$$\vec{r}_p = x_p\hat{x} + y_p\hat{y} + z_p\hat{z}$$

$$\hat{r}_p = \frac{\vec{r}_p}{|\vec{r}_p|}$$

$$|\vec{r}_p| = \sqrt{\vec{r}_p \cdot \vec{r}_p}$$

$$d\vec{\ell} = dx\,\hat{x} + dy\,\hat{y} + dz\,\hat{z}$$

$$\vec{r}_{ip} = \vec{r}_p - \vec{r}_i \qquad \vec{r}_i = 2\hat{x}$$

$$\vec{r}_p = 1\hat{x}$$

$$\vec{r}_{ip} = (1-2)\hat{x} = -\hat{x}$$

$i(2,5,7)$ $\quad$ $p(4,6,8)$

$\vec{r}_i = 2\hat{x} + 5\hat{y} + 7\hat{z}$

$\vec{r}_p = 4\hat{x} + 6\hat{y} + 8\hat{z}$

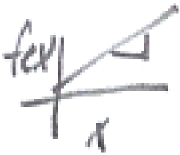
$\vec{r}_{ip} = \vec{r}_p - \vec{r}_i = (4-2)\hat{x} + (6-8)\hat{y} + (8-7)\hat{z}$

$= 2\hat{x} - 2\hat{y} + 1\hat{z}$

$\hat{r}_{ip} = \dfrac{\vec{r}_{ip}}{|\vec{r}_{ip}|}$ $\quad$ $|\vec{r}_{ip}| = \sqrt{2^2 + 2^2 + 1^2}$

$= \sqrt{4+4+1} = \sqrt{9} = 3$

$\hat{r}_{ip} = \frac{2}{3}\hat{x} - \frac{2}{3}\hat{y} + \frac{1}{3}\hat{z}$



$$y = mx + b$$

$$\frac{dy}{dx} = m$$

$$df = \left(\frac{df}{dx}\right) dx$$

$$f(x, y, z)$$

$$df = \left(\frac{\partial f}{\partial x}\right)_{y,z} dx + \left(\frac{\partial f}{\partial y}\right) dy + \left(\frac{\partial f}{\partial z}\right) dz$$

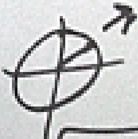
$$\vec{\nabla} f = \frac{\partial f}{\partial x}\hat{x} + \frac{\partial f}{\partial y}\hat{y} + \frac{\partial f}{\partial z}\hat{z}$$

$$df = \vec{\nabla} f \cdot d\vec{l}$$

$f = r = \sqrt{x^2+y^2+z^2}$ $\quad (x^2+y^2+z^2)^{1/2}$

$\vec{\nabla} f :$

$\frac{\partial f}{\partial x} = \frac{1}{2}(x^2+y^2+z^2)^{-1/2} \cdot 2x$



$= \frac{x}{\sqrt{x^2+y^2+z^2}}$ $\quad \vec{r} = x\hat{x} + y\hat{y} + z\hat{z}$

$\boxed{\vec{\nabla} f = \frac{\vec{r}}{|\vec{r}|} = \hat{r}}$ $\quad \vec{r} = 2x\hat{x}$

$|\vec{r}| = 2x$

$\vec{\nabla} r = 2\hat{x}$ $\quad \frac{\vec{r}}{|\vec{r}|} = \frac{2x\hat{x}}{\sqrt{4x^2}} = \hat{x}$

$$s = \sqrt{x^2 + y^2}$$

$$\vec{\nabla} s = \frac{1}{2} \cdot \frac{1}{\sqrt{x^2+y^2}} \cdot 2x\,\hat{x}$$

$$+ \frac{y}{\sqrt{x^2+y^2}}\,\hat{y} = \frac{x\hat{x} + y\hat{y}}{|s|}$$

$$= \frac{\vec{s}}{|\vec{s}|} = \hat{s}$$

$\frac{f}{x} + f$

$$f = e^{xyz} \quad \vec{\nabla} f = yzf\hat{x} + xzf\hat{y} + xyf\hat{z}$$

$$= f\left(\frac{f}{x}\hat{x} + \frac{f}{y}\hat{y} + \frac{f}{z}\hat{z}\right)$$

$$\vec{r}_i = x_i \vec{x} + y_i \vec{y} + z_i \vec{z}$$

$$\vec{r}_p = x_p \vec{x} + y_p \vec{y} + z_p \vec{z}$$

$i, p \leq$

$$r_{ip} = r_p - r_i$$

$$\vec{\nabla}_p r_{ip}^2 =$$

$$r_{ip}^2 = (x_p - x_i)^2 + (y_p - y_i)^2 + (z_p - z_i)^2$$

$$\vec{\nabla}_p r_{ip}^2 = 2(x_p - x_i)\vec{x} + 2(y_p - y_i)\vec{y} + 2(z_p - z_i)\vec{z}$$

$$= 2\vec{r}_{ip}$$

$$\vec{\nabla}_p \left(\frac{1}{r_{ip}} \right)$$

$$r_{ip} = \sqrt{(x_p - x_i)^2 + (y_p - y_i)^2 + (z_p - z_i)^2}$$

$$\frac{1}{r_{ip}} = [\ ]^{-1/2}$$

$$-\frac{1}{2} [\ ]^{-3/2} (2(x_p - x_i)) \hat{x}$$

$$\cdots\cdots$$

$$= -2 \frac{\vec{r}_{ip}}{|\hat{r}_{ip}|^2}$$

$$\vec{\nabla}_p (r_{ip}^n)$$

$$r_{ip}^n = [r_{ip}]^n$$

$$r_{ip}^n = (x_p - x_i)^n$$

$$\vec{\nabla}_p r_{ip}^n = n(x_p - x_i)^{n-1} \cdot 1 \cdot \hat{r}_{ip}$$

$$= n \cdot r_{ip}^{n-1} \hat{r}_{ip}$$