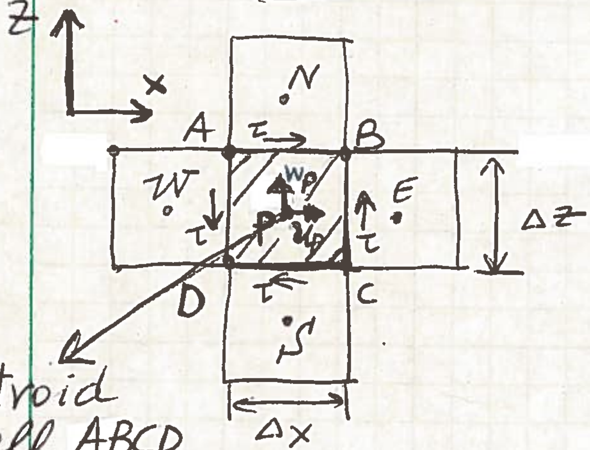
Application of momentum equation on a cell in CFD (cell ABCD)



P: centroid of cell ABCD

$$\sum F_x = \underbrace{\int_{C.S.} (\rho q_n \, ds)\, u}_{\text{rate of momentum (along x) coming out of C.S. of cell ABCD}}$$

$$\sum F_z = \int_{C.S.} (\rho q_n \, ds)\, W$$

- $C.S.$ = Control surface = $\underbrace{AB + BC + CD + DA}_{\text{FACES of cell}}$
- q_n = normal velocity through a surface
- $\rho q_n \, ds$ = mass rate = $\rho \cdot$ flux (out of an element ds of C.S.)

So: $\sum F_x = P_{AD} \times AD - P_{BC} \times BC + \tau_{AB} \times AB - \tau_{DC} \times DC$

$$\int_{C.S.} (\rho q_n \, ds)\, u = \underbrace{\rho u_{BC} (BC)}_{\text{mass rate out of BC}} u_{BC} + \underbrace{\rho W_{AB} (AB)}_{\text{mass rate out of AB}} u_{AB}$$

u at midpoint of face BC

$$- \underbrace{\rho u_{AD} (AD)}_{\text{mass rate into AD}} u_{AD} - \underbrace{\rho W_{DC} (DC)}_{\text{mass rate into DC}} u_{DC}$$

Expressing mass rates through the cell faces, velocities at the midpoints of faces, in terms of velocities at the cell centroids (of ABCD + neighboring cells at N, S, W, E)

Examples:

u_{BC} = (u velocity at midpoint of face BC)

$$= \frac{u_P + u_E}{2}$$

w_{DC} = (w velocity at midpoint of face DC)

$$= \frac{w_P + w_S}{2}$$

etc, until only values of u, w at the centroids of ABCD, and its neighbors are involved!