

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

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$$(k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 \quad (k+1)^4 - k^4$$

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$$(k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 \quad (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1$$

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$$\frac{(k+1)^4 - k^4}{2^4} = k^4 + 4k^3 + 6k^2 + 4k + 1 \quad (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1$$

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$$\begin{array}{ccc} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \end{array} \quad (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1$$

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$$\begin{array}{rcl} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \\ & & = 4 \times 1^3 \end{array} \quad \begin{array}{l} (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ = 4 \times 1^3 \end{array}$$

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$$\begin{array}{rcl} (k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 \qquad \qquad - \qquad \qquad 1^4 \qquad = 4 \times 1^3 \qquad \qquad + 6 \times 1^2 \end{array}$$

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$$\begin{array}{ccccccccc} (k+1)^4 & = & k^4 & + & 4k^3 & + & 6k^2 & + & 4k + 1 \\ 2^4 & - & 1^4 & = & 4 \times 1^3 & & & & \\ & & & & & + 6 \times 1^2 & & & \\ & & & & & & + & 4 \times 1 & \\ & & & & & & & & + \\ & & & & & & & & 1 \end{array}$$

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$$\begin{array}{ccccccccc} (k+1)^4 & = & k^4 & + & 4k^3 & + & 6k^2 & + & 4k + 1 \\ 2^4 & - & 1^4 & = & 4 \times 1^3 & & + 6 \times 1^2 & + & 4 \times 1 \\ 3^4 & - & 2^4 & = & 4 \times 2^3 & & + 6 \times 2^2 & + & 4 \times 2 \\ & & \vdots & & & & & & \\ n^4 & - & & & & & & & \end{array}$$
$$(k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1$$
$$+ 6 \times 1^2 + 4 \times 1 + 1$$
$$+ 6 \times 2^2 + 4 \times 2 + 1$$

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$$\begin{array}{ccccccccc} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 & = 4 \times 1^3 & + 6 \times 1^2 & + & 4 \times 1 & + & 1 \\ 3^4 & - & 2^4 & = 4 \times 2^3 & + 6 \times 2^2 & + & 4 \times 2 & + & 1 \\ & & \vdots & & & & & & \\ n^4 & - & (n-1)^4 & & & & & & \end{array}$$

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$$\begin{array}{ccccccccc} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 & = 4 \times 1^3 & + 6 \times 1^2 & + & 4 \times 1 & + & 1 \\ 3^4 & - & 2^4 & = 4 \times 2^3 & + 6 \times 2^2 & + & 4 \times 2 & + & 1 \\ & & \vdots & & & & & & \\ n^4 & - & (n-1)^4 & = 4 \times (n-1)^3 & + 6 \times (n-1)^2 & + & 4 \times (n-1) & + & 1 \\ (n+1)^4 & & & & & & & & \end{array}$$

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$$\begin{array}{rcl} (k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 \quad - \quad 1^4 \quad = 4 \times 1^3 \quad + 6 \times 1^2 \quad + \quad 4 \times 1 \quad + \quad 1 \\ 3^4 \quad - \quad 2^4 \quad = 4 \times 2^3 \quad + 6 \times 2^2 \quad + \quad 4 \times 2 \quad + \quad 1 \\ \vdots \end{array}$$

$$\begin{array}{rcl} n^4 \quad - \quad (n-1)^4 \quad = 4 \times (n-1)^3 \quad + 6 \times (n-1)^2 \quad + \quad 4 \times (n-1) \quad + \quad 1 \\ (n+1)^4 \quad - \quad n^4 \quad = 4 \times n^3 \quad + 6 \times n^2 \quad + \quad 4 \times n \quad + \quad 1 \end{array}$$

변변함
더하면

$$(n+1)^4$$

$$\sum_{k=1}^n k^3$$

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$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \\ 3^4 & - & 2^4 \\ & \vdots & \\ n^4 & - & (n-1)^4 \\ (n+1)^4 & - & n^4 \end{array} \quad \begin{array}{rcl} (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 \\ = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 \\ & & + 1 \\ & & + 1 \\ & & + 1 \end{array}$$

$$\begin{array}{rcl} \text{변변} \bar{\text{h}} & & \text{더} \bar{\text{h}} \text{면} \\ (n+1)^4 & - & 1^4 \end{array}$$

$$\sum_{k=1}^n k^3$$

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$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \\ 3^4 & - & 2^4 \\ & & \vdots \\ n^4 & - & (n-1)^4 \\ (n+1)^4 & - & n^4 \end{array} \quad \begin{array}{rcl} (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 \\ = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 \\ & & \vdots \\ = 4 \times (n-1)^3 & + 6 \times (n-1)^2 & + 4 \times (n-1) \\ = 4 \times n^3 & + 6 \times n^2 & + 4 \times n \end{array} \quad \begin{array}{rcl} & & + 1 \\ & & + 1 \\ & & + 1 \\ & & + 1 \\ & & + 1 \end{array}$$

