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Binomial Expansion non integer powers | Past Paper Question | C4 Edexcel June 2013 Q2(a)

(a) Use the binomial expansion to show that $\sqrt{\left(\frac{1+x}{1-x}\right)} = 1 + x + \frac{1}{2}x^2, \quad |x| < 1 \quad (6)$

$$(1+a)^n \equiv 1 + na + \frac{n(n-1)}{2!}a^2 + \frac{n(n-1)(n-2)}{3!}a^3 + \dots$$

$$\begin{aligned}\sqrt{\left(\frac{1+x}{1-x}\right)} &= (1+x)^{1/2} (1-x)^{-1/2} \\ &\approx \left[1 + \left(\frac{1}{2}\right)x + \left(\frac{1}{2}\right)\left(-\frac{1}{2}\right)\frac{x^2}{2!} + \dots\right] \left[1 + \left(-\frac{1}{2}\right)(-x) + \left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)\frac{(-x)^2}{2!} + \dots\right] \\ &\approx \left(1 + \frac{x}{2} - \frac{x^2}{8} + \dots\right) \left(1 + \frac{x}{2} + \frac{3x^2}{8} + \dots\right) \\ &\approx 1 + \frac{x}{2} + \frac{3x^2}{8} + \frac{x}{2} + \frac{x^2}{4} - \frac{x^2}{8} + \dots \\ &\approx 1 + x + \frac{1}{2}x^2 + \dots\end{aligned}$$

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