients of a^m and a^n in the expansion of $(1 + a)^{m+n}$ are equal.

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Q10

The coefficients of the $(r - 1)^{\text{th}}$, r^{th} and $(r + 1)^{\text{th}}$ terms in the expansion of $(x + 1)^n$ are in the ratio 1 : 3 : 5. Find n and r .

Answer.

It is known that $(k+1)^{\text{th}}$ term, (T_{k+1}) , in the binomial expansion of $(a+b)^n$ is given by

$$T_{k+1} = {}^nC_k a^{n-k} b^k$$

$(r-1)^{\text{th}}$ term in the expansion of $(x+1)^n$ is $T_{r-1} = {}^nC_{r-2} (x)^{n-(r-2)} (1)^{(r-2)} = {}^nC_{r-2} x^{n-r+2}$

r^{th} term in the expansion of $(x+1)^n$ is $T_r = {}^nC_{r-1} (x)^{n-(r-1)} (1)^{(r-1)} = {}^nC_{r-1} x^{n-r+1}$

Therefore, the coefficients of the $(r-1)^{\text{th}}$, r^{th} , and $(r+1)^{\text{th}}$ terms in the expansion of $(x+1)^n$ are ${}^nC_{r-2}$, ${}^nC_{r-1}$, and ${}^nC_r$ respectively.

since these coefficients are in the ratio $1 : 3 : 5$, we obtain

$$\begin{aligned} \frac{{}^nC_{r-2}}{{}^nC_{r-1}} &= \frac{1}{3} \text{ and } \frac{{}^nC_{r-1}}{{}^nC_r} = \frac{3}{5} \\ \frac{{}^nC_{r-2}}{{}^nC_{r-1}} &= \frac{n!}{(r-2)!(n-r+2)!} \times \frac{(r-1)!(n-r+1)!}{n!} \\ &= \frac{(r-1)(r-2)!(n-r+1)!}{n!} \\ &= \frac{(r-1)(r-2)!(n-r+1)!}{(r-2)!(n-r+2)(n-r+1)!} \\ &= \frac{r-1}{n-r+2} \end{aligned}$$

$$\therefore \frac{r-1}{n-r+2} = \frac{1}{3}$$

$$\Rightarrow 3r - 3 = n - r + 2$$

$$\Rightarrow n - 4r + 5 = 0$$

$$\frac{{}^nC_{r-1}}{{}^nC_r} = \frac{n!}{(r-1)!(n-r+1)!} \times \frac{r!(n-r)!}{n!} = \frac{r(r-1)!(n-r)!}{(r-1)!(n-r+1)(n-r)!}$$

$$= \frac{r}{n-r+1}$$

$$\therefore \frac{r}{n-r+1} = \frac{3}{5}$$

$$\Rightarrow 5r = 3n - 3r + 3$$

$$\Rightarrow 3n - 8r + 3 = 0$$

Multiplying (1) by 3 and subtracting it from (2), we obtain

Putting the value of r in (1), we obtain

$$n - 12 + 5 = 0$$

$$\Rightarrow n = 7$$

Thus, $n = 7$ and $r = 3$

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Q11

Prove that the coefficient of x^n in the expansion of $(1+x)^2$ is twice the coefficient of x^n in the expansion of $(1+x)^{2n-1}$.

Answer.

It is known that $(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by

$$T_{r+1} = {}^nC_r a^{n-r} b^r$$

Assuming that x^n occurs in the $(r+1)^{\text{th}}$ term of the expansion of $(1+x)^{2n}$, we obtain

$$T_{r+1} = {}^{2n}C_r (1)^{2n-r} (x)^r = {}^{2n}C_r (x)^r$$

Therefore, the coefficient of x^n in the expansion of $(1+x)^{2n}$ is

$${}^{2n}C_n = \frac{(2n)!}{n!(2n-n)!} = \frac{(2n)!}{n!n!} = \frac{(2n)!}{(n!)^2}$$

