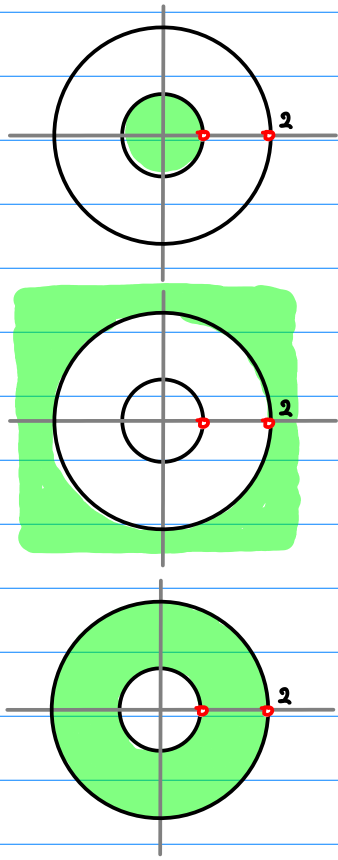
Laurent Series and z-Transform Examples case 3.B

20171226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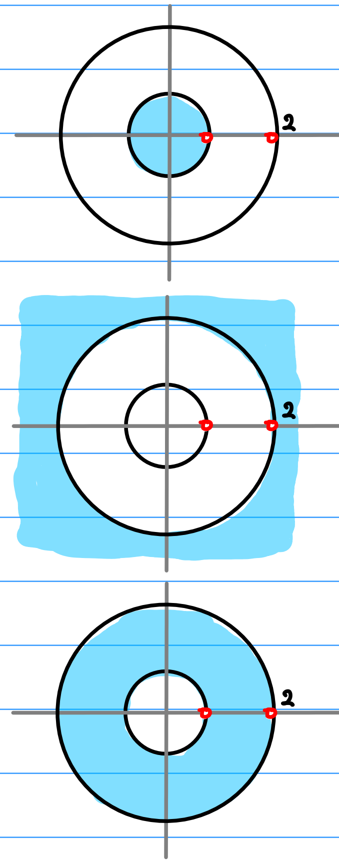
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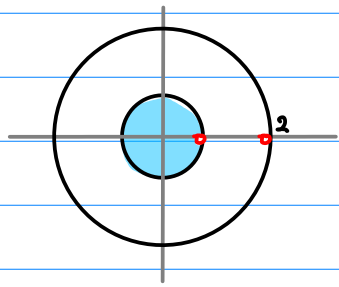
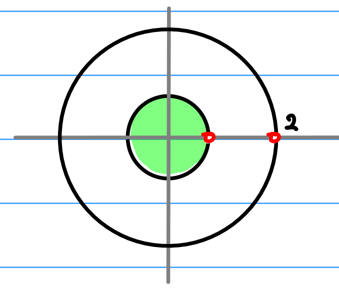
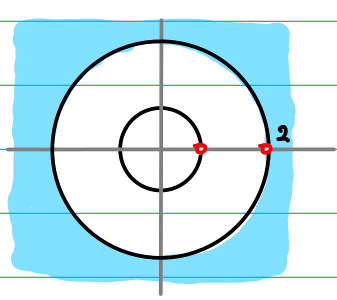
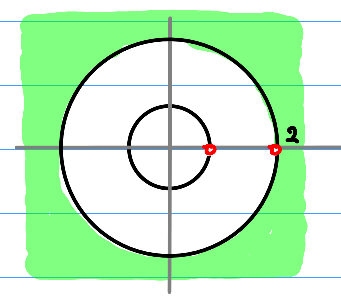
3.B $\quad f(z) = \frac{3}{2} \frac{-1}{(z-1)(z-2)} = X(z) = \frac{3}{2} \frac{-1}{(z-1)(z-2)}$



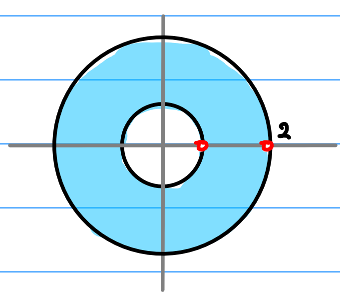


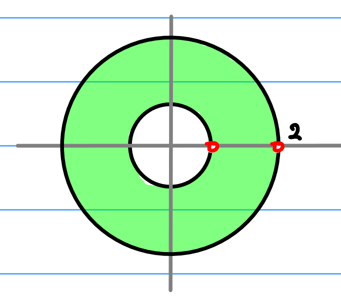
$$\sum_{n=0}^{\infty} \left[\left(\tfrac{1}{2}\right)^{n+1} - 2^{n+1}\right] z^n \xleftrightarrow{-n} \sum_{n=0}^{-\infty} \left[2^{n-1} - \left(\tfrac{1}{2}\right)^{n-1}\right] z^{-n}$$





$$\sum_{n=-1}^{\infty} \left[2^{n+1} - \left(\tfrac{1}{2}\right)^{n+1}\right] z^n \xleftrightarrow{-n} \sum_{n=1}^{\infty} \left[\left(\tfrac{1}{2}\right)^{n-1} - 2^{n-1}\right] z^{-n}$$





$$\sum_{n=-1}^{\infty} 2^{n+1} z^n + \sum_{n=0}^{\infty} \left(\tfrac{1}{2}\right)^{n+1} z^n \xleftrightarrow{-n} \sum_{n=1}^{\infty} \left(\tfrac{1}{2}\right)^{n-1} z^{-n} + \sum_{n=0}^{-\infty} 2^{n-1} z^{-n}$$

