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A FIGURATE NUMBER CURIOSITY: EVERY INTEGER IS A
QUADRATIC FUNCTION OF A FIGURATE NUMBER

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In this note we prove the following: Every positive integer n can be expressed in an infinite number of ways as a quadratic function for each of the infinite number of figurate number types.

The nth figurate r-sided number p_n^r is given by

$$(1) \qquad p_n^r = n\big((r - 2)n - r + 4\big)/2,$$

where $n = 1, 2, 3, \ldots$ and $r = 3, 4, 5, \ldots$. Therefore, the snth figurate number is given by

$$(2) \qquad p_{sn}^r = sn\big((r - 2)sn - r + 4\big)/2.$$

However, (2) is a quadratic in n. Solving for n and taking the positive root yields

$$(3) \qquad n = \frac{(r - 4) + \sqrt{(r - 4)^2 + 8(r - 2)p_{sn}^r}}{2(r - 2)s},$$

which allows us to express n as stated above. A special case of (3) for pentagonal numbers ($r = 5$) was obtained by Hansen [1].

REFERENCE

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