Assuming that x^n occurs in the $(k + 1)^{\text{th}}$ term of the expansion $(1 + x)^{2n-1}$, we obtain

$$T_{k+1} = {}^{2n-1}C_k (1)^{2n-1-k} (x)^k = {}^{2n-1}C_k (x)^k$$

x^n in the expansion of $(1 + x)^{2n-1}$

$$\begin{aligned} 2n - 1 &= \frac{(2n - 1)!}{n!(2n - 1 - n)!} = \frac{(2n - 1)!}{n!(n - 1)!} \\ &= \frac{2n \cdot (2n - 1)!}{2n \cdot n!(n - 1)!} = \frac{(2n)!}{2 \cdot n!n!} = \frac{1}{2} \left[\frac{(2n)!}{(n!)^2} \right] \end{aligned}$$

From (1) and (2), it is observed that

$$\frac{1}{2} ({}^{2n}C_n) = {}^{2n-1}C_n$$

$$\Rightarrow {}^{2n}C_n = 2 ({}^{2n-1}C_n)$$

Therefore, the coefficient of x^n in the expansion of $(1 + x)^{2n}$ is twice the coefficient of x^n in the expansion of $(1 + x)^{2n-1}$.

Hence, proved.

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Q12

Find a positive value of m for which the coefficient of x^2 in the expansion $(1 + x)^n$ is 6.

Answer.

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by

$$T_{r+1} = {}^nC_r a^{n-r} b^r$$

Assuming that x^2 occurs in the $(r + 1)^{\text{th}}$ term of the expansion $(1 + x)^m$, we obtain

$$T_{r+1} = {}^mC_r (1)^{m-r} (x)^r = {}^mC_r (x)^r$$

Comparing the indices of x in x^2 and in T_{r+1} , we obtain

$$r = 2$$

Therefore, the coefficient of x^2 is ${}^mC_2$

It is given that the coefficient of x^2 in the expansion $(1 + x)^m$ is 6

$$\therefore {}^mC_2 = 6$$

$$\Rightarrow \frac{m!}{2!(m-2)!} = 6$$

$$\Rightarrow \frac{m(m-1)(m-2)!}{2 \times (m-2)!} = 6$$

$$\Rightarrow m(m-1) = 12$$

$$\Rightarrow m^2 - m - 12 = 0$$

$$\Rightarrow m^2 - 4m + 3m - 12 = 0$$

$$\Rightarrow m(m-4) + 3(m-4) = 0$$

$$\Rightarrow (m-4)(m+3) = 0$$

$$\Rightarrow (m-4) = 0 \text{ or } (m+3) = 0$$

$$\Rightarrow m = 4 \text{ or } m = -3$$

Thus, the positive value of m , for which the coefficient of x^2 in the expansion

$(1 + x)^m$ is 6, is 4.

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Q1

Find a, b and n in the expansion of $(a + b)^n$ if the first three terms of the expansion are 729, 7290 and 30375, respectively.

Answer.

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by

$$T_{r+1} = {}^nC_r a^{n-r} b^r$$

The first three terms of the expansion are given as 729, 7290, and 30375 respectively.

Therefore, we obtain

$$T_1 = {}^nC_0 a^{n-0} b^0 = a^n = 729$$

$$T_2 = {}^nC_1 a^{n-1} b^1 = na^{n-1}b = 7290$$

$$T_3 = {}^nC_2 a^{n-2} b^2 = \frac{n(n-1)}{2} a^{n-2} b^2 = 30375 \quad \dots (3)$$