3.B $\quad f(z) = \frac{3}{2}\,\frac{-1}{(z-1)(z-2)} \quad = \quad X(z) = \frac{3}{2}\,\frac{-1}{(z-1)(z-2)}$

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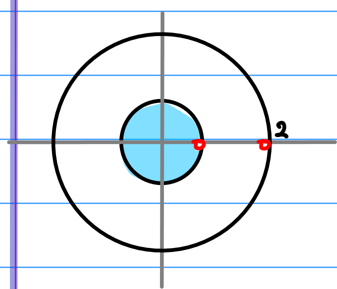

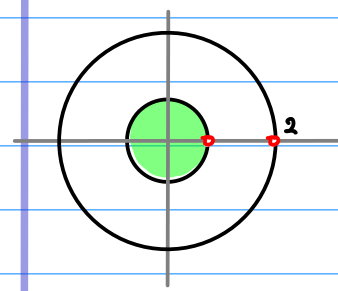

$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} - 2^{n+1} & (n \geq 0) \\ 0 & (n < 0) \end{cases} \qquad x_n = \begin{cases} 0 & (n > 0) \\ 2^{n-1} - \left(\frac{1}{2}\right)^{n-1} & (n \leq 0) \end{cases}$$

$$f(z) = \sum_{n=0}^{\infty} \left[\left(\frac{1}{2}\right)^{n+1} - 2^{n+1}\right] z^n \qquad X(z) = \sum_{n=0}^{-\infty} \left[2^{n-1} - \left(\frac{1}{2}\right)^{n-1}\right] z^{-n}$$

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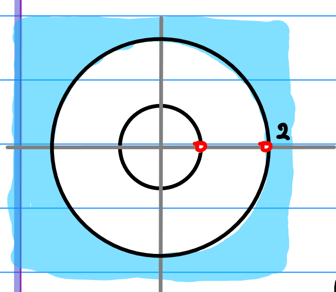

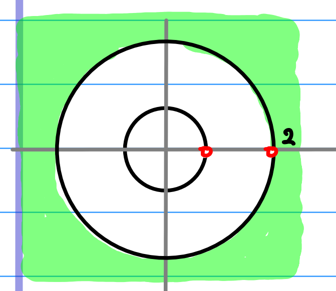

$$a_n = \begin{cases} 0 & (n \geq 0) \\ 2^{n+1} - \left(\frac{1}{2}\right)^{n+1} & (n < 0) \end{cases} \qquad x_n = \begin{cases} \left(\frac{1}{2}\right)^{n-1} - 2^{n-1} & (n > 0) \\ 0 & (n \leq 0) \end{cases}$$

$$f(z) = \sum_{n=-1}^{\infty} \left[2^{n+1} - \left(\frac{1}{2}\right)^{n+1}\right] z^n \qquad X(z) = \sum_{n=1}^{\infty} \left[\left(\frac{1}{2}\right)^{n-1} - 2^{n-1}\right] z^{-n}$$

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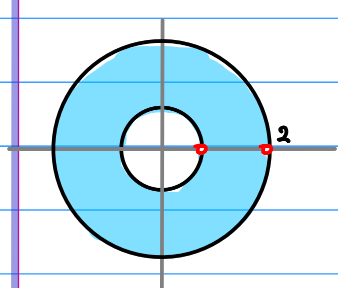
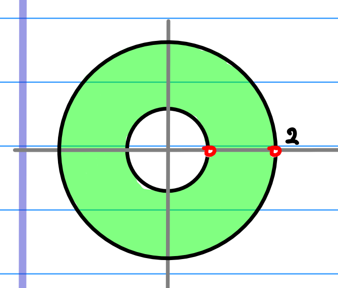




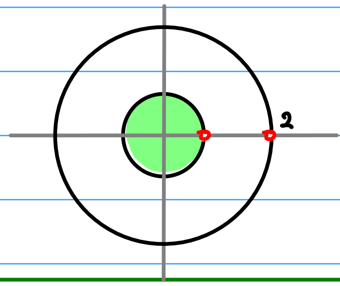
$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} & (n \geq 0) \\ 2^{n+1} & (n < 0) \end{cases} \qquad x_n = \begin{cases} \left(\frac{1}{2}\right)^{n-1} & (n > 0) \\ 2^{n-1} & (n \leq 0) \end{cases}$$

$$f(z) = \sum_{n=-1}^{\infty} 2^{n+1} z^n + \sum_{n=0}^{\infty} \left(\frac{1}{2}\right)^{n+1} z^n \qquad X(z) = \sum_{n=1}^{\infty} \left(\frac{1}{2}\right)^{n-1} z^{-n} + \sum_{n=0}^{-\infty} 2^{n-1} z^{-n}$$

$$X(z) = \frac{3}{2}\,\frac{-1}{(z-0.5)(z-2)} = \left(\frac{1}{z-0.5} - \frac{1}{z-2}\right)$$

