

**Fundamental Mathematics for Robotics**  
**Homework Set #08-2, Dr.T**

[1] Compute the Jacobian matrix of the following vector functions.

$$(a) \begin{bmatrix} x(\theta_1, \theta_2) \\ y(\theta_1, \theta_2) \end{bmatrix} = \begin{bmatrix} 2\cos(\theta_1) + 4\cos(\theta_1 + \theta_2) \\ 3\sin(\theta_1) + 2\sin(\theta_1 + \theta_2) \end{bmatrix}$$

$$(b) \begin{bmatrix} x(\theta_1, \theta_2, \theta_3) \\ y(\theta_1, \theta_2, \theta_3) \end{bmatrix} = \begin{bmatrix} 2\cos(\theta_1) + 4\cos(\theta_1 + \theta_2) + 3\cos(\theta_1 + \theta_2 + \theta_3) \\ 3\sin(\theta_1) + 2\sin(\theta_1 + \theta_2) + 4\sin(\theta_1 + \theta_2 + \theta_3) \end{bmatrix}$$

$$(c) \text{ (Extra) } \begin{bmatrix} x(\theta_1, \theta_2) \\ y(\theta_1, \theta_2) \\ z(\theta_1, \theta_2) \end{bmatrix} = \begin{bmatrix} -3\cos(\theta_1 + \theta_2) + 2\cos(\theta_1 - \theta_2) \\ 2\cos(\theta_1 + \theta_2) - 3\sin(\theta_1 - \theta_2) \\ -\sin(\theta_1 + \theta_2) + 4\sin(\theta_1 - \theta_2) \end{bmatrix}$$

[2] Compute the total differential for the following function:

$$(a) f(x, y) = \tan(4x^2 - 3xy + 6y^2)$$

$$(b) h(x, y, z) = Ae^{\alpha x^2} \cos(\omega z + \gamma) + Be^{\beta y^2} \sin(\omega z + \gamma)$$

$$(c) \text{ (Extra) } \begin{bmatrix} x(\theta_1, \theta_2) \\ y(\theta_1, \theta_2) \end{bmatrix} = \begin{bmatrix} 3\sin(\theta_1) - 2\sin(\theta_1 + \theta_2) \\ -4\cos(\theta_1) + 5\cos(\theta_1 + \theta_2) \end{bmatrix} \quad \text{Hint: The total differential is a vector.}$$