

18. Multivariable Calculus: Directional Derivatives and Gradients

18.1. Directional Derivatives and Gradients: Review

$$\frac{\partial f}{\partial x} = \lim_{h \rightarrow 0} \frac{f(x+h, y) - f(x, y)}{h}, \quad \frac{\partial f}{\partial y} = \lim_{h \rightarrow 0} \frac{f(x, y+h) - f(x, y)}{h}$$

18.2. Directional Derivatives: Let $f(x, y, z)$ be a scalar field and \mathbf{u} a unit vector in the direction of the gradient.

18.3. Directional Derivative: $\frac{\partial f}{\partial \mathbf{u}} = \nabla f \cdot \mathbf{u}$ (where ∇f is the gradient vector)

18.4. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j}$ in the xy -plane.

18.5. Directional Derivative: $\frac{\partial f}{\partial \mathbf{u}} = \cos \theta \frac{\partial f}{\partial x} + \sin \theta \frac{\partial f}{\partial y}$

18.6. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

18.7. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

$$\frac{\partial f}{\partial \mathbf{u}} = \cos \theta \frac{\partial f}{\partial x} + \sin \theta \frac{\partial f}{\partial y} + \cos \phi \frac{\partial f}{\partial z}$$

18.8. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

18.9. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

18.10. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

18.11. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

18.12. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

18.13. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

$$\frac{\partial f}{\partial \mathbf{u}} = \cos \theta \frac{\partial f}{\partial x} + \sin \theta \frac{\partial f}{\partial y} + \cos \phi \frac{\partial f}{\partial z}$$

18.14. Directional Derivative: Let $\mathbf{u} = \cos \theta \mathbf{i} + \sin \theta \mathbf{j} + \cos \phi \mathbf{k}$ in 3D space.

$$\frac{\partial f}{\partial \mathbf{u}} = \cos \theta \frac{\partial f}{\partial x} + \sin \theta \frac{\partial f}{\partial y} + \cos \phi \frac{\partial f}{\partial z}$$

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