$|z| < 0.5$

$|z| < 2$



$$-\frac{(2)}{1-(2z)} + \frac{\left(\frac{1}{2}\right)}{1-\left(\frac{z}{2}\right)}$$

$$= -\sum_{n=0}^{\infty}(2)(2z)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)\left(\frac{z}{2}\right)^n$$

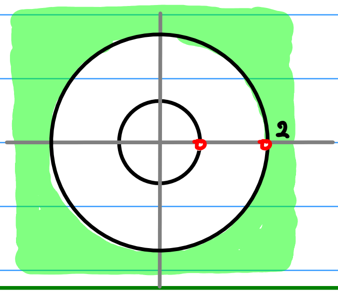
$$= -\sum_{n=0}^{\infty} 2^{n+1} z^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^{n+1} z^n$$

$$= \sum_{n=0}^{\infty}\left[\left(\frac{1}{2}\right)^{n+1} - 2^{n+1}\right] z^n$$

$$\boxed{\sum_{n=0}^{-\infty}\left[2^{n-1} - \left(\frac{1}{2}\right)^{n-1}\right] z^{-n}}$$

$0.5 < |z|$

$2 < |z|$



$$\frac{\left(\frac{1}{z}\right)}{1-\left(\frac{1}{2z}\right)} - \frac{\left(\frac{1}{z}\right)}{1-\left(\frac{2}{z}\right)}$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{2z}\right)^n - \sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{2}{z}\right)^n$$

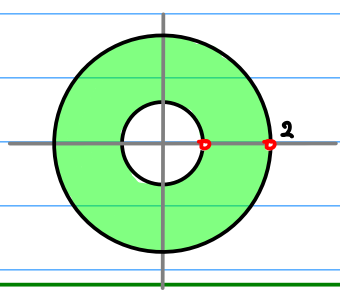
$$= +\sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^n z^{-n-1} - \sum_{n=0}^{\infty}(2)^n z^{-n-1}$$

$$= \sum_{n=1}^{\infty}\left[\left(\frac{1}{2}\right)^{n-1} - 2^{n-1}\right] z^{-n}$$

$$\boxed{\sum_{n=1}^{\infty}\left[\left(\frac{1}{2}\right)^{n-1} - 2^{n-1}\right] z^{-n}}$$

$0.5 < |z|$

$|z| < 2$



$$+\frac{\left(\frac{1}{z}\right)}{1-\left(\frac{1}{2z}\right)} + \frac{\left(\frac{1}{2}\right)}{1-\left(\frac{z}{2}\right)}$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{2z}\right)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)\left(\frac{z}{2}\right)^n$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^n z^{-n-1} + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^{n+1} z^n$$

$$= \sum_{n=1}^{\infty}\left(\frac{1}{2}\right)^{n-1} z^{-n} + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^{n+1} z^n$$

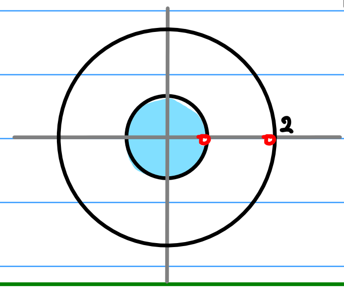
$$\boxed{\sum_{n=1}^{\infty}\left(\frac{1}{2}\right)^{n-1} z^{-n} + \sum_{n=0}^{-\infty} 2^{n-1} z^{-n}}$$

$$X(z) = \frac{3}{2}\,\frac{-1}{(z-0.5)(z-2)} = \left(\frac{1}{z-0.5} - \frac{1}{z-2}\right)$$

$$f(z) = \frac{3}{2}\,\frac{-1}{(z-0.5)(z-2)} = \left(\frac{1}{z-0.5} - \frac{1}{z-2}\right)$$

$|z| < 0.5$

$|z| < 2$



$$-\frac{(2)}{1-(2z)} + \frac{(\frac{1}{2})}{1-(\frac{z}{2})}$$

$$= -\sum_{n=0}^{\infty}(2)(2z)^n + \sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)\left(\tfrac{z}{2}\right)^n$$