Dividing (2) by (1), we obtain

$$na^{n-1}b = \frac{7290}{729}$$

$$\Rightarrow nba = 10$$

Dividing (3) by (2), we obtain

$$n(n-1)a^{n-2}b^2 \cdot 2na^{n-1}b = \frac{30375}{7290}$$

$$\Rightarrow (n-1)b^2a = \frac{30375}{7290}$$

$$\Rightarrow (n-1)ba = \frac{30375 \times 2}{7290} = \frac{25}{3}$$

$$\Rightarrow nba - \frac{b}{a} = \frac{25}{3}$$

$$\Rightarrow 10 - \frac{b}{a} = \frac{25}{3}$$

$$\Rightarrow ba = 10 - \frac{25}{3} = \frac{5}{3}$$

From (4) and (5), we obtain

$$n \cdot \frac{5}{3} = 10$$

$$\Rightarrow n = 6$$

Substituting $n = 6$ in equation (1), we obtain

$$a^6 = 729$$

$$\Rightarrow a = \sqrt[6]{729} = 3$$

From (5), we obtain

$$\frac{b}{3} = \frac{5}{3} \Rightarrow b = 5$$

Thus, $a = 3, b = 5$, and $n = 6$

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Q2 Find a if the coefficients of x^2 and x^3 in the expansion of $(3 + ax)^9$

Answer.

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by

$$T_{r+1} = {}^nC_r a^{n-r} b^r$$

Assuming that x^2 occurs in the $(r + 1)^{\text{th}}$ term in the expansion of $(3 + ax)^9$, we obtain

$$T_{r+1} = {}^9C_r (3)^{9-r} (ax)^r = {}^9C_r (3)^{9-r} a^r x^r$$

Thus, the coefficient of x^2 is

$${}^9C_2(3)^{9-2}a^2 = \frac{9!}{2!7!}(3)^7a^2 = 36(3)^7a^2$$

Assuming that x^3 occurs in the $(k+1)^{\text{th}}$ term in the expansion of $(3+ax)^9$, we obtain

$$T_{k+1} = {}^9C_k(3)^{9-k}(ax)^k = {}^9C_k(3)^{9-k}a^kx^k$$

Thus, the coefficient of x^3 is

$${}^9C_3(3)^{9-3}a^3 = \frac{9!}{3!6!}(3)^6a^3 = 84(3)^6a^3$$

$$84(3)^6a^3 = 36(3)^7a^2$$

$$\Rightarrow 84a = 36 \times 3$$

$$\Rightarrow a = \frac{36 \times 3}{84} = \frac{108}{84}$$

$$\Rightarrow a = \frac{9}{7}$$

Thus, the required value of a is $\frac{9}{7}$

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Q3 Find the coefficient of x^5 in the product $(1+2x)^6(1-x)^7$

Answer.

$$\begin{aligned}(1+2x)^6 &= {}^6C_0 + {}^6C_1(2x) + {}^6C_2(2x)^2 + {}^6C_3(2x)^3 + {}^6C_4(2x)^4 \\ &\quad + {}^6C_5(2x)^5 + {}^6C_6(2x)^6 \\ &= 1 + 6(2x) + 15(2x)^2 + 20(2x)^3 + 15(2x)^4 + 6(2x)^5 + (2x)^6 \\ &= 1 + 12x + 60x^2 + 160x^3 + 240x^4 + 192x^5 + 64x^6\end{aligned}$$

$$\begin{aligned}(1-x)^7 &= {}^7C_0 - {}^7C_1(x) + {}^7C_2(x)^2 - {}^7C_3(x)^3 + {}^7C_4(x)^4 \\ &\quad - {}^7C_5(x)^5 + {}^7C_6(x)^6 - {}^7C_7(x)^7 \\ &= 1 - 7x + 21x^2 - 35x^3 + 35x^4 - 21x^5 + 7x^6 - x^7\end{aligned}$$

$$\begin{aligned}\therefore (1+2x)^6(1-x)^7 &= (1 + 12x + 60x^2 + 160x^3 + 240x^4 + 192x^5 + 64x^6) (1 - 7x + 21x^2 - 35x^3 + 35x^4 - 21x^5 + 7x^6 - x^7)\end{aligned}$$

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Q4

If a and b are distinct integers, prove that $a-b$ is a factor of $a^n - b^n$, whenever n is a positive integer.