변변함
[**변** **변** **함**] 더하면

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

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$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \\ 3^4 & - & 2^4 \\ & \vdots & \\ n^4 & - & (n-1)^4 \\ (n+1)^4 & - & n^4 \end{array} \quad \begin{array}{rcl} (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 \\ = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 \\ & & + 1 \\ & & + 1 \\ & & + 1 \end{array}$$

$$\text{변변} \bar{\text{h}} \quad \text{더하} \bar{\text{h}} \text{면}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 &= k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 &-& 1^4 &= 4 \times 1^3 & +6 \times 1^2 & + 4 \times 1 & + 1 \\ 3^4 &-& 2^4 &= 4 \times 2^3 & +6 \times 2^2 & + 4 \times 2 & + 1 \\ && \vdots &&&& \\ n^4 &-& (n-1)^4 &= 4 \times (n-1)^3 & +6 \times (n-1)^2 & + 4 \times (n-1) & + 1 \\ (n+1)^4 &-& n^4 &= 4 \times n^3 & +6 \times n^2 & + 4 \times n & + 1 \\ \text{변변} \bar{\text{h}} && \text{더하} \bar{\text{h}} \text{면} &&&& \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2$$

$$\sum_{k=1}^n k^3$$

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$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \\ 3^4 & - & 2^4 \\ & \vdots & \\ n^4 & - & (n-1)^4 \\ (n+1)^4 & - & n^4 \end{array} \quad \begin{array}{rcl} (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 \\ = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 \\ & & + 1 \\ & & + 1 \\ & & + 1 \end{array}$$

변변함

$$\begin{array}{rcl} & & \text{더하면} \\ (n+1)^4 & - & 1^4 \\ & & = 4 \times (n-1)^3 + 6 \times (n-1)^2 + 4 \times (n-1) + 1 \\ & & = 4 \times n^3 + 6 \times n^2 + 4 \times n + 1 \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 & = & k^4 + 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 \\ 3^4 & - & 2^4 \\ & \vdots & \\ n^4 & - & (n-1)^4 \\ (n+1)^4 & - & n^4 \end{array} \quad \begin{array}{rcl} (k+1)^4 - k^4 & = & 4k^3 + 6k^2 + 4k + 1 \\ = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 \\ = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 \\ & & + 1 \\ & & + 1 \\ & & + 1 \end{array}$$

$$\begin{array}{rcl} \text{변변} \bar{\text{h}} & \text{더하} \bar{\text{h}} \text{면} & \\ (n+1)^4 & - & 1^4 \\ & = & 4 \times (n-1)^3 + 6 \times (n-1)^2 + 4 \times (n-1) + 1 \\ & = & 4 \times n^3 + 6 \times n^2 + 4 \times n + 1 \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k$$

$$\sum_{k=1}^n k^3$$

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$$\begin{array}{rcl} (k+1)^4 &= k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 &-& 1^4 &= 4 \times 1^3 & +6 \times 1^2 & +& 4 \times 1 & +& 1 \\ 3^4 &-& 2^4 &= 4 \times 2^3 & +6 \times 2^2 & +& 4 \times 2 & +& 1 \\ &&&\vdots&&&&&& \\ n^4 &-& (n-1)^4 &= 4 \times (n-1)^3 & +6 \times (n-1)^2 & +& 4 \times (n-1) & +& 1 \\ (n+1)^4 &-& n^4 &= 4 \times n^3 & +6 \times n^2 & +& 4 \times n & +& 1 \\ \text{변변} \bar{\text{h}} && \text{더하} \bar{\text{h}} \text{면} &&&&&&& \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

