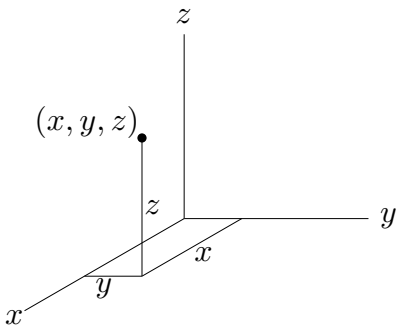
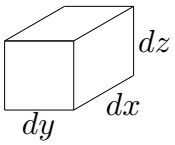
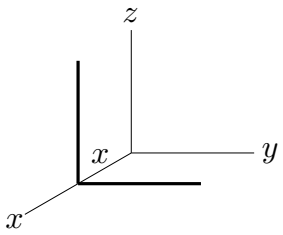
# CARTESIAN COORDINATES

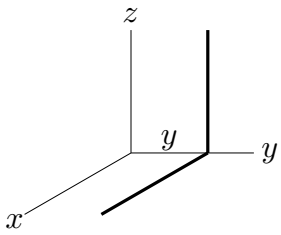


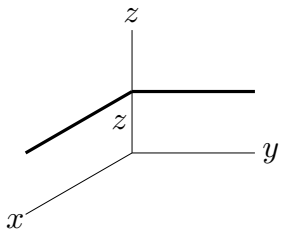

volume element $dV = dx\,dy\,dz$




surface of constant $x$

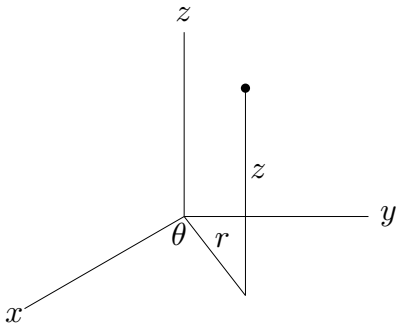


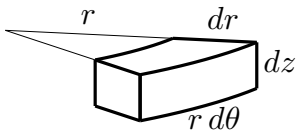

surface of constant $y$



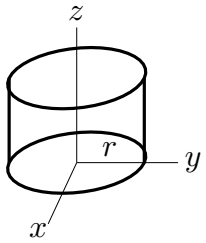

surface of constant $z$

# CYLINDRICAL COORDINATES

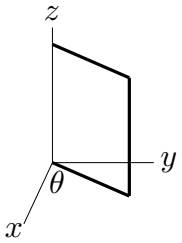


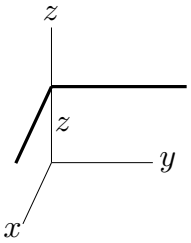

volume element $dV = r\,dr\,d\theta\,dz$




surface of constant $r$




surface of constant $\theta$

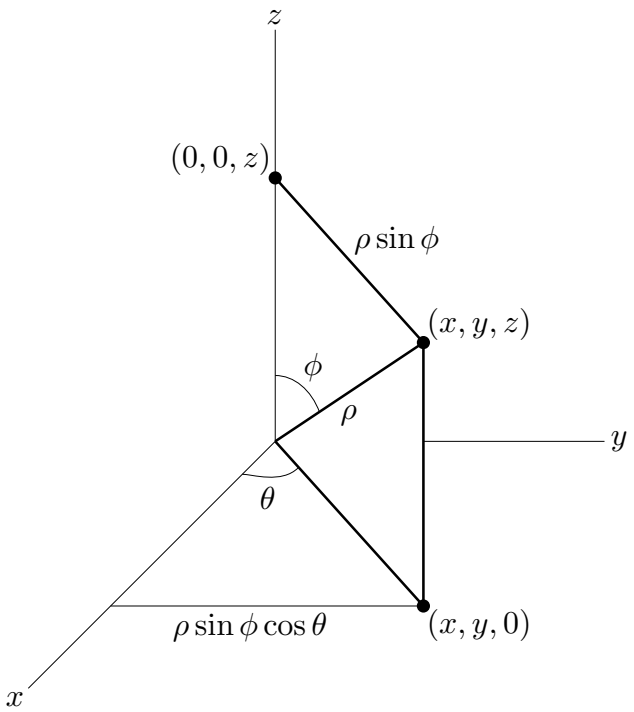


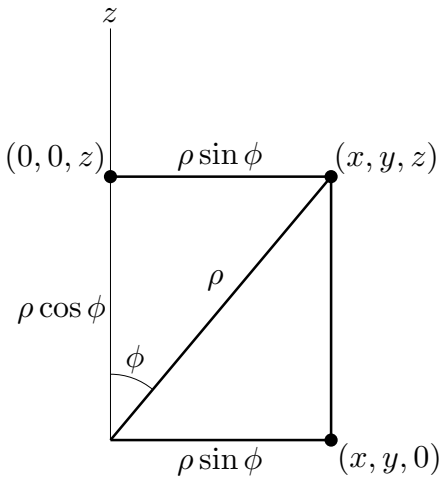

surface of constant $z$

$$x = r\cos\theta \qquad y = r\sin\theta \qquad z = z$$

$$r = \sqrt{x^2 + y^2} \qquad \theta = \tan^{-1}\frac{y}{x} \qquad z = z$$

# SPHERICAL COORDINATES




Side View

$\rho =$ distance from $(x, y, z)$ to $(0, 0, 0)$

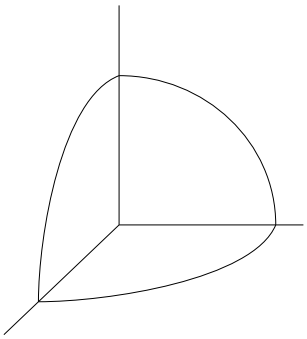
$\phi =$ angle between the line $\overline{(0, 0, 0)\,(x, y, z)}$ and the $z$ axis

$\theta =$ angle between the line $\overline{(0, 0, 0)\,(x, y, 0)}$ and the $x$ axis

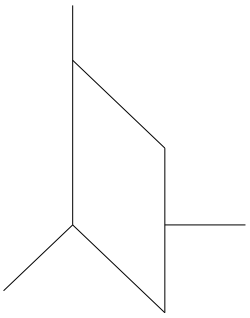
$$x = \rho \sin\phi \cos\theta \qquad \rho = \sqrt{x^2 + y^2 + z^2}$$

$$y = \rho \sin\phi \sin\theta \qquad \theta = \tan^{-1} \frac{y}{x}$$

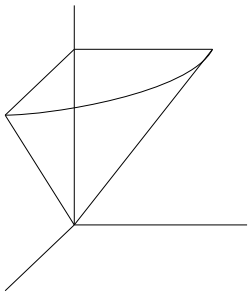
$$z = \rho \cos\phi \qquad \phi = \tan^{-1} \frac{\sqrt{x^2 + y^2}}{z}$$