Answer.

In order to prove that $(a-b)$ is a factor of $(a^n - b^n)$, it has to be proved that $a^n - b^n = k(a-b)$, where k is some natural number

It can be written that, $a = a - b + b$

$$\begin{aligned}\therefore a^n &= (a - b + b)^n = [(a - b) + b]^n \\ &= {}^nC_0(a-b)^n + {}^nC_1(a-b)^{n-1}b + \dots + {}^nC_{n-1}(a-b)b^{n-1} + {}^nC_nb^n \\ &= (a-b)^n + {}^nC_1(a-b)^{n-1}b + \dots + {}^nC_{n-1}(a-b)b^{n-1} + b^n \\ \Rightarrow a^n - b^n &= (a-b) [(a-b)^{n-1} + {}^nC_1(a-b)^{n-2}b + \dots + {}^nC_{n-1}b^{n-1}] \\ \Rightarrow a^n - b^n &= k(a-b)\end{aligned}$$

where, $k = [(a-b)^{n-1} + {}^nC_1(a-b)^{n-2}b + \dots + {}^nC_{n-1}b^{n-1}]$ is a natural number

This shows that $(a-b)$ is a factor of $(a^n - b^n)$, where n is a positive integer.

Q5 Evaluate

$$(\sqrt{3} + \sqrt{2})^6 - (\sqrt{3} - \sqrt{2})^6$$

Answer.

Firstly, the expression $(a + b)^6 - (a - b)^6$ is simplified by using Binomial Theorem.

This can be done as

$$\begin{aligned}(a + b)^6 &= {}^6C_0 a^6 + {}^6C_1 a^5 b + {}^6C_2 a^4 b^2 + {}^6C_3 a^3 b^3 + {}^6C_4 a^2 b^4 + {}^6C_5 a b^5 + {}^6C_6 b^6 \\&= a^6 + 6a^5 b + 15a^4 b^2 + 20a^3 b^3 + 15a^2 b^4 + 6ab^5 + b^6 \\(a - b)^6 &= {}^6C_0 a^6 - {}^6C_1 a^5 b + {}^6C_2 a^4 b^2 - {}^6C_3 a^3 b^3 + {}^6C_4 a^2 b^4 - {}^6C_5 a b^5 + {}^6C_6 b^6 \\&= a^6 - 6a^5 b + 15a^4 b^2 - 20a^3 b^3 + 15a^2 b^4 - 6ab^5 + b^6\end{aligned}$$

Putting $a = \sqrt{3}$ and $b = \sqrt{2}$, we obtain

$$\begin{aligned}(\sqrt{3} + \sqrt{2})^6 - (\sqrt{3} - \sqrt{2})^6 &= 2 [6(\sqrt{3})^5(\sqrt{2}) + 20(\sqrt{3})^3(\sqrt{2})^3 + 6(\sqrt{3})(\sqrt{2})^5] \\&= 2[54\sqrt{6} + 120\sqrt{6} + 24\sqrt{6}] \\&= 2 \times 198\sqrt{6} \\&= 396\sqrt{6}\end{aligned}$$

Q6 Find the value of

$$\left(a^2 + \sqrt{a^2 - 1}\right)^4 + \left(a^2 - \sqrt{a^2 - 1}\right)^4$$

Answer.

Firstly, the expression $(x + y)^4 + (x - y)^4$ is simplified by using Binomial Theorem.