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$$(n+1)^4$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 \quad - \quad 1^4 \quad = 4 \times 1^3 & + 6 \times 1^2 \quad + \quad 4 \times 1 \quad + \quad 1 \\ 3^4 \quad - \quad 2^4 \quad = 4 \times 2^3 & + 6 \times 2^2 \quad + \quad 4 \times 2 \quad + \quad 1 \\ \vdots & & \end{array}$$

$$\begin{array}{rcl} n^4 \quad - \quad (n-1)^4 \quad = 4 \times (n-1)^3 & + 6 \times (n-1)^2 \quad + \quad 4 \times (n-1) \quad + \quad 1 \\ (n+1)^4 \quad - \quad n^4 \quad = 4 \times n^3 & + 6 \times n^2 \quad + \quad 4 \times n \quad + \quad 1 \\ \text{변변함} & \text{더함} & \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 & + 1 \\ 3^4 & - & 2^4 = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 & + 1 \\ & & \vdots & & & \\ n^4 & - & (n-1)^4 = 4 \times (n-1)^3 & + 6 \times (n-1)^2 & + 4 \times (n-1) & + 1 \\ (n+1)^4 & - & n^4 = 4 \times n^3 & + 6 \times n^2 & + 4 \times n & + 1 \\ \text{변변함} & & \text{더함} & & & \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3$$

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$$\begin{array}{rcl} (k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 & + 1 \\ 3^4 & - & 2^4 = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 & + 1 \end{array}$$

⋮

$$\begin{array}{rcl} n^4 & - & (n-1)^4 = 4 \times (n-1)^3 & + 6 \times (n-1)^2 & + 4 \times (n-1) & + 1 \\ (n+1)^4 & - & n^4 = 4 \times n^3 & + 6 \times n^2 & + 4 \times n & + 1 \end{array}$$

변변함
더함면

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 = k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 & - & 1^4 = 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 & + 1 \\ 3^4 & - & 2^4 = 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 & + 1 \\ & & \vdots & & & \\ n^4 & - & (n-1)^4 = 4 \times (n-1)^3 & + 6 \times (n-1)^2 & + 4 \times (n-1) & + 1 \\ (n+1)^4 & - & n^4 = 4 \times n^3 & + 6 \times n^2 & + 4 \times n & + 1 \\ \text{변변함} & & \text{더함} & & & \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3$$

$$\sum_{k=1}^n k^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

$$\begin{array}{rcl} (k+1)^4 &= k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 &-& 1^4 &= 4 \times 1^3 & +6 \times 1^2 & + 4 \times 1 & + 1 \\ 3^4 &-& 2^4 &= 4 \times 2^3 & +6 \times 2^2 & + 4 \times 2 & + 1 \end{array}$$

⋮

$$\begin{array}{rcl} n^4 &-& (n-1)^4 &= 4 \times (n-1)^3 & +6 \times (n-1)^2 & + 4 \times (n-1) & + 1 \\ (n+1)^4 &-& n^4 &= 4 \times n^3 & +6 \times n^2 & + 4 \times n & + 1 \end{array}$$

변변하고
더하고면

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \frac{n(n+1)(2n+1)}{6} + 4$$

$$\sum_{k=1}^n k^3$$

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$$\begin{array}{rcl} (k+1)^4 &= k^4 + 4k^3 + 6k^2 + 4k + 1 & (k+1)^4 - k^4 = 4k^3 + 6k^2 + 4k + 1 \\ 2^4 &-& 1^4 &= 4 \times 1^3 & + 6 \times 1^2 & + 4 \times 1 & + 1 \\ 3^4 &-& 2^4 &= 4 \times 2^3 & + 6 \times 2^2 & + 4 \times 2 & + 1 \end{array}$$

⋮

$$\begin{array}{rcl} n^4 &-& (n-1)^4 &= 4 \times (n-1)^3 & + 6 \times (n-1)^2 & + 4 \times (n-1) & + 1 \\ (n+1)^4 &-& n^4 &= 4 \times n^3 & + 6 \times n^2 & + 4 \times n & + 1 \\ \text{변변함} && \text{더함} & & & & \end{array}$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \frac{n(n+1)(2n+1)}{6} + 4 \times \frac{n(n+1)}{2}$$

$$\sum_{k=1}^n k^3$$

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$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \frac{n(n+1)(2n+1)}{6} + 4 \times \frac{n(n+1)}{2} + n$$

$$\sum_{k=1}^n k^3$$

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$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \sum_{k=1}^n k^2 + 4 \times \sum_{k=1}^n k + n$$

$$(n+1)^4 - 1^4 = 4 \times \sum_{k=1}^n k^3 + 6 \times \frac{n(n+1)(2n+1)}{6} + 4 \times \frac{n(n+1)}{2} + n$$

$$\sum_{k=1}^n k^3$$

Github:

<https://min7014.github.io/math20200720001.html>

Click or paste URL into the URL search bar, and you can see a picture moving.