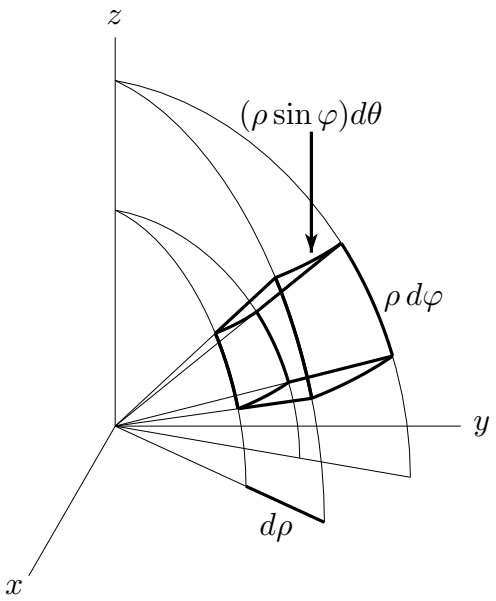
Surface of constant $\rho$



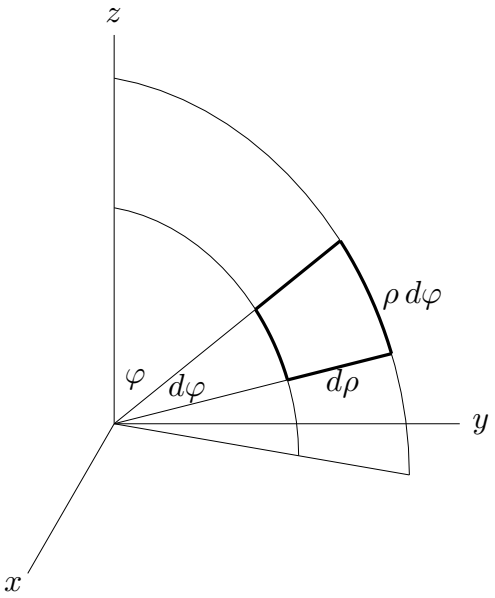
Surface of constant $\theta$

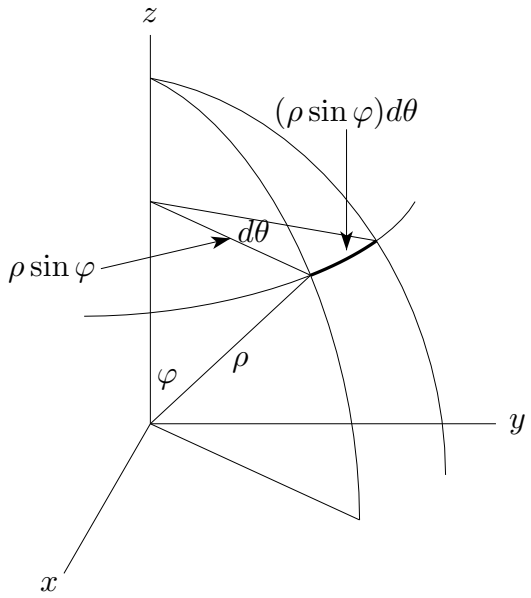


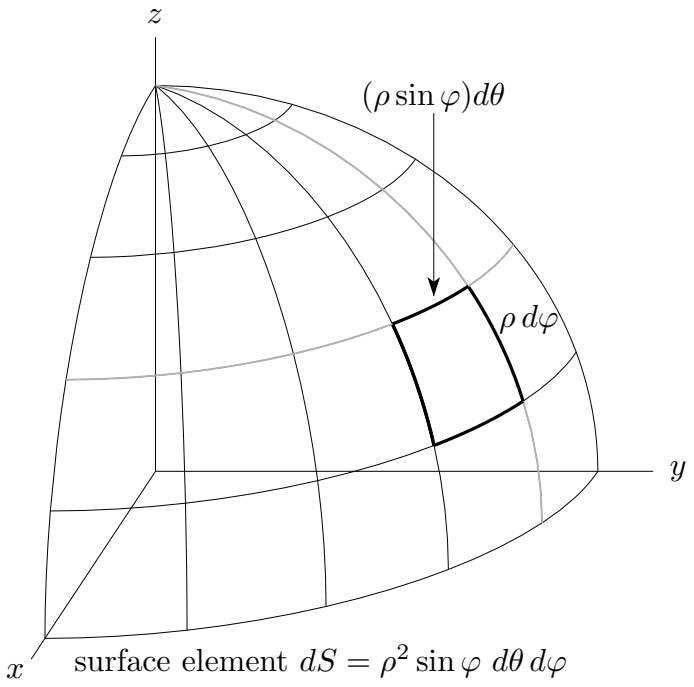
Surface of constant $\phi$

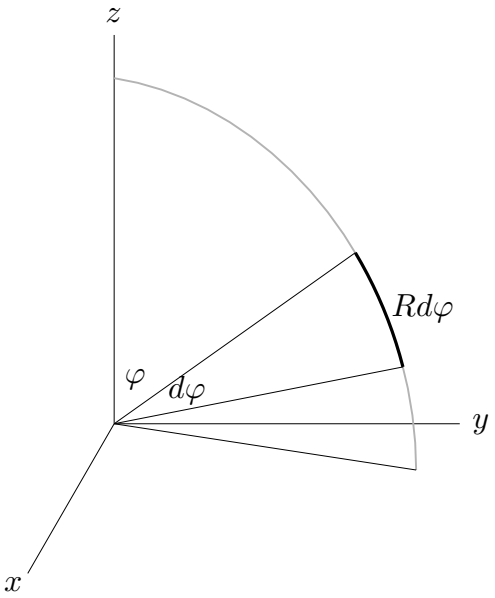


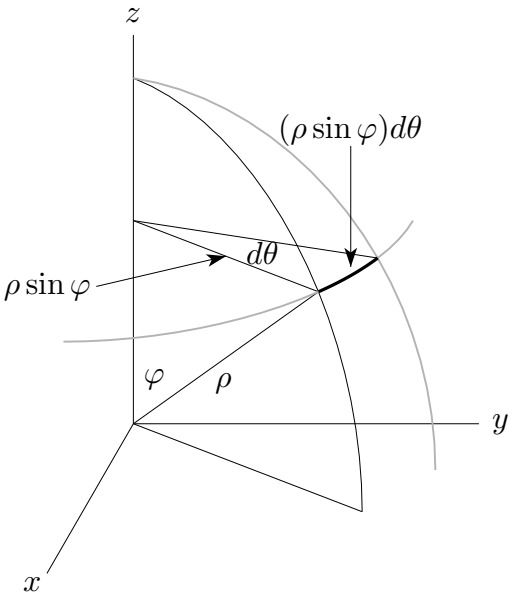

volume element $dV = \rho^2 \sin\varphi \; d\rho \, d\theta \, d\varphi$




z
$(\rho \sin \varphi) d\theta$
$\rho\, d\varphi$
y
x
surface element $dS = \rho^2 \sin \varphi \; d\theta \, d\varphi$


z
$Rd\varphi$
$\varphi$
$d\varphi$
y
x


z
$(\rho \sin \varphi) d\theta$
$d\theta$
$\rho \sin \varphi$
$\varphi$
$\rho$
y
x