This can be done as

$$\begin{aligned}(x + y)^4 &= {}^4C_0 x^4 + {}^4C_1 x^3 y + {}^4C_2 x^2 y^2 + {}^4C_3 x y^3 + {}^4C_4 y^4 \\&= x^4 + 4x^3 y + 6x^2 y^2 + 4x y^3 + y^4 \\(x - y)^4 &= {}^4C_0 x^4 - {}^4C_1 x^3 y + {}^4C_2 x^2 y^2 - {}^4C_3 x y^3 + {}^4C_4 y^4 \\&= x^4 - 4x^3 y + 6x^2 y^2 - 4x y^3 + y^4 \\\therefore (x + y)^4 + (x - y)^4 &= 2(x^4 + 6x^2 y^2 + y^4)\end{aligned}$$

Putting $x = a^2$ and $y = \sqrt{a^2 - 1}$, we obtain

$$\begin{aligned}\left(a^2 + \sqrt{a^2 - 1}\right)^4 + \left(a^2 - \sqrt{a^2 - 1}\right)^4 &= 2 \left[(a^2)^4 + 6(a^2)^2 (\sqrt{a^2 - 1})^2 + (\sqrt{a^2 - 1})^4 \right] \\&= 2 \left[a^8 + 6a^4 (a^2 - 1) + (a^2 - 1)^2 \right] \\&= 2 \left[a^8 + 6a^6 - 6a^4 + a^4 - 2a^2 + 1 \right] \\&= 2 \left[a^8 + 6a^6 - 5a^4 - 2a^2 + 1 \right] \\&= 2a^8 + 12a^6 - 10a^4 - 4a^2 + 2\end{aligned}$$

Q7 Find an approximation of $(0.99)^5$ using the first three terms of its expansion

Answer.

$$0.99 = 1 - 0.01$$

$$\begin{aligned}\therefore (0.99)^5 &= (1 - 0.01)^5 \\ &= {}^5C_0(1)^5 - {}^5C_1(1)^4(0.01) + {}^5C_2(1)^3(0.01)^2 \\ &= 1 - 5(0.01) + 10(0.01)^2 \\ &= 1 - 0.05 + 0.001 \\ &= 0.951 \\ &= 0.951\end{aligned}$$

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Q8

Find n , if the ratio of the fifth term from the beginning to the fifth term from the end in the expansion of $\left(\sqrt[4]{2} + \frac{1}{\sqrt[4]{3}}\right)^n$ is $\sqrt{6} : 1$

Answer.

It is known that in the expansion $(a + b)^n$, if n is even, then the middle term is $\left(\frac{n}{2} + 1\right)^{\text{th}}$ term.

$$\begin{aligned}{}^nC_4(\sqrt[4]{2})^{n-1}\left(\frac{1}{\sqrt[4]{3}}\right)^4 &= {}^nC_4\frac{(\sqrt[4]{2})^n}{(\sqrt[4]{2})^4} \cdot \frac{1}{3} = {}^nC_4\frac{(\sqrt[4]{2})^n}{2} \cdot \frac{1}{3} = \frac{n!}{6 \cdot 4!(n-4)!}(\sqrt[4]{2})^n \\ {}^nC_{n-4}(\sqrt[4]{2})^4\left(\frac{1}{\sqrt[4]{3}}\right)^{n-4} &= {}^nC_{n-1} \cdot 2 \cdot \frac{(\sqrt[4]{3})^4}{(\sqrt[4]{3})^n} = {}^nC_{n-1} \cdot 2 \cdot \frac{3}{(\sqrt[4]{3})^n} = \frac{6n!}{(n-4)!4!} \cdot \frac{1}{(\sqrt[4]{3})^n} \\ \frac{n!}{6 \cdot 4!(n-4)!}(\sqrt[4]{2})^n : \frac{6n!}{(n-4)!4!} \cdot \frac{1}{(\sqrt[4]{3})^n} &= \sqrt{6} : 1 \\ \Rightarrow \frac{(\sqrt[4]{2})^n}{6} : \frac{6}{(\sqrt[4]{3})^n} &= \sqrt{6} : 1 \\ \Rightarrow \frac{(\sqrt[4]{2})^n}{6} \times \frac{(\sqrt[4]{3})^n}{6} &= \sqrt{6} \\ \Rightarrow (\sqrt[4]{6})^n &= 36\sqrt{6} \\ \Rightarrow 6^{\frac{n}{4}} &= 6^{\frac{5}{2}} \\ \Rightarrow \frac{n}{4} &= \frac{5}{2} \\ \Rightarrow n &= 4 \times \frac{5}{2} = 10\end{aligned}$$

Thus, the value of n is 10.