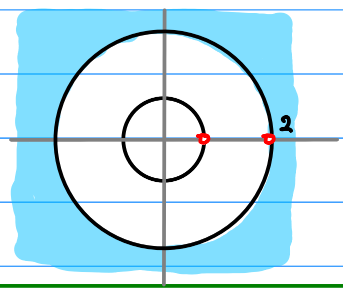
$$= -\sum_{n=0}^{\infty} 2^{n+1} z^n + \sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)^{n+1} z^n$$

$$= \sum_{n=0}^{\infty}\left[\left(\tfrac{1}{2}\right)^{n+1} - 2^{n+1}\right] z^n$$

$$\boxed{\sum_{n=0}^{\infty}\left[\left(\tfrac{1}{2}\right)^{n+1} - 2^{n+1}\right] z^n}$$

$0.5 < |z|$

$2 < |z|$



$$\frac{(\frac{1}{z})}{1-(\frac{1}{2z})} - \frac{(\frac{1}{z})}{1-(\frac{2}{z})}$$

$$= +\sum_{n=0}^{\infty}\left(\tfrac{1}{z}\right)\left(\tfrac{1}{2z}\right)^n - \sum_{n=0}^{\infty}\left(\tfrac{1}{z}\right)\left(\tfrac{2}{z}\right)^n$$

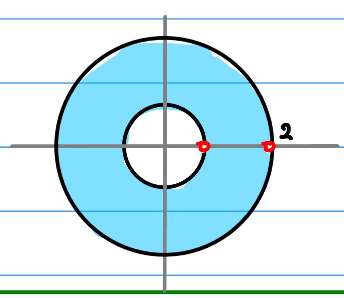
$$= +\sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)^n z^{-n-1} - \sum_{n=0}^{\infty}(2)^n z^{-n-1}$$

$$= \sum_{n=1}^{\infty}\left[\left(\tfrac{1}{2}\right)^{n-1} - 2^{n-1}\right] z^{-n}$$

$$\boxed{\sum_{n=-1}^{\infty}\left[2^{n+1} - \left(\tfrac{1}{2}\right)^{n+1}\right] z^n}$$

$0.5 < |z|$

$|z| < 2$



$$+\frac{(\frac{1}{z})}{1-(\frac{1}{2z})} + \frac{(\frac{1}{2})}{1-(\frac{z}{2})}$$

$$= +\sum_{n=0}^{\infty}\left(\tfrac{1}{z}\right)\left(\tfrac{1}{2z}\right)^n + \sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)\left(\tfrac{z}{2}\right)^n$$

$$= +\sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)^n z^{-n-1} + \sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)^{n+1} z^n$$

$$= \sum_{n=1}^{\infty}\left(\tfrac{1}{2}\right)^{n-1} z^{-n} + \sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)^{n+1} z^n$$

$$\boxed{\sum_{n=-1}^{\infty} 2^{n+1} z^n + \sum_{n=0}^{\infty}\left(\tfrac{1}{2}\right)^{n+1} z^n}$$

$$f(z) = \frac{3}{2}\,\frac{-1}{(z-0.5)(z-2)} = \left(\frac{1}{z-0.5} - \frac{1}{z-2}\right)$$

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$$f(z) = \frac{-1}{(z-1)(z-2)} = X(z)$$

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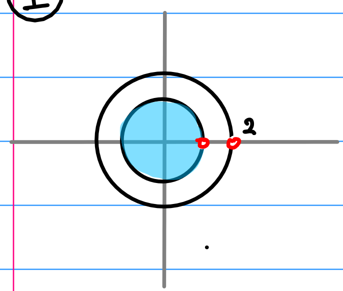

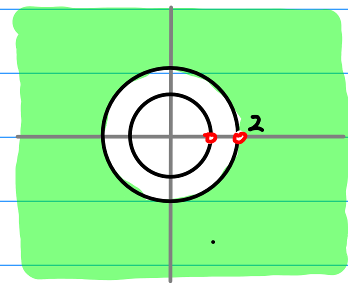

$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} - 1 & (n \geq 0) \\ 0 & (n < 0) \end{cases}$$

$$x_n = \begin{cases} 1 - 2^{n-1} & (n > 0) \\ 0 & (n \leq 0) \end{cases}$$

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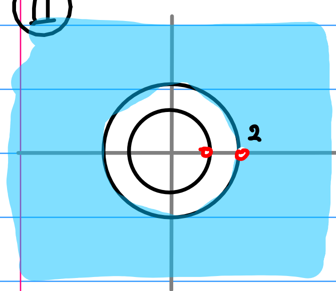

