Intuitive Way

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If we change the variables for the integration, we need to multiply the integrand by the absolute value of the determinant of the Jacobian matrix. There is an intuitive way to explain this.

Here, we consider changing the variables from $(x_1, x_2, \cdots, x_n)$ to $(y_1, y_2, \cdots, y_n)$.

$$\Delta y_i = y_i(x_1 + \Delta x_1, x_2 + \Delta x_2, \cdots, x_n + \Delta x_n) - y_i(x_1, x_2, \cdots, x_n)$$