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Q9 Expand using binomial theorem $\left(1 + \frac{x}{2} - \frac{2}{x}\right)^4$, $x \neq 0$

Answer.

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by

$$T_{r+1} = {}^nC_ra^{n-1}b^r$$

Assuming that a^m occurs in the $(r + 1)^{\text{th}}$ term of the expansion $(1 + a)^{m+n}$, we obtain

$$T_{r+1} = {}^{m+n}C_r(1)^{m+n-r}(a)^r = {}^{m+n}C_ra^r$$

Therefore, the coefficient of a^m is

$$m + a_m = \frac{(m+n)!}{m!(m+n-m)!} = \frac{(m+n)!}{m!n!}$$

Therefore, the coefficient of a^n is

$$m + nC_n = \frac{(m+n)!}{n!(m+n-n)!} = \frac{(m+n)!}{n!m!}$$

$${}^{m+n}C_n = \frac{(m+n)!}{n!(m+n-n)!} = \frac{(m+n)!}{n!m!}$$

Thus, from (1) and (2), it can be observed that the coefficients of a^m and a^n in the expansion of $(1+a)^{m+n}$ are equal.

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Q10 Find the expression $(3x^2 - 2ax + 3a^2)^3$ using binomial theorem

Answer.

It is known that $(k+1)^{\text{th}}$ term, (T_{k+1}) , in the binomial expansion of $(a+b)^n$ is given by

$$T_{k+1} = {}^nC_1 a^{n-k} b^k$$

Therefore, $(r-1)^{\text{th}}$ term in the expansion of $(x+1)^n$ is

$$T_{r-1} = {}^nC_{1-2} (x)^{n-(r-2)} (1)^{(r-2)} = {}^nC_{r-2} x^{n-r+2}$$

$$\begin{aligned} & [(3x^2 - 2ax) + 3a^2]^3 \\ &= {}^3C_0 (3x^2 - 2ax)^3 + {}^3C_1 (3x^2 - 2ax)^2 (3a^2) + {}^3C_2 (3x^2 - 2ax) (3a^2)^2 + {}^3C_3 (3a^2)^3 \\ &= (3x^2 - 2ax)^3 + 3(9x^4 - 12ax^3 + 4a^2x^2)(3a^2) + 3(3x^2 - 2ax)(9a^4) + 27a^6 \\ &= (3x^2 - 2ax)^3 + 81a^2x^4 - 108a^3x^3 + 36a^4x^2 + 81a^4x^2 - 54a^5x + 27a^6 \\ &= (3x^2 - 2ax)^3 + 81a^2x^4 - 108a^3x^3 + 117a^4x^2 - 54a^5x + 27a^6 \end{aligned}$$

Again by using Binomial Theorem, we obtain

$$\begin{aligned} & (3x^2 - 2ax)^3 \\ &= {}^3C_0 (3x^2)^3 - {}^3C_1 (3x^2)^2 (2ax) + {}^3C_2 (3x^2) (2ax)^2 - {}^3C_3 (2ax)^3 \\ &= 27x^6 - 3(9x^4)(2ax) + 3(3x^2)(4a^2x^2) - 8a^3x^3 \\ &= 27x^6 - 54ax^5 + 36a^2x^4 - 8a^3x^3 \\ & (3x^2 - 2ax + 3a^2)^3 \\ &= 27x^6 - 54ax^5 + 36a^2x^4 - 8a^3x^3 + 81a^2x^4 - 108a^3x^3 + 117a^4x^2 - 54a^5x + 27a^6 \\ &= 27x^6 - 54ax^5 + 117a^2x^4 - 116a^3x^3 + 117a^4x^2 - 54a^5x + 27a^6 \end{aligned}$$

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