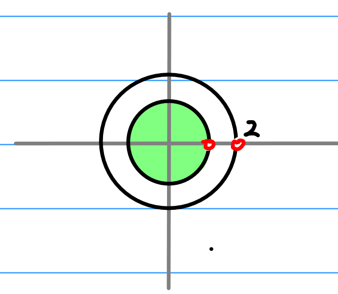

$$a_n = \begin{cases} 0 & (n \geq 0) \\ & (n < 0) \end{cases}$$

$$x_n = \begin{cases} 0 & (n > 0) \\ 2^{n-1} - 1 & (n \leq 0) \end{cases}$$

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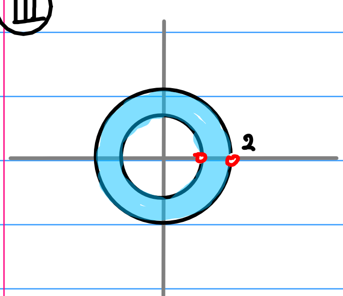
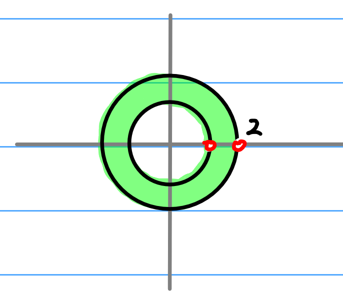




$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} & (n \geq 0) \\ 1 & (n < 0) \end{cases}$$

$$x_n = \begin{cases} 1 & (n > 0) \\ 2^{n-1} & (n \leq 0) \end{cases}$$

$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} - 1 & (n \geq 0) \\ 0 & (n < 0) \end{cases}$$

$$x_n = \begin{cases} 0 & (n > 0) \\ \left(\frac{1}{2}\right)^{-n+1} - 1 & (n \leq 0) \end{cases}$$

$$f(z) = \sum_{n=0}^{\infty} \left(\frac{1}{2}\right)^{n+1} z^n - \sum_{n=0}^{\infty} 1 \cdot z^n$$

$$X(z) = \sum_{n=0}^{-\infty} \left(\frac{1}{2}\right)^{-n+1} z^{-n} - \sum_{n=0}^{-\infty} 1 \cdot z^{-n}$$

$$= \sum_{n=0}^{\infty} \left(\frac{1}{2}\right)^{n+1} z^n - \sum_{n=0}^{\infty} 1 \cdot z^n$$

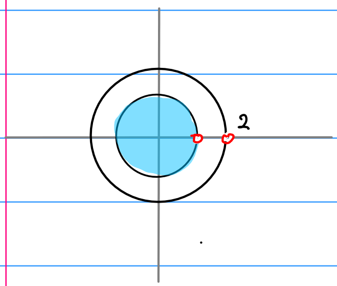
$$= \frac{\left(\frac{1}{2}\right)}{1 - \left(\frac{z}{2}\right)} - \frac{1}{1 - z}$$

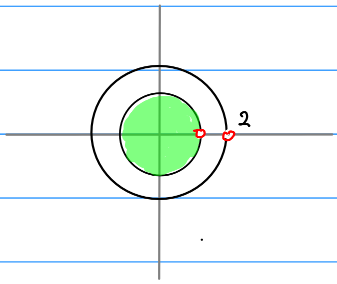
$$= \frac{-1}{z-2} + \frac{1}{z-1}$$

$$= \frac{-z+1+z-2}{(z-1)(z-2)}$$

$$= \frac{-1}{(z-1)(z-2)}$$

$$\left|\frac{z}{2}\right| < 1 \qquad \left|\frac{z}{1}\right| < 1$$





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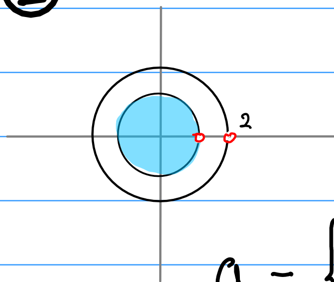
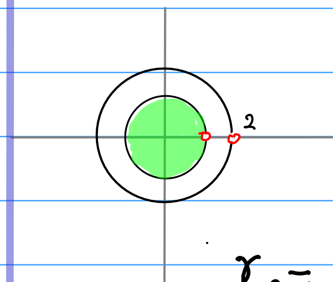


$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} - 1 & (n \geq 0) \\ 0 & (n < 0) \end{cases}$$

$$f(z) = \sum_{n=0}^{\infty} 2^{-n-1} \cdot z^n - \sum_{n=0}^{\infty} 1 \cdot z^n$$



$$x_n = \begin{cases} 0 & (n > 0) \\ 2^{n-1} - 1 & (n \leq 0) \end{cases}$$

$$X(z) = \sum_{n=0}^{-\infty} 2^{n-1} \cdot z^{-n} - \sum_{n=0}^{-\infty} 1 \cdot z^{-n}$$

