Differentiation with vectors and matrices

Assume that $f(\underline{X})$ be continuous function of the element of $\underline{X}' = (X_1\ X_2\ \cdots\ X_n)$ whose first and second partial drivative exists

$$\frac{\partial f(\underline{X})}{\partial X_i}\ ,\ \frac{\partial^2 f(\underline{X})}{\partial X_i \partial X_j} \quad \forall i,j = 1,2,\cdots,n$$

where $f(\underline{X})$ is function of vector $\underline{X}$

$$\frac{\partial f(\underline{X})}{\partial \underline{X}} = \begin{bmatrix} \frac{\partial f(\underline{X})}{\partial X_1} \\ \frac{\partial f(\underline{X})}{\partial X_2} \\ \vdots \\ \frac{\partial f(\underline{X})}{\partial X_n} \end{bmatrix}$$

① $f(\underline{X}) = \underline{a}' = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix} \Longrightarrow \frac{\partial f(\underline{X})}{\partial \underline{X}} = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \end{bmatrix} = \underline{0}$

② $f(\underline{X}) = \underline{a}'\underline{X} = \underline{X}'\underline{a} = \sum a_i X_i$ where $\underline{a}$ is a vector of Constant

$$\frac{\partial f(\underline{X})}{\partial \underline{X}} = \underline{a}$$

column vector