

### PROBLEM #1.

Calc Jacob. Matrix

$$u(x,y) = x^2 - y^2$$

$$v(x,y) = 2xy$$

$$J = \begin{bmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{bmatrix}$$

$$= \begin{bmatrix} 2x & -2y \\ 2y & 2x \end{bmatrix}$$

$$\frac{\partial u}{\partial x} = \frac{\partial}{\partial x}(x^2 - y^2)$$

$$= 2x$$

$$\frac{\partial u}{\partial y} = -2y$$

$$\frac{\partial v}{\partial x} = 2y$$

$$\frac{\partial v}{\partial y} = 2x$$

### PROBLEM #2

Calculate Jacobian matrix

$$u(x,y,z) = 2x + 3y$$

$$v(x,y,z) = \cos x \sin z$$

$$w(x,y,z) = e^{x+y+z}$$

$$J = \begin{bmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{bmatrix}$$

$$= \begin{bmatrix} 2 & 3 & 0 \\ -\sin x \sin z & 0 & \cos z \cos x \\ e^{x+y+z} & e^{x+y+z} & e^{x+y+z} \end{bmatrix}$$

$$\frac{\partial u}{\partial x} = 2 \quad \frac{\partial v}{\partial x} = -\sin x \sin z$$

$$\frac{\partial u}{\partial y} = 3 \quad \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial u}{\partial z} = 0 \quad \frac{\partial v}{\partial z} = \cos z \cos x$$

$$\frac{\partial w}{\partial x} = e^{x+y+z}$$

$$\frac{\partial w}{\partial y} = e^{x+y+z}$$

$$\frac{\partial w}{\partial z} = e^{x+y+z}$$

### PROBLEM #3.

Calc Jacobian matrix.

$$u(x, y) = ax + by$$

$$v(x, y) = cx + dy \rightarrow \text{where } a, b, c, d \text{ are const.}$$

$$J = \begin{bmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{bmatrix}$$

$$= \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

$\rightarrow$  just equals coefficients of the concerned var of the partial derivative.

### PROBLEM #4.

Calc Jacobian matrix & eval at  $\vec{0}$ .

$$u(x, y, z) = 9x^2y^2 + ze^x$$

$$v(x, y, z) = xy + x^2y^3 + 2z$$

$$w(x, y, z) = \cos x \sin z e^y$$

$$\frac{\partial u}{\partial x} = 18xy^2 + e^x z$$

$$\frac{\partial u}{\partial y} = 2y9x^2$$

$$\frac{\partial u}{\partial z} = e^x$$

$$J = \begin{bmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{bmatrix}$$

$$\frac{\partial v}{\partial x} = y + 2xy^3$$

$$\frac{\partial v}{\partial y} = x + 3y^2x^2$$

$$\frac{\partial v}{\partial z} = 2$$

$$\frac{\partial w}{\partial x} = -\sin x \sin z e^y$$

$$\frac{\partial w}{\partial y} = e^y \cos x \sin z \quad \frac{\partial w}{\partial z} = \cos z \cos x e^y$$

$$J = \begin{bmatrix} 18xy^2 + e^x z & 2y^9 x^2 & e^x \\ y + 2xy^3 & x + 3y^2 x^2 & 2 \\ -\sin x \sin z e^y & e^y \cos x \sin z & \cos z \cos x e^y \end{bmatrix}$$

$$J\vec{0} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 2 \\ 0 & 0 & 1 \end{bmatrix}$$

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### PROBLEM #5.

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Calc. Jacobian matrix.

$$x(r, \theta, \phi) = r \cos \theta \sin \phi$$

$$y(r, \theta, \phi) = r \sin \theta \sin \phi$$

$$z(r, \theta, \phi) = r \cos \phi$$

$$J = \begin{bmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \theta} & \frac{\partial x}{\partial \phi} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \theta} & \frac{\partial y}{\partial \phi} \\ \frac{\partial z}{\partial r} & \frac{\partial z}{\partial \theta} & \frac{\partial z}{\partial \phi} \end{bmatrix}$$

=

$$\frac{\partial x}{\partial r} = \cos \theta \sin \phi$$

$$\frac{\partial x}{\partial \theta} = -\sin \theta \sin \phi$$

$$\frac{\partial x}{\partial \phi} = r \cos \theta \cos \phi$$

$$\frac{\partial y}{\partial r} = \sin \theta \sin \phi$$

$$\frac{\partial y}{\partial \theta} = r \cos \theta \sin \phi$$

$$\frac{\partial y}{\partial \phi} = r \sin \theta \cos \phi$$

$$\frac{\partial z}{\partial r} = \cos \phi$$

$$\frac{\partial z}{\partial \theta} = 0$$

$$\frac{\partial z}{\partial \phi} = -r \sin \phi.$$

$$J = \begin{bmatrix} \cos\theta \sin\phi & -\sin\theta \sin\phi & r\cos\theta \cos\phi \\ \sin\theta \sin\phi & r\cos\theta \sin\phi & r\sin\theta \cos\phi \\ \cos\phi & 0 & -r\sin\phi \end{bmatrix}$$