

NCERT 10.5.3 Q16

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Question : A sum of ₹700 is to be used to give seven cash prizes to students of a school for their overall academic performance. If each prize is ₹20 less than its preceding prize, find the value of each of the prizes.

Solution:

Parameter	Description	Value
$x(n)$	n^{th} term of discrete signal	$(x(0)+nd)u(n)$
$x(0)$	1 st term of the AP	?
d	Common Difference of the AP	-20

TABLE 0: Given parameters

From (??)

$$X(z) = \frac{x(0)}{1 - z^{-1}} - \frac{20 \cdot z^{-1}}{(1 - z^{-1})^2}; |z| > 1 \quad (1)$$

$$\therefore y(n) = x(n) * u(n) \quad (2)$$

$$Y(z) = X(z)U(z) \quad (3)$$

$$\Rightarrow Y(z) = \frac{x(0)}{(1 - z^{-1})^2} - \frac{20 \cdot z^{-1}}{(1 - z^{-1})^3}; |z| > 1 \quad (4)$$

$$y(6) = \frac{1}{2\pi j} \oint_c Y(z)z^5 dz \quad (5)$$

$$= \frac{1}{2\pi j} \int \frac{x(0) \cdot z^7}{(z-1)^2} dz - \frac{1}{2\pi j} \int \frac{20 \cdot z^7}{(z-1)^3} dz \quad (6)$$

$$\therefore R = \frac{1}{(m-1)!} \lim_{z \rightarrow a} \frac{d^{m-1}}{dz^{m-1}} ((z-a)^m f(z)) \quad (7)$$

$$R_1 = \frac{1}{1!} \lim_{z \rightarrow 1} \frac{d}{dz} \left((z-1)^2 \cdot \frac{x(0) \cdot z^7}{(z-1)^2} \right) \quad (8)$$

$$= 7x(0) \quad (9)$$

$$R_2 = \frac{1}{2!} \lim_{z \rightarrow 1} \frac{d^2}{dz^2} \left((z-1)^3 \cdot \frac{-20 \cdot z^7}{(z-1)^3} \right) \quad (10)$$

$$= -420 \quad (11)$$

$$\Rightarrow y(6) = R_1 + R_2 \quad (12)$$

$$700 = -420 + 7x(0) \quad (13)$$

$$\Rightarrow x(0) = 160 \quad (14)$$

The value of each of the prizes is 160,140,120,100,80,60,40.

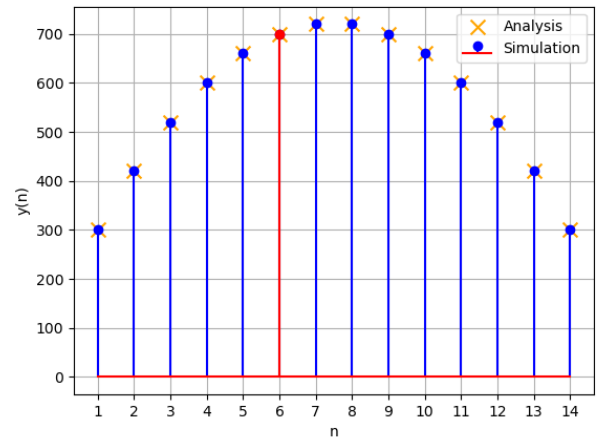


Fig. 0: $y(n) = 170n - 10n^2$

Using contour integration for inverse Z transformation,