CURL
DIV.

$F_1 \quad F_2 \quad F_3$

$$\nabla f = \langle f_x, f_y, f_z \rangle$$

$F_{1z} - F_{3x} = 0 \quad F_{1y} - F_{2x} = 0 \quad F_{2z} - F_{3y} = 0$

$f_{xz} - f_{zx} = 0 \quad f_{xy} - f_{yx} \quad f_{yz} - f_{zy}$

$$F = \langle F_1, F_2, F_3 \rangle$$

conservative?
curl F
$= 0$

$$\text{curl } F = \begin{vmatrix} i & j & k \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ F_{1\,M} & F_{2\,N} & F_{3\,P} \end{vmatrix}$$

$\langle F_{3y} - F_{2z}, F_{3x} - F_{1z}, F_{1y} - F_{2x} \rangle = 0$

$\langle P_y - N_z, P_x - M_z, M_y - N_x \rangle = 0$

$$\langle 2xz,\ 3z^2,\ x^2+6yz \rangle$$

$$f_x \qquad f_y \qquad f_z$$

$$\int 2xz\,dx \qquad \int 3z^2\,dy \qquad \int x^2+6yz\,dz$$

$$x^2z + (y,z) \qquad 3yz^2 + (x,z) \qquad x^2z + 3yz^2 + (x,y)$$

$$f = x^2z + 3yz^2$$

$$\nabla f = F$$

Point $(0,0,0) \rightarrow (1,1,1)$

or

$$f(1,1,1) - f(0,0,0)$$

$$1+3 - 0 = 4$$

$$4$$

$$x^2+y^2-z^2=9$$

$$x = 3\cos u \cosh v$$

$$y = 3\sin u \cosh v$$

$$z = 3\sinh v$$

$$x^2+y^2 =$$

$$9\cos^2 u \cosh^2 v + 9\sin^2 u \cosh^2 v$$

$$9\cosh^2 v \left[\underbrace{\cos^2 u + \sin^2 u}_{1}\right]$$

$$x^2+y^2 = 9\cosh^2 v$$

$$z^2 = 9\sinh^2 v$$

$$x^2+y^2 = z^2$$

$$9\cosh^2 v - 9\sinh^2 v$$

$$9(\cosh^2 v - \sinh^2 v)$$

$$9 \cdot 1$$

$$x^2 - y^2 - z^2 = 1$$

$x = \cosh v \qquad \underbrace{y = \cos u \sinh v \qquad z = \sin u \sinh v}$

$$y^2 + z^2$$

$$x^2 \quad \cosh^2 v \qquad \sinh^2 v$$

$$x^2 - y^2 - z^2$$

$$\cosh^2 v - \sinh^2 v = 1$$

$$2 \le z \le 3$$

$$\tfrac{2}{3} \le \sinh v \le \tfrac{3}{3}$$

$$\sinh^{-1}(\tfrac{2}{3}) \le v \le \sinh^{-1}(1)$$