## PROBLEM #1

Calc. Jacobian of $f(x,y) = x^2y + \frac{3}{4}xy + 10$.

$$\frac{\partial f}{\partial x} = \frac{\partial}{\partial x}\left(x^2y + \frac{3}{4}xy + 10\right)$$

$$= y2x + x\frac{\partial}{\partial x}\left(\frac{3}{4}y\right) + \frac{\partial}{\partial x}(10) + \frac{3}{4}y\frac{\partial}{\partial x}x$$

$$= y2x + x(0) + (0) + \frac{3}{4}y(1)$$

$$= y2x + \frac{3y}{4}$$

$$\frac{\partial f}{\partial y} = \frac{\partial}{\partial y}\left(x^2y + \frac{3}{4}xy + 10\right)$$

$$= y\frac{\partial}{\partial y}x^2 + x^2\frac{\partial}{\partial y}y + y\frac{\partial}{\partial y}\left(\frac{3}{4}x\right) + \frac{3}{4}x\frac{\partial}{\partial y}(y)$$

$$= y(0) + x^2(1) + y(0) + \frac{3}{4}x(1)$$

$$= x^2 + \frac{3x}{4}$$

$$J = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$$

$$= \left[y2x + \frac{3y}{4}, x^2 + \frac{3x}{4}\right]$$

## PROBLEM #2.

Calc Jacobian row vector for $f(x,y) = e^x\cos(y) + xe^{3y} - 2$

$$\frac{\partial f}{\partial x} = \frac{\partial}{\partial x}\left(e^x\cos(y) + xe^{3y} - 2\right)$$

$$= e^x\frac{\partial}{\partial x}\cos y + \cos y\frac{\partial}{\partial x}e^x + x\frac{\partial}{\partial x}e^{3y} + e^{3y}\frac{\partial}{\partial x}x + 0$$

$$= e^x(0) + \cos y\, e^x(1) + x(0) + e^{3y}(1)$$

$$= \cos(y)\, e^x + e^{3y}$$

$$\frac{\partial f}{\partial y} = \frac{\partial}{\partial y}\left(e^x\cos(y) + xe^{3y} - 2\right)$$

$$= \cos y \frac{\partial}{\partial y} e^x + e^x \frac{\partial}{\partial y}\cos y + e^{3y}\frac{\partial}{\partial y}x + x\frac{\partial}{\partial y}e^{3y} + 0$$

$$= \cos y(0) + e^x(-\sin y) + e^{3y}(0) + x\,e^{3y}\,3$$

$$= -\sin y\, e^x + 3xe^{3y}$$

$$J = \left[\cos(y)e^x + e^{3y},\ -\sin y\, e^x + 3xe^{3y}\right]$$

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PROBLEM #3.

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Calculate Jacobian row vector

$$f(x,y,z) = e^x\cos y + x^2y^2z^2$$

$$\frac{\partial f}{\partial x} = \frac{\partial}{\partial x}\left(e^x\cos y + x^2y^2z^2\right)$$

$$= e^x\frac{\partial}{\partial x}\cos y + \cos y\frac{\partial}{\partial x}e^x + x^2\frac{\partial}{\partial x}y^2z^2 + y^2z^2\frac{\partial}{\partial x}x^2$$

$$= \cos(y)e^x + y^2z^2 2x$$

$$\frac{\partial f}{\partial y} = \frac{\partial}{\partial y}\left(e^x\cos y + x^2y^2z^2\right)$$

$$= \cos y\frac{\partial}{\partial y}e^x + e^x\frac{\partial}{\partial y}\cos y + y^2\frac{\partial}{\partial y}x^2z^2 + x^2z^2\frac{\partial}{\partial y}y^2$$

$$= e^x(-\sin y) + x^2z^2 2y$$

$$\frac{\partial f}{\partial z} = \frac{\partial}{\partial z}\left(e^x\cos y + x^2y^2z^2\right)$$

$$= \frac{\partial}{\partial z}(z^2)\cdot x^2y^2$$

$$= x^2y^2 2z.$$

$$J = [(\cos y)e^x + y^2z^2 2x\ ,\ e^x(-\sin y) + x^2z^2 2y\ ,\ x^2y^2 2z]$$

PROBLEM # 4.

Calculate Jacob. row vec and eval at $\vec{0}$.

$$f(x,y,z) = x^2 + 3e^y e^z + \cos x \sin z$$

$$\frac{\partial f}{\partial x} = \frac{\partial}{\partial x} x^2 + \frac{\partial}{\partial x}(3e^y e^z) + \frac{\partial}{\partial x}(\cos x)\cdot \sin z$$

$$= 2x - \sin x \cdot \sin z$$

$$\frac{\partial f}{\partial y} = \frac{\partial}{\partial y}(x^2 + 3e^y e^z + \cos x \sin z)$$

$$= e^z \frac{\partial}{\partial y} e^y + 3e^y \frac{\partial}{\partial y} e^z + \frac{\partial}{\partial y}(\cos x \sin z)$$

$$= 3e^z e^y$$

$$\frac{\partial f}{\partial z} = \frac{\partial}{\partial z}(x^2 + 3e^y e^z + \cos x \sin z)$$

$$= \frac{\partial}{\partial z}(x^2) + 3e^y \frac{\partial}{\partial z} e^z + \cos x \frac{\partial}{\partial z} \sin z$$

$$= 3e^y e^z + \cos x \cos z$$

$$J = [2x - \sin x \cdot \sin z\ ,\ 3e^z e^y\ ,\ 3e^y e^z + \cos x \cos z]$$

Eval @ $u = \vec{0}$:

$$J_u = [0, 3, 4]$$

PROBLEM #5

Calc Jacobian row vector and eval at $u = 0$.

$$f(x,y,z) = xe^y \cos z + 5x^2 \sin(y) e^z$$

$$\frac{\partial f}{\partial x} = \frac{\partial}{\partial x}\left(xe^y\cos z + 5x^2\sin(y)e^z\right)$$

$$= e^y\cos z\frac{\partial}{\partial x}x + 5\sin(y)e^z\frac{\partial}{\partial x}x^2$$

$$= e^y\cos z(1) + 5\sin(y)e^z 2x$$

$$\frac{\partial f}{\partial y} = \frac{\partial}{\partial y}\left(xe^y\cos z + 5x^2\sin(y)e^z\right)$$

$$= x\cos z\frac{\partial}{\partial y}e^y + 5x^2e^z\frac{\partial}{\partial y}\sin y$$

$$= x\cos(z)e^y + 5x^2e^z\cos y$$

$$\frac{\partial f}{\partial z} = \frac{\partial}{\partial z}\left(xe^y\cos z + 5x^2\sin(y)e^z\right)$$

$$= xe^y\frac{\partial}{\partial z}\cos z + 5x^2\sin(y)\frac{\partial}{\partial z}e^z$$

$$= xe^y(-\sin z) + 5x^2\sin y\, e^z$$

$$J = [e^y\cos z(1) + 5\sin(y)e^z 2x, \quad x\cos(z)e^y + 5x^2e^z\cos y, \quad xe^y(-\sin z) + 5x^2\sin y\, e^z]$$

Eval $Ju$ @ $u=\vec{0}$,

$Ju = [1, 0, 0]$