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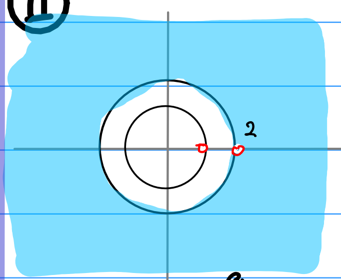
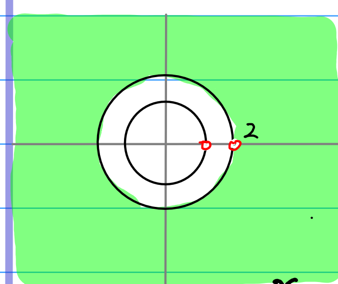


$$a_n = \begin{cases} 0 & (n \geq 0) \\ 1 - \left(\frac{1}{2}\right)^{n+1} & (n < 0) \end{cases}$$

$$f(z) = \sum_{n=-1}^{-\infty} 1 \cdot z^n - \sum_{n=-1}^{-\infty} 2^{-n-1} \cdot z^n$$



$$x_n = \begin{cases} 1 - 2^{n-1} & (n > 0) \\ 0 & (n \leq 0) \end{cases}$$

$$X(z) = \sum_{n=1}^{\infty} 1 \cdot z^{-n} - \sum_{n=1}^{\infty} 2^{n-1} \cdot z^{-n}$$

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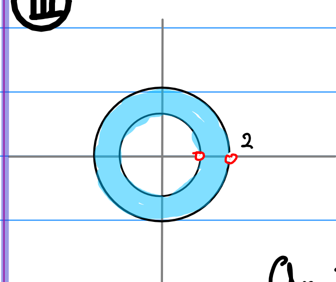
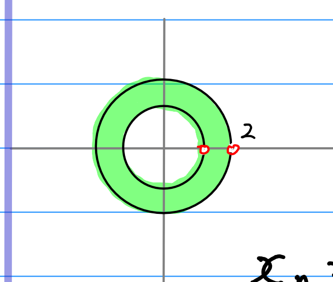


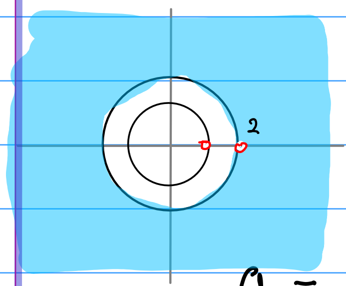
$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} & (n \geq 0) \\ 1 & (n < 0) \end{cases}$$

$$f(z) = \sum_{n=-1}^{-\infty} 1 \cdot z^n - \sum_{n=0}^{\infty} 2^{-n-1} \cdot z^n$$



$$x_n = \begin{cases} 1 & (n > 0) \\ 2^{n-1} & (n \leq 0) \end{cases}$$

$$X(z) = \sum_{n=1}^{\infty} 1 \cdot z^{-n} - \sum_{n=0}^{-\infty} 2^{n-1} \cdot z^{-n}$$



$$a_n = \begin{cases} 0 & (n \geq 0) \\ 1-\left(\frac{1}{2}\right)^{n+1} & (n<0) \end{cases}$$

$$f(z) = \sum_{n=-1}^{-\infty} 1 \cdot z^n - \sum_{n=-1}^{-\infty} 2^{-n-1} z^n$$

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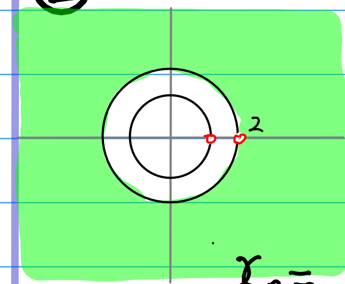
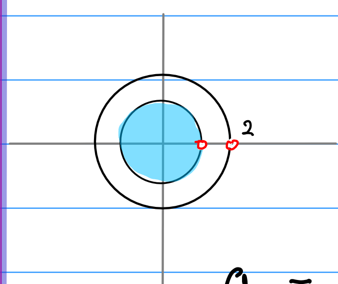


$$x_n = \begin{cases} 1-2^{n-1} & (n>0) \\ 0 & (n \leq 0) \end{cases}$$

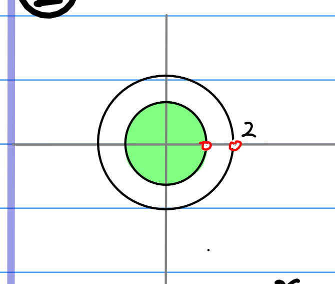
$$X(z) = \sum_{n=1}^{\infty} 1 \cdot z^{-n} - \sum_{n=1}^{\infty} 2^{n-1} z^{-n}$$



$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} - 1 & (n \geq 0) \\ 0 & (n<0) \end{cases}$$

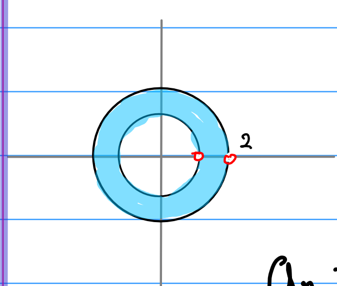
$$f(z) = \sum_{n=0}^{\infty} 2^{-n-1} \cdot z^n - \sum_{n=0}^{\infty} 1 \cdot z^n$$

