

# Multi 13.6 Notes

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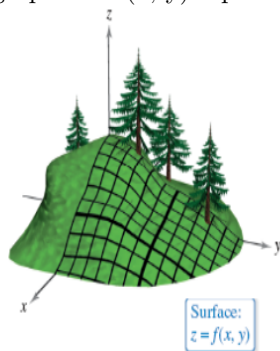
## 0.1 The Directional Derivative:

The directional derivative tells us the slope in a direction:

$$\frac{\partial f}{\partial x} = \text{slope in } x - \text{dir} \quad (1)$$

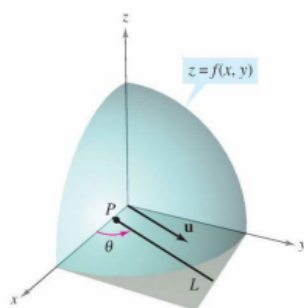
$$\frac{\partial f}{\partial y} = \text{slope in } y - \text{dir} \quad (2)$$

Figure 1: A graph  $z = f(x, y)$  represents the hill



We want to find the slope in a certain direction, a rotation of theta in cylindrical

Figure 2: Rotation of theta

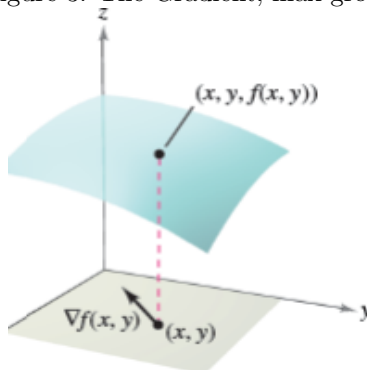


So our direction vector  $u$  Therefore our directional derivative is the dot product of two vectors, now which vectors?

## 0.2 The Gradient

The gradient tells us the biggest derivative vector at a certain point in the graph!

Figure 3: The Gradient, max growth



$$\nabla f(x, y) = \frac{\partial f}{\partial x} \vec{i} + \frac{\partial f}{\partial y} \vec{j} \quad (3)$$

So now, if we rotate this gradient by an angle theta, then we can say that the gradient is a subset of rotated gradients Or that  $\nabla f(x, y) \in G$  where  $G$  is the superset

For the final step, the directional derivative must be a scalar quantity as it is a slope, so:

$$\text{Directional derivative} = \nabla f(x, y) \cdot u \quad (4)$$

Whereby  $u$  is the direction vector for angle  $\theta$

### 0.2.1 Using $\nabla f(x, y)$ to find Directional Derivative

Find the directional derivative of  $f(x, y) = 3x^2 - 2y^2$  at  $(-3/4, 0)$  in the direction of:  $3/4\vec{i} + \vec{j}$

$$\nabla f(x, y) = 6x\vec{i} - 4y\vec{j} \quad (5)$$

$$u = 3/5\vec{i} + 4/5\vec{j} \quad (6)$$

$$\nabla f(-3/4, 0) \cdot u = -9/2\vec{i} \cdot (3/5\vec{i} + 4/5\vec{j}) \quad (7)$$

So the directional derivative or dot product for this question evaluates to: -27/10