

# 行列式的计算方法总结

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# 1. 利用定义计算

$$\begin{vmatrix} 0 & 0 & \cdots & 0 & 1 \\ 0 & 0 & \cdots & 2 & 0 \\ \vdots & \vdots & & \vdots & \vdots \\ 0 & n-1 & \cdots & 0 & 0 \\ n & 0 & \cdots & 0 & 0 \end{vmatrix} \qquad \begin{vmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 2 & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & n-1 \\ n & 0 & 0 & \cdots & 0 \end{vmatrix}$$

## 2. 利用行列式性质把行列式化为上、下三角形行列式.

$$\begin{vmatrix} 3 & 1 & 1 & 1 \\ 1 & 3 & 1 & 1 \\ 1 & 1 & 3 & 1 \\ 1 & 1 & 1 & 3 \end{vmatrix} \qquad \begin{vmatrix} 1+x & 1 & 1 & 1 \\ 1 & 1-x & 1 & 1 \\ 1 & 1 & 1+y & 1 \\ 1 & 1 & 1 & 1-y \end{vmatrix}$$

有时也可化成斜上、斜下三角形行列式

$$\begin{vmatrix} b & \cdots & b & b & a \\ b & \cdots & b & a & b \\ b & \cdots & a & b & b \\ \vdots & & \vdots & \vdots & \vdots \\ a & \cdots & b & b & b \end{vmatrix} = \begin{vmatrix} b & \cdots & b & b & a + (n-1)b \\ b & \cdots & b & a & a + (n-1)b \\ b & \cdots & a & b & a + (n-1)b \\ \vdots & & \vdots & \vdots & \vdots \\ a & \cdots & b & b & a + (n-1)b \end{vmatrix} \\
 = (a + (n-1)b) \begin{vmatrix} b & \cdots & b & b & 1 \\ b & \cdots & b & a & 1 \\ b & \cdots & a & b & 1 \\ \vdots & & \vdots & \vdots & \vdots \\ a & \cdots & b & b & 1 \end{vmatrix} = (a + (n-1)b) \begin{vmatrix} b & \cdots & b & b & 1 \\ 0 & \cdots & 0 & a-b & 0 \\ 0 & \cdots & a-b & 0 & 0 \\ \vdots & & \vdots & \vdots & \vdots \\ a-b & \cdots & 0 & 0 & 0 \end{vmatrix} \\
 = (-1)^{\frac{n(n-1)}{2}} (a + (n-1)b)(a-b)^{n-1}$$

### 3. 行列式按一行 (一列) 展开, 或按多行 (多列) 展开 (Laplace 定理)

$$D_{2n} = \begin{vmatrix} a_n & & & & b_n \\ & \ddots & & & \\ & & a_1 & b_1 & \\ & & c_1 & d_1 & \\ & & & & \\ & \ddots & & & \\ c_n & & & & d_n \end{vmatrix} = \prod_{i=1}^n (a_i d_i - b_i c_i).$$

#### 4. 箭头形行列式或者可以化为箭头形的行列式

$$\begin{vmatrix} a_0 & 1 & 1 & \cdots & 1 \\ 1 & a_1 & 0 & \cdots & 0 \\ 1 & 0 & a_2 & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 1 & 0 & 0 & \cdots & a_n \end{vmatrix} = \begin{vmatrix} a_0 - \sum_{i=1}^n \frac{1}{a_i} & 1 & 1 & \cdots & 1 \\ 0 & a_1 & 0 & \cdots & 0 \\ 0 & 0 & a_2 & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & a_n \end{vmatrix}$$
$$= \left( a_0 - \sum_{i=1}^n \frac{1}{a_i} \right) a_1 a_2 \cdots a_n$$

$$\begin{aligned}
& \begin{vmatrix} x_1 - m & x_2 & x_3 & \cdots & x_n \\ x_1 & x_2 - m & x_3 & \cdots & x_n \\ x_1 & x_2 & x_3 - m & \cdots & x_n \\ \vdots & \vdots & \vdots & & \vdots \\ x_1 & x_2 & x_3 & \cdots & x_n - m \end{vmatrix} \\
= & \begin{vmatrix} x_1 - m & x_2 & x_3 & \cdots & x_n \\ m & -m & 0 & \cdots & 0 \\ m & 0 & -m & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ m & 0 & 0 & \cdots & 0 - m \end{vmatrix} \\
= & \begin{vmatrix} \sum_{i=1}^n x_i - m & x_2 & x_3 & \cdots & x_n \\ 0 & -m & 0 & \cdots & 0 \\ 0 & 0 & -m & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & 0 - m \end{vmatrix} = \left( \sum_{i=1}^n x_i - m \right) (-m)^{n-1}
\end{aligned}$$

$$\begin{vmatrix}
1 & 1 & \cdots & 1 & a_0 \\
0 & 0 & \cdots & a_1 & 1 \\
\vdots & \vdots & & \vdots & \vdots \\
0 & a_{n-1} & \cdots & 0 & 1 \\
a_n & 0 & \cdots & 0 & 1
\end{vmatrix}$$