Ⅱ



$$x_n = \begin{cases} 0 & (n>0) \\ 2^{n-1} - 1 & (n \leq 0) \end{cases}$$

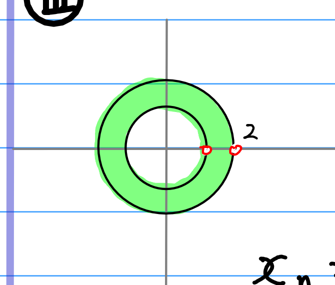
$$X(z) = \sum_{n=0}^{-\infty} 2^{n-1} \cdot z^{-n} - \sum_{n=0}^{-\infty} 1 \cdot z^{-n}$$



$$a_n = \begin{cases} \left(\frac{1}{2}\right)^{n+1} & (n \geq 0) \\ 1 & (n<0) \end{cases}$$

$$f(z) = \sum_{n=-1}^{-\infty} 1 \cdot z^n + \sum_{n=0}^{\infty} 2^{-n-1} \cdot z^n$$

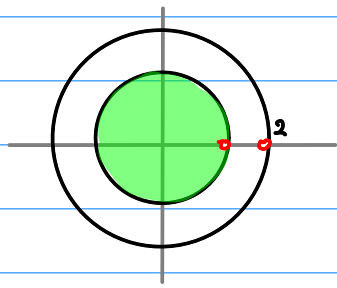
Ⅲ

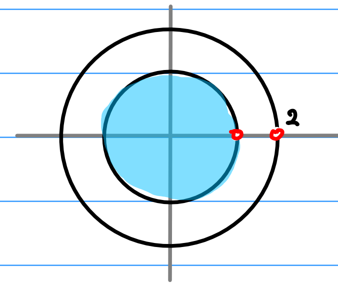


$$x_n = \begin{cases} 1 & (n>0) \\ 2^{n-1} & (n \leq 0) \end{cases}$$

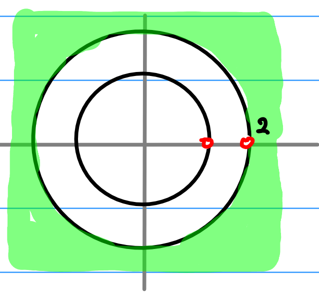
$$X(z) = \sum_{n=0}^{-\infty} 2^{n-1} \cdot z^{-n} + \sum_{n=1}^{\infty} 1 \cdot z^{-n}$$

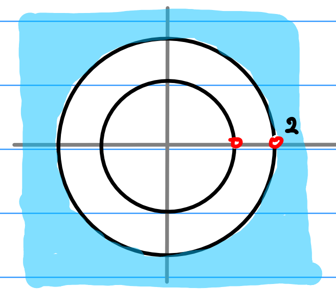
3.B $X(z) = \frac{-1}{(z-1)(z-2)}$ $=$ $f(z) = \frac{-1}{(z-1)(z-2}$



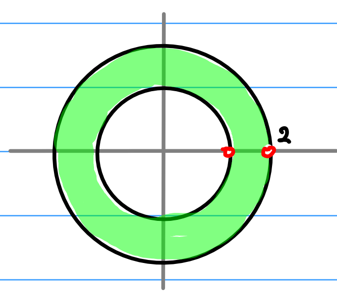


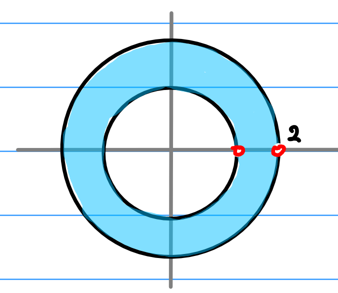
$\sum_{n=0}^{\infty} [(\frac{1}{2})^{n+1} - 1] z^{-n} \xrightarrow{-n} \sum_{n=0}^{-\infty} [2^{n-1} - 1] z^{-n}$





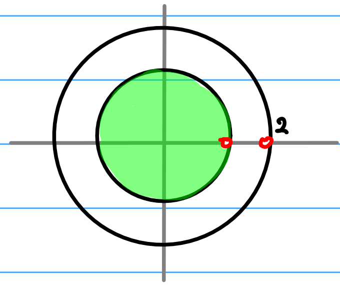
$\sum_{n=-1}^{-\infty} [(\frac{1}{2})^{n+1} - 1] z^{-n} \xrightarrow{-n} \sum_{n=1}^{\infty} [1 - 2^{n-1}] z^{-n}$





