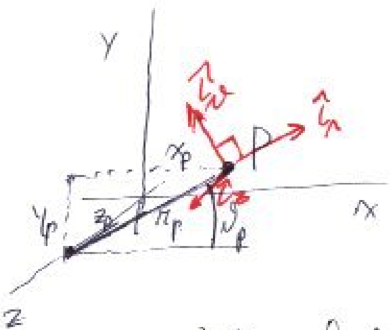
See math handbook "vector analysis"

Cylindrical, including polar r, ϑ, z



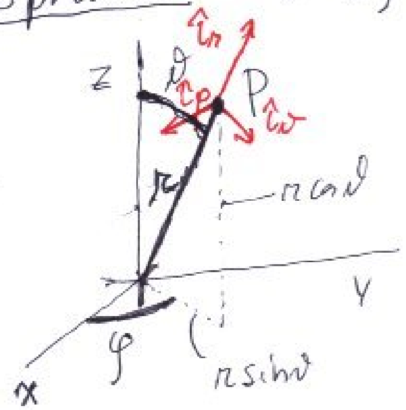
$$\left.\begin{aligned} x &= r\cos\vartheta \\ y &= r\sin\vartheta \\ z &= z \end{aligned}\right\} \quad \vec{r} = \begin{pmatrix} r\cos\vartheta \\ r\sin\vartheta \\ z \end{pmatrix}$$

$$\frac{\partial \vec{r}}{\partial r} \equiv h_r \hat{\imath}_r = \begin{pmatrix} \cos\vartheta \\ \sin\vartheta \\ 0 \end{pmatrix} \longrightarrow \boxed{\hat{\imath}_r = \begin{pmatrix} \cos\vartheta \\ \sin\vartheta \\ 0 \end{pmatrix} \quad h_r = 1}$$

$$\frac{\partial \vec{r}}{\partial \vartheta} \equiv h_\vartheta \hat{\imath}_\vartheta = \begin{pmatrix} -r\sin\vartheta \\ r\cos\vartheta \\ 0 \end{pmatrix} \longrightarrow \boxed{\hat{\imath}_\vartheta = \begin{pmatrix} -\sin\vartheta \\ \cos\vartheta \\ 0 \end{pmatrix} \quad h_\vartheta = r}$$

$$\frac{\partial \vec{r}}{\partial z} \equiv h_z \hat{\imath}_z = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \longrightarrow \boxed{\hat{\imath}_z = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \quad h_z = 1}$$

Spherical r, ϑ, φ



$$\begin{aligned} x &= r\sin\vartheta\cos\varphi \\ y &= r\sin\vartheta\sin\varphi \\ z &= r\cos\vartheta \end{aligned}$$

$$\frac{\partial \vec{r}}{\partial r} \equiv h_r \hat{\imath}_r = \begin{pmatrix} \sin\vartheta\cos\varphi \\ \sin\vartheta\sin\varphi \\ \cos\vartheta \end{pmatrix} \qquad \boxed{\hat{\imath}_r = \begin{pmatrix} \sin\vartheta\cos\varphi \\ \sin\vartheta\sin\varphi \\ \cos\vartheta \end{pmatrix} \quad h_r = 1}$$

$$\frac{\partial \vec{r}}{\partial \vartheta} = h_\vartheta \hat{\imath}_\vartheta = \begin{pmatrix} r\cos\vartheta\cos\varphi \\ r\cos\vartheta\sin\varphi \\ -r\sin\vartheta \end{pmatrix} \qquad \boxed{\hat{\imath}_\vartheta = \begin{pmatrix} \cos\vartheta\cos\varphi \\ \cos\vartheta\sin\varphi \\ -\sin\vartheta \end{pmatrix} \quad h_\vartheta = r}$$

$$\frac{\partial \vec{r}}{\partial \varphi} = h_\varphi \hat{\imath}_\varphi = \begin{pmatrix} -r\sin\vartheta\sin\varphi \\ r\sin\vartheta\cos\varphi \\ 0 \end{pmatrix} \qquad \boxed{\hat{\imath}_\varphi = \begin{pmatrix} -\sin\varphi \\ \cos\varphi \\ 0 \end{pmatrix} \quad h_\varphi = r\sin\vartheta}$$

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HW 1: 2) Couette Flow, stress tensor compute forces surface
3)
4) Rotate coordinates

HW 2: 1) vorticity, S, diagonalize, s_i,
2) Solid body rotation
3) Poiseuille → S, incomp?, ω, find s_1, s_2, s_3 given $\hat{i}, \hat{j}, \hat{k}$
4)
5)
6)

HW 3 1) Poiseuille: τ^{visc} τ^{tot}
2) stress in principal axes
3) Pancit do $\int \rho \vec{v} \cdot \vec{n}\, dA$, $\left(\int \rho \vec{v} \cdot \vec{n}\, \vec{v}_z\, dA\right)_z$, $\int (\bar{\bar{\tau}}^T \vec{n}) dA$, $\left(-\int p \vec{n}\, dA\right)_z$
4)
5)
6) elbow same

HW 4 1) momentum equation same
2)
3
4) velocity B.C.
5) B.C.; $\bar{\bar{\tau}}$ given
6) plug in N.S. eqs,

HW 5: 1) streamlines, streaklines, particle paths
2) find $\vec{a}$, pressure force, viscous force/unit volume
3) streamlines pathlines streaklines
4)

~~5~~ Hydrostatics

OVER

HW6. ~~1)~~ Euler equations

~~2)~~ acoustics.

3) N.S eqs, incomp nondimensional

~~4)~~ } dimensional analysis, common sense
~~5)~~

6 } find stress tensor, integrate $\left(\int \overline{\overline{\tau}}^T \vec{n}\, dA\right)_x$
7 }

HW7. 1) } with N.S., apply assumptions, B.C, earlier results → find flow
~~3~~ 2) } $\int \overline{\overline{\tau}}^T \cdot \vec{n} \times \vec{r}$
3) } $\left(\int \vec{r} \times \overline{\overline{\tau}}^T \vec{n}\, dA\right)_z$
4) }
5)