Miscellaneous Formulas.

- **Polar Coordinates.** $x = r\cos(\theta)$; $y = r\sin(\theta)$

$$dA = r dr d\theta$$

- **Cylindrical Coordinates.** $x = r\cos(\theta)$; $y = r\sin(\theta)$; $z = z$

$$dV = r dr d\theta dz$$

- **Spherical Coordinates.** $x = \rho\sin(\phi)\cos(\theta)$; $y = \rho\sin(\phi)\sin(\theta)$; $z = \rho\cos(\phi)$

$$dV = \rho^2 \sin(\phi) d\rho d\phi d\theta$$

- **General Coordinates in 2-d.**

$$dA = \left|\frac{\partial(x,y)}{\partial(u,v)}\right| du dv$$

where

$$\frac{\partial(x,y)}{\partial(u,v)} = \begin{vmatrix} x_u & x_v \\ y_u & y_v \end{vmatrix}$$

- **General Coordinates in 3-d.**

$$dV = \left|\frac{\partial(x,y,z)}{\partial(u,v,w)}\right| du dv dw$$

where

$$\frac{\partial(x,y,z)}{\partial(u,v,w)} = \begin{vmatrix} x_u & x_v & x_w \\ y_u & y_v & y_w \\ z_u & z_v & z_w \end{vmatrix}$$

- **Surface Area.** Area element of the portion of the graph $z = f(x,y)$ which lies over the rectangle $dxdy$

$$dA = \sqrt{1 + f_x^2 + f_y^2} dx dy$$