

**Recall:** If  $A$  is square matrix then the  $ij$ -cofactor of  $A$  is the number

$$C_{ij} = (-1)^{i+j} \det A_{ij}$$

### Definition

If  $A$  is an  $n \times n$  matrix then the *adjoint* (or *adjugate*) of  $A$  is the matrix

$$\operatorname{adj} A = \begin{bmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & \vdots & & \vdots \\ C_{n1} & C_{n2} & \cdots & C_{nn} \end{bmatrix}^T = \begin{bmatrix} C_{11} & C_{21} & \cdots & C_{n1} \\ C_{12} & C_{22} & \cdots & C_{n2} \\ \vdots & \vdots & & \vdots \\ C_{1n} & C_{2n} & \cdots & C_{nn} \end{bmatrix}$$

### Theorem

If  $A$  is an invertible matrix then

$$A^{-1} = \frac{1}{\det A} \cdot \operatorname{adj} A$$

**Example.** Compute  $A^{-1}$  for

$$A = \begin{bmatrix} 1 & 1 & 2 \\ 4 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

**Recall:** If  $A$  is an invertible matrix then the equation  $A\mathbf{x} = \mathbf{b}$  has only one solution:  $\mathbf{x} = A^{-1}\mathbf{b}$ .

### Definition

If  $A$  is an  $n \times n$  matrix and  $\mathbf{b} \in \mathbb{R}^n$  then  $A_i(\mathbf{b})$  is the matrix obtained by replacing the  $i^{\text{th}}$  column of  $A$  with  $\mathbf{b}$ .

**Example.**

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \quad \mathbf{b} = \begin{bmatrix} 10 \\ 20 \\ 30 \end{bmatrix}$$

### Theorem (Cramer's Rule)

If  $A$  is an  $n \times n$  invertible matrix and  $\mathbf{b} \in \mathbb{R}^n$  then the unique solution of the equation

$$A\mathbf{x} = \mathbf{b}$$

is given by

$$\mathbf{x} = \frac{1}{\det A} \begin{bmatrix} \det A_1(\mathbf{b}) \\ \vdots \\ \det A_n(\mathbf{b}) \end{bmatrix}$$

**Example.** Solve the equation

$$\begin{bmatrix} 1 & 1 & 2 \\ 4 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$$