$$= \begin{vmatrix}
1 & 1 & \cdots & 1 & a_0 - \sum_{i=1}^n \frac{1}{a_i} \\
0 & 0 & \cdots & a_1 & 0 \\
\vdots & \vdots & & \vdots & \vdots \\
0 & a_{n-1} & \cdots & 0 & 0 \\
a_n & 0 & \cdots & 0 & 0
\end{vmatrix}$$

$$= (-1)^{\frac{n(n-1)}{2}} a_1 a_2 \cdots a_n \left( a_0 - \sum_{i=1}^n \frac{1}{a_i} \right)$$



$$\begin{vmatrix} b & \cdots & b & b & a \\ b & \cdots & b & a & b \\ b & \cdots & a & b & b \\ \vdots & & \vdots & \vdots & \vdots \\ a & \cdots & b & b & b \end{vmatrix} = \begin{vmatrix} b & b & \cdots & b & a \\ 0 & 0 & \cdots & a-b & b-a \\ \vdots & \vdots & & \vdots & \vdots \\ 0 & a-b & \cdots & 0 & b-a \\ a-b & 0 & \cdots & 0 & b-a \end{vmatrix}$$

$$= \begin{vmatrix} b & b & \cdots & b & a + (n-1)b \\ 0 & 0 & \cdots & a-b & 0 \\ \vdots & \vdots & & \vdots & \vdots \\ 0 & a-b & \cdots & 0 & 0 \\ a-b & 0 & \cdots & 0 & 0 \end{vmatrix}$$

$$= (-1)^{\frac{n(n-1)}{2}} (a + (n-1)b)(a-b)^{n-1}$$

## 5. 逐行逐列相加减

行列式特点是每相邻两行 (列) 之间有许多元素相同. 用逐行 (列) 相减可以化出零.

$$\begin{vmatrix} 1 & 2 & 2 & \cdots & 2 \\ 2 & 2 & 2 & \cdots & 2 \\ 2 & 2 & 3 & \cdots & 2 \\ \vdots & \vdots & \vdots & & \vdots \\ 2 & 2 & 2 & \cdots & n \end{vmatrix} = \begin{vmatrix} -1 & 0 & 0 & \cdots & 0 \\ 2 & 2 & 2 & \cdots & 2 \\ 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & n-2 \end{vmatrix} = (-2)(n-2)!$$

$$\begin{vmatrix}
1 & 2 & 3 & \cdots & n-1 & n \\
2 & 2 & 3 & \cdots & n-1 & n \\
3 & 3 & 3 & \cdots & n-1 & n \\
\vdots & \vdots & \vdots & & \vdots & \vdots \\
n-1 & n-1 & n-1 & \cdots & n-1 & n \\
n & n & n & \cdots & n & n
\end{vmatrix}$$

$$= \begin{vmatrix}
-1 & 0 & 0 & \cdots & 0 & 0 \\
-1 & -1 & 0 & \cdots & 0 & 0 \\
-1 & -1 & -1 & \cdots & 0 & 0 \\
\vdots & \vdots & \vdots & & \vdots & \vdots \\
-1 & -1 & -1 & \cdots & -1 & 0 \\
n & n & n & \cdots & n & n
\end{vmatrix} = (-1)^{n-1} n.$$

$$\begin{aligned}
& \left| \begin{array}{cccccc} 1 & 2 & 3 & \cdots & n-1 & n \\ 2 & 3 & 4 & \cdots & n & 1 \\ 3 & 4 & 5 & \cdots & 1 & 2 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ n-1 & n & 1 & \cdots & n-3 & n-2 \\ n & 1 & 2 & \cdots & n-2 & n-1 \end{array} \right| = \left| \begin{array}{cccccc} 1 & 2 & 3 & \cdots & n-1 & n \\ 1 & 1 & 1 & \cdots & 1 & 1-n \\ 1 & 1 & 1 & \cdots & 1-n & 1 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ 1 & 1 & 1-n & \cdots & 1 & 1 \\ 1 & 1-n & 1 & \cdots & 1 & 1 \end{array} \right| \\
& = \left| \begin{array}{cccccc} \frac{n(n+1)}{2} & 2 & 3 & \cdots & n-1 & n \\ 0 & 1 & 1 & \cdots & 1 & 1-n \\ 0 & 1 & 1 & \cdots & 1-n & 1 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ 0 & 1 & 1-n & \cdots & 1 & 1 \\ 0 & 1-n & 1 & \cdots & 1 & 1 \end{array} \right| = \frac{n(n+1)}{2} \left| \begin{array}{ccccc} 1 & 1 & \cdots & 1 & 1-n \\ 1 & 1 & \cdots & 1-n & 1 \\ \vdots & \vdots & & \vdots & \vdots \\ 1 & 1-n & \cdots & 1 & 1 \\ 1-n & 1 & \cdots & 1 & 1 \end{array} \right| \\
& = \dots\dots\dots
\end{aligned}$$

