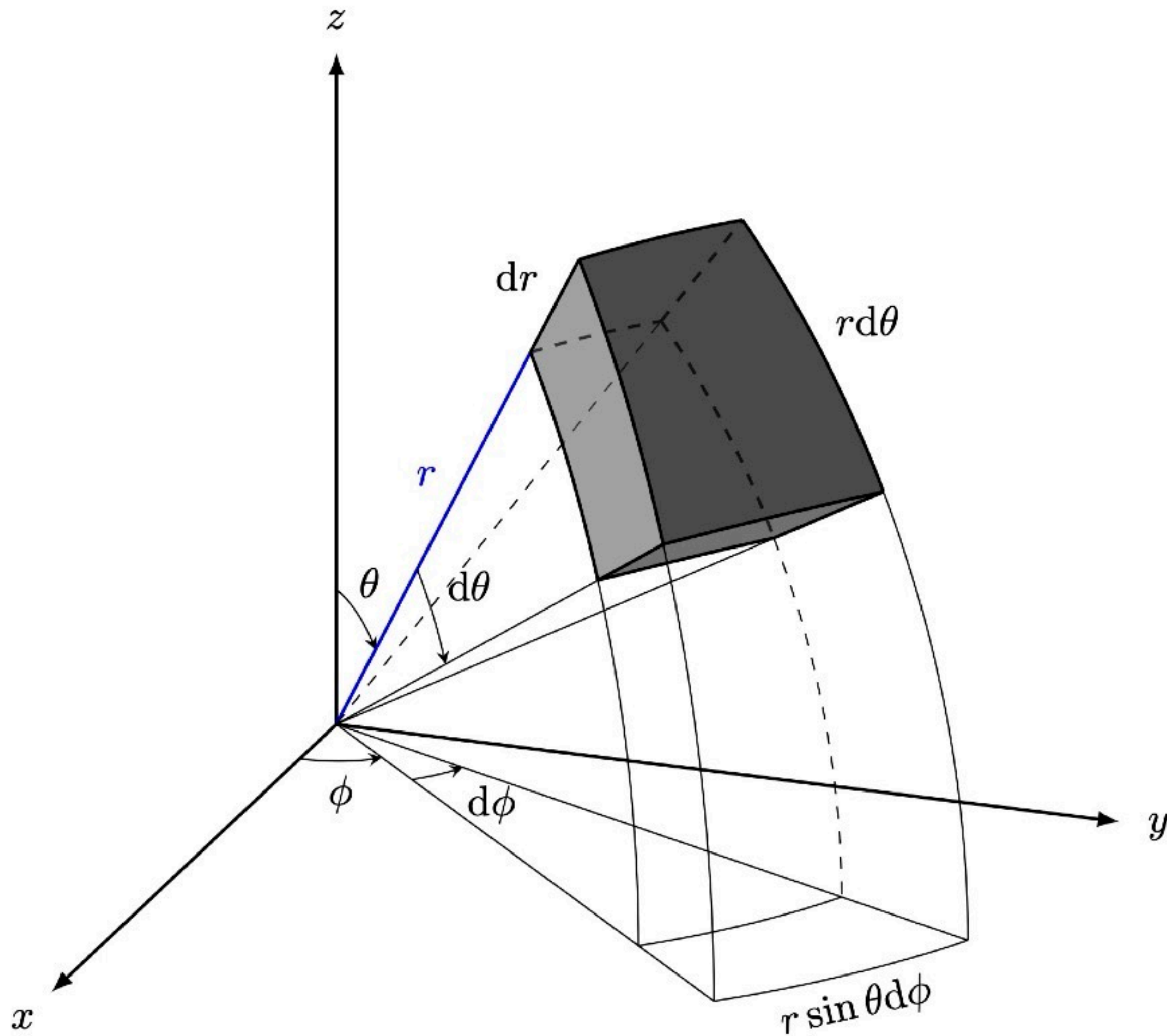


Spherical Coordinates

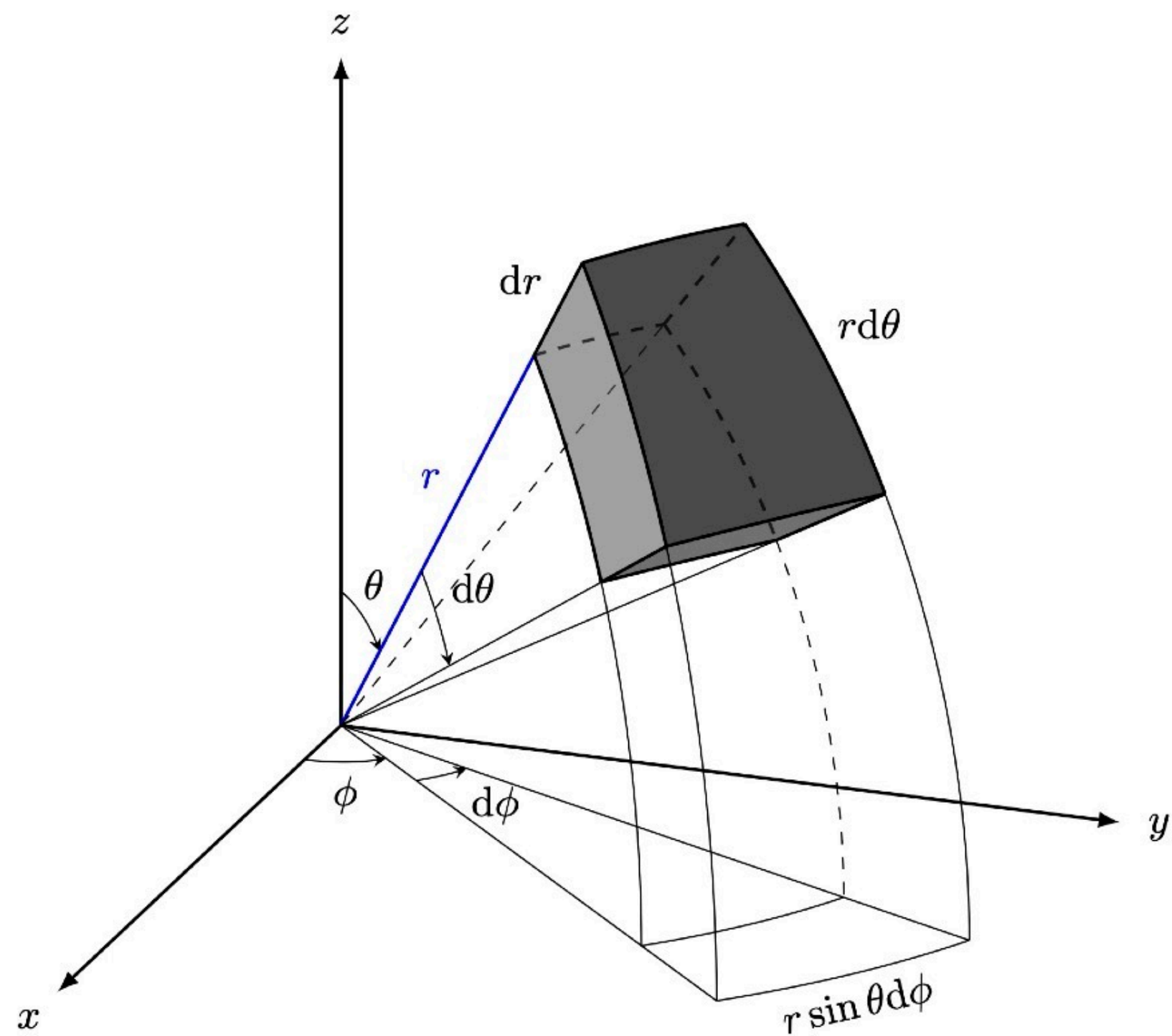
Volume and area elements

$$\begin{aligned} dV &= dA \, dr = (r \, d\theta) (r \sin \theta \, d\phi) (dr) \\ &= r^2 \sin \theta \, dr \, d\theta \, d\phi \end{aligned}$$

$$\begin{aligned} dA &= (r \, d\theta) (r \sin \theta \, d\phi) \\ &= r^2 \sin(\theta) \, d\theta \, d\phi \end{aligned}$$



Jacobian Determinant



$$x = r \sin \theta \cos \phi$$

$$y = r \sin \theta \sin \phi$$

$$z = r \cos \theta$$

$$\begin{vmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \theta} & \frac{\partial x}{\partial \phi} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \theta} & \frac{\partial y}{\partial \phi} \\ \frac{\partial z}{\partial r} & \frac{\partial z}{\partial \theta} & \frac{\partial z}{\partial \phi} \end{vmatrix} = \begin{vmatrix} \sin \theta \cos \phi & r \cos \theta \cos \phi & -r \sin \theta \sin \phi \\ \sin \theta \sin \phi & r \cos \theta \sin \phi & r \sin \theta \cos \phi \\ \cos \theta & -r \sin \theta & 0 \end{vmatrix} = r^2 \sin \theta$$