$- \sum_{n=0}^{\infty} z^{-n} - \sum_{n=-1}^{\infty} 2^{-n-1} z^{-n} \xrightarrow{-n} + \sum_{n=1}^{\infty} z^{-n} + \sum_{n=0}^{-\infty} 2^{n-1} z^{-n}$

$$X(z) = \frac{-1}{(z-1)(z-2)} = \frac{1}{(z-1)} - \frac{1}{(z-2)}$$

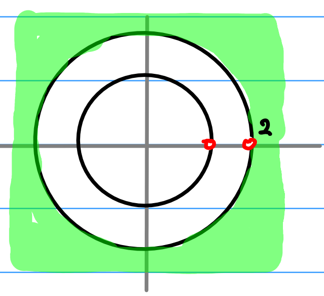


$$-\frac{\left(\frac{1}{1}\right)}{1-\left(\frac{z}{1}\right)} + \frac{\left(\frac{1}{2}\right)}{1-\left(\frac{z}{2}\right)}$$

$$= -\sum_{n=0}^{\infty}(1)\left(\frac{z}{1}\right)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)\left(\frac{z}{2}\right)^n$$

$$= \sum_{n=0}^{\infty}\left[\left(\frac{1}{2}\right)^{n+1} - 1\right] z^n$$

$$= \sum_{n=0}^{-\infty}\left[2^{n-1} - 1\right] z^{-n}$$

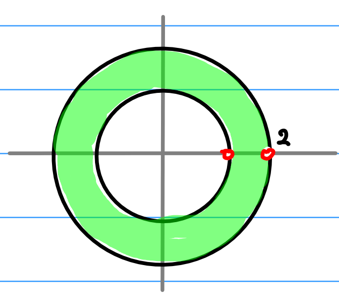


$$+\frac{\left(\frac{1}{z}\right)}{1-\left(\frac{1}{z}\right)} - \frac{\left(\frac{1}{z}\right)}{1-\left(\frac{2}{z}\right)}$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{z}\right)^n - \sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{2}{z}\right)^n$$

$$= \sum_{n=0}^{\infty}\left[1 - 2^n\right] z^{-n-1}$$

$$= \sum_{n=1}^{\infty}\left[1 - 2^{n-1}\right] z^{-n}$$



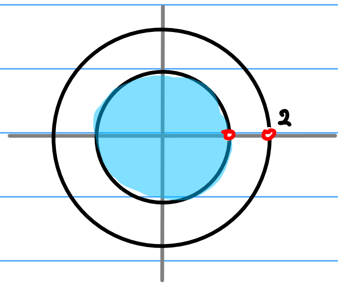
$$+\frac{\left(\frac{1}{z}\right)}{1-\left(\frac{1}{z}\right)} + \frac{\left(\frac{1}{2}\right)}{1-\left(\frac{z}{2}\right)}$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{z}\right)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)\left(\frac{z}{2}\right)^n$$

$$= +\sum_{n=0}^{\infty} z^{-n-1} + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^{n+1} z^n$$

$$= +\sum_{n=1}^{\infty} z^{-n} + \sum_{n=0}^{-\infty} 2^{n-1} z^{-n}$$

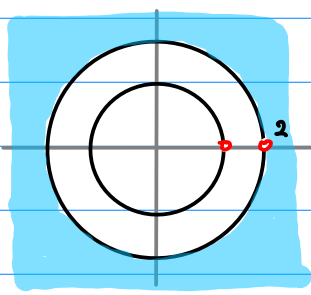
$$f(z) = \frac{-1}{(z-1)(z-2)} = \frac{1}{(z-1)} - \frac{1}{(z-2)}$$



$$-\frac{\left(\frac{1}{1}\right)}{1-\left(\frac{z}{1}\right)} + \frac{\left(\frac{1}{2}\right)}{1-\left(\frac{z}{2}\right)}$$

$$= -\sum_{n=0}^{\infty}(1)\left(\frac{z}{1}\right)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)\left(\frac{z}{2}\right)^n$$

$$= \sum_{n=0}^{\infty}\left[\left(\frac{1}{2}\right)^{n+1} - 1\right] z^n$$

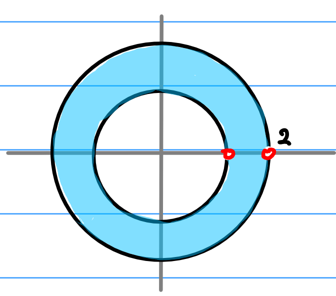


$$+\frac{\left(\frac{1}{z}\right)}{1-\left(\frac{1}{z}\right)} - \frac{\left(\frac{1}{z}\right)}{1-\left(\frac{2}{z}\right)}$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{z}\right)^n - \sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{2}{z}\right)^n$$

$$= \sum_{n=0}^{\infty}\left[1 - 2^n\right] z^{-n-1}$$

$$= \sum_{n=-1}^{-\infty}\left[1 - \left(\frac{1}{2}\right)^{n+1}\right] z^n$$



$$+\frac{\left(\frac{1}{z}\right)}{1-\left(\frac{1}{z}\right)} + \frac{\left(\frac{1}{2}\right)}{1-\left(\frac{z}{2}\right)}$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{z}\right)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)\left(\frac{z}{2}\right)^n$$

$$= +\sum_{n=0}^{\infty}\left(\frac{1}{z}\right)\left(\frac{1}{z}\right)^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^{n+1} z^n$$

$$= +\sum_{n=-1}^{-\infty} z^n + \sum_{n=0}^{\infty}\left(\frac{1}{2}\right)^{n+1} z^n$$