## 6. 加边法 (添加一行一列, 利于计算, 但同时保持行列式不变)

$$\begin{vmatrix}
 a+x_1 & a & a & \cdots & a \\
 a & a+x_2 & a & \cdots & a \\
 a & a & a+x_3 & \cdots & a \\
 \vdots & \vdots & \vdots & & \vdots \\
 a & a & a & \cdots & a+x_n
 \end{vmatrix}$$

$$= \begin{vmatrix}
 1 & a & a & a & \cdots & a \\
 0 & a+x_1 & a & a & \cdots & a \\
 0 & a & a+x_2 & a & \cdots & a \\
 0 & a & a & a+x_3 & \cdots & a \\
 \vdots & \vdots & \vdots & \vdots & & \vdots \\
 0 & a & a & a & \cdots & a+x_n
 \end{vmatrix}$$

## 7. 利用数学归纳法证明行列式

$$\begin{vmatrix} \alpha + \beta & \alpha\beta & 0 & \cdots & 0 & 0 \\ 1 & \alpha + \beta & \alpha\beta & \cdots & 0 & 0 \\ 0 & 1 & \alpha + \beta & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & \alpha + \beta & \alpha\beta \\ 0 & 0 & 0 & \cdots & 1 & \alpha + \beta \end{vmatrix} = \frac{\alpha^{n+1} - \beta^{n+1}}{\alpha - \beta}$$

证明: 利用第二数学归纳法: 若  $n = 1$ , 则  $D_1 = \alpha + \beta = \frac{\alpha^2 - \beta^2}{\alpha - \beta}$ , 成立.

假设结论对所有小于  $n$  的都成立.

将  $D_n$  按第一行 (或第一列) 展开得  $D_n = (\alpha + \beta)D_{n-1} - \alpha\beta D_{n-2}$ ,

利用归纳假设可得

$$D_n = (\alpha + \beta)D_{n-1} - \alpha\beta D_{n-2} = (\alpha + \beta)\frac{\alpha^n - \beta^n}{\alpha - \beta} - \alpha\beta\frac{\alpha^{n-1} - \beta^{n-1}}{\alpha - \beta} = \frac{\alpha^{n+1} - \beta^{n+1}}{\alpha - \beta}.$$

## 8. 利用递推公式

解: 按第一行展开得  $D_n = (\alpha + \beta)D_{n-1} - \alpha\beta D_{n-2}$ , 将此式化为:

$$D_n - \alpha D_{n-1} = \beta (D_{n-1} - \alpha D_{n-2}) \quad (1)$$

$$D_n - \beta D_{n-1} = \alpha (D_{n-1} - \beta D_{n-2}) \quad (2)$$

利用公式 (1) 得

$$D_n - \alpha D_{n-1} = \beta (D_{n-1} - \alpha D_{n-2}) = \cdots = \beta^{n-2} (D_2 - \alpha D_1) = \beta^n,$$

利用公式 (2) 得

$$D_n - \beta D_{n-1} = \alpha (D_{n-1} - \beta D_{n-2}) = \cdots = \alpha^{n-2} (D_2 - \beta D_1) = \alpha^n,$$

解得  $D_n = \begin{cases} \frac{\alpha^{n+1} - \beta^{n+1}}{\alpha - \beta}, & \alpha \neq \beta \\ (n+1)\alpha^n, & \alpha = \beta \end{cases}$

$$D_n = \begin{vmatrix} 7 & 2 & & & \\ 5 & 7 & \ddots & & \\ & \ddots & \ddots & \ddots & \\ & & \ddots & 7 & 2 \\ & & & 5 & 7 \end{vmatrix} = 7D_{n-1} - 10D_{n-2}$$



## 9. 拆项法：将行列式的其中一行（列）拆成两个数的和

要点：分解成两个容易求的行列式的和.

$$\begin{aligned}
 D_n &= \begin{vmatrix} a & b & b & \cdots & b & b \\ c & a & b & \cdots & b & b \\ c & c & a & \cdots & b & b \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ c & c & c & \cdots & a & b \\ c & c & c & \cdots & c & a \end{vmatrix} = \begin{vmatrix} c+a-c & b & b & \cdots & b & b \\ c & a & b & \cdots & b & b \\ c & c & a & \cdots & b & b \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ c & c & c & \cdots & a & b \\ c & c & c & \cdots & c & a \end{vmatrix} \\
 &= \begin{vmatrix} c & b & b & \cdots & b & b \\ c & a & b & \cdots & b & b \\ c & c & a & \cdots & b & b \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ c & c & c & \cdots & a & b \\ c & c & c & \cdots & c & a \end{vmatrix} + \begin{vmatrix} a-c & b & b & \cdots & b & b \\ 0 & a & b & \cdots & b & b \\ 0 & c & a & \cdots & b & b \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ 0 & c & c & \cdots & a & b \\ 0 & c & c & \cdots & c & a \end{vmatrix}
 \end{aligned}$$