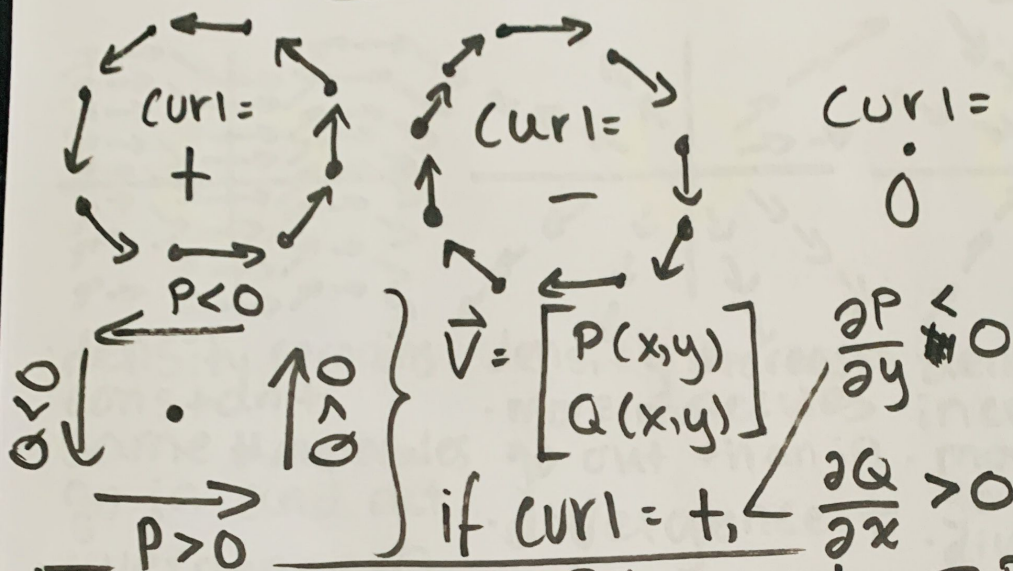


CURL



$$\therefore \text{curl } \vec{v}(x,y) = \frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y} \quad \left. \begin{array}{l} \text{2D} \\ \text{CURL} \end{array} \right\}$$

$$\text{2D curl } \vec{v}(x,y) = \begin{bmatrix} \frac{\partial}{\partial x} \\ \frac{\partial}{\partial y} \end{bmatrix} \times \begin{bmatrix} P(x,y) \\ Q(x,y) \end{bmatrix}$$

$$\text{3D curl } \vec{v}(x,y,z) = \underbrace{\begin{bmatrix} \frac{\partial}{\partial x} \\ \frac{\partial}{\partial y} \\ \frac{\partial}{\partial z} \end{bmatrix}}_{\nabla} \times \underbrace{\begin{bmatrix} P(x,y,z) \\ Q(x,y,z) \\ R(x,y,z) \end{bmatrix}}_{\vec{v}(x,y,z)}$$

CURL II

$$3D \text{ curl } \vec{v}(x, y, z) = \begin{bmatrix} \partial/\partial x \\ \partial/\partial y \\ \partial/\partial z \end{bmatrix} \times \begin{bmatrix} P(x, y, z) \\ Q(x, y, z) \\ R(x, y, z) \end{bmatrix}$$

$$\det \begin{pmatrix} \hat{i} & \hat{j} & \hat{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ P & Q & R \end{pmatrix} = \begin{pmatrix} \partial/\partial x & \partial/\partial y \\ P & Q \end{pmatrix} \hat{i} + \begin{pmatrix} \partial/\partial x & \partial/\partial z \\ P & R \end{pmatrix} \hat{j} - \begin{pmatrix} \partial/\partial y & \partial/\partial z \\ Q & R \end{pmatrix} \hat{k}$$

$$\left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y} \right) \hat{j} + \left(\frac{\partial R}{\partial x} - \frac{\partial P}{\partial z} \right) \hat{j} -$$

$$\left(\frac{\partial R}{\partial y} - \frac{\partial Q}{\partial z} \right) \hat{k} = \begin{bmatrix} \frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y} \\ \frac{\partial R}{\partial x} - \frac{\partial P}{\partial z} \\ \frac{\partial R}{\partial y} - \frac{\partial Q}{\partial z} \end{bmatrix}$$