Sequence(19) 10.5.3

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Question :-

200 logs are stacked in the following manner: 20 logs in the bottom row, 19 in the next row, 18 in the row next to it and so on . In how many rows are the 200 logs placed and how many logs are in the top row?

Symbol	Description	Value
$x(0)$	bottom row	20
d	common difference	-1
y(n)	total number of logs	200
x(n)	number of logs in n row	depends on n

TABLE I

For an Arithmetic Progression :-

$$x(n) = [x(0) + nd]\,u(n) \tag{1}$$
$$x(n) = [20 - n]\,u(n) \tag{2}$$
$$X(z) = \frac{20 - 21z^{-1}}{(1 - z^{-1})^2} \quad |z| > 1 \tag{3}$$
$$y(n) = x(n) * u(n) \tag{4}$$
$$Y(z) = X(z)\,U(z) \tag{5}$$
$$Y(z) = \frac{20 - 21z^{-1}}{(1 - z^{-1})^3} \tag{6}$$

Using Contour Integration to find the inverse Z-transform,

$$y(n) = \frac{1}{2\pi j}\oint_C Y(z)\,z^{n-1}\,dz \tag{7}$$
$$= \frac{1}{2\pi j}\oint_C \frac{(20 - 21z^{-1})z^{n-1}}{(1 - z^{-1})^3}\,dz \tag{8}$$

We can observe that the pole is repeated 3 times and thus $m = 3$,

$$R = \frac{1}{(m-1)!}\lim_{z\to a}\frac{d^{m-1}}{dz^{m-1}}\left((z-a)^m f(z)\right) \tag{9}$$
$$\implies \frac{1}{(2)!}\lim_{z\to 1}\frac{d^2}{dz^2}\left(20z^{n+2} - 21z^{n+1}\right) \tag{10}$$
$$\implies \frac{1}{2}\lim_{z\to 1}(20(n+2)(n+1)z^n - 21(n)(n+1)z^{n-1}) \tag{11}$$
$$\implies \frac{1}{2}[20(n+2)(n+1) - 21(n)(n+1)] \tag{12}$$

$$R = y(n) \tag{13}$$
$$200 = \frac{1}{2}\left[20\,(n+2)\,(n+1) - 21\,(n)\,(n+1)\right] \tag{14}$$
$$n = 15\ ,\ 24 \tag{15}$$

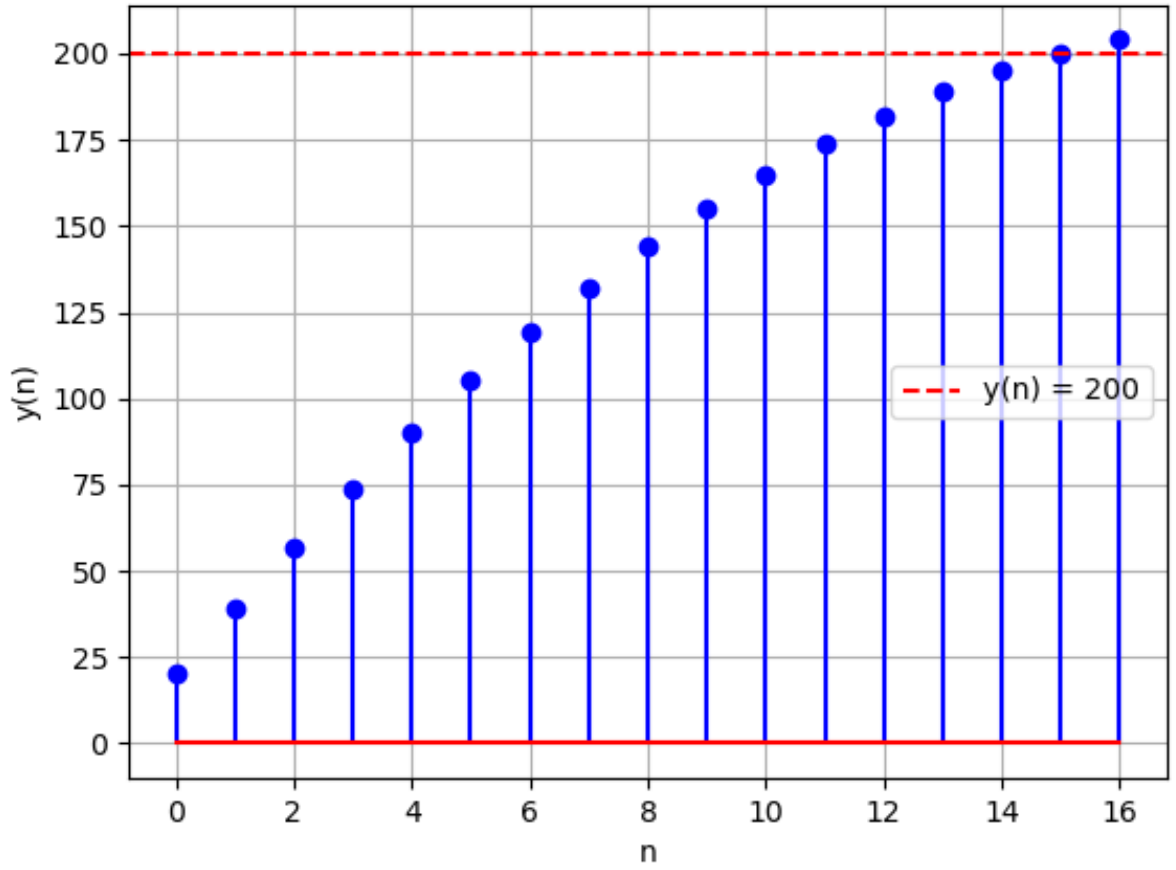
$$x(n) > 0 \tag{16}$$

Using equation 2

$$x(15) = 5 \tag{17}$$
$$x(24) = -4 \tag{18}$$

x(24) is rejected because it is negative

$$x(15) = 5 \tag{19}$$


y(n)
n
y(n) = 200
0
25
50
75
100
125
150
175
200
0
2
4
6
8
10
12
14
16