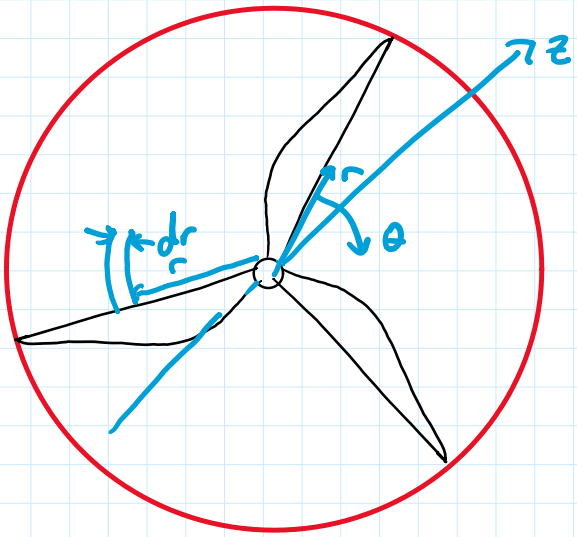
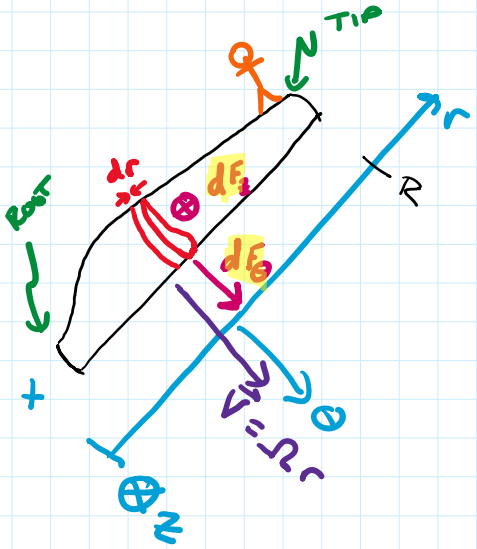
1-D MODEL DEVELOPMENT

↳ FLUID-STRUCTURE INTERACTION (FSI)

↳ r IS OUR DEPENDENT VARIABLE



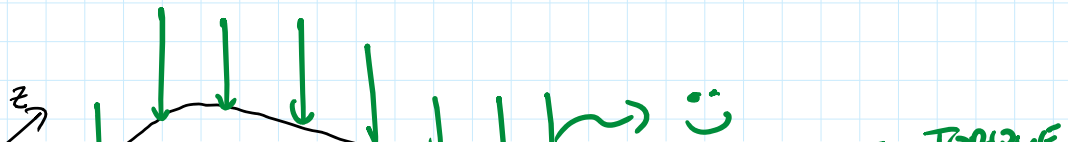


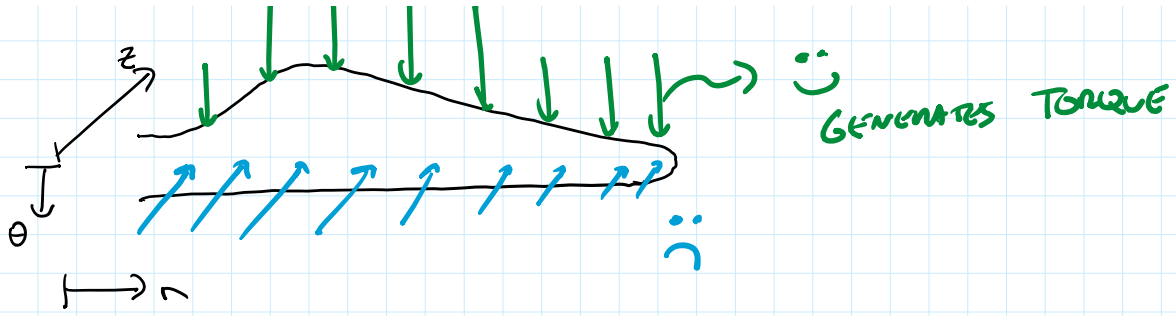
DEFN:

TIP SPEED RATIO

$$\lambda[-] = \frac{|\text{VELOCITY OF THE BLADE TIP}|}{|\text{VELOCITY OF THE WIND}|}$$

$$\lambda = \frac{\Omega R}{V_{WIND}}$$





TORQUE

$$T = n \int_{BLADE} r\, dF_\theta \quad \Rightarrow \quad T = n \int_0^R r\, F'_\theta\, dr$$

(n: # OF BLADES)

or

$$T = n \int_0^R r\, q_\theta\, dr$$

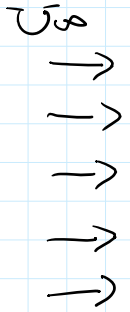
FORCE IN THE Z-DIR

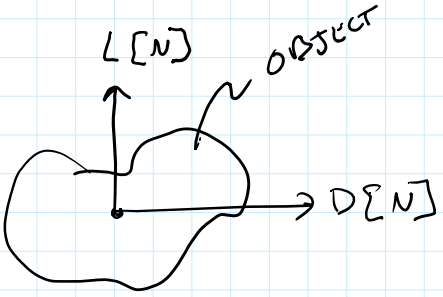
$$F_z = n \int_{BLADE} dF_z \quad \Rightarrow \quad F_z = n \int_0^R F'_z\, dr$$

or

$$= n \int_0^r q_z\, dr$$

EXTERNAL FLOWS





① DRAG FORCE IN THE DIRECTION OF FLOW

② LIFT FORCE THAT IS NORMAL TO THE FLOW DIRECTION

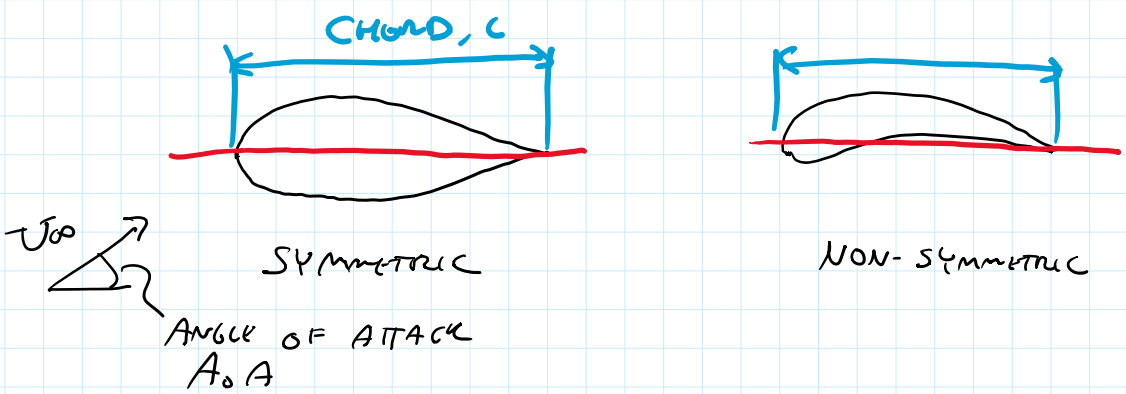
DEFN

$$C_D \equiv \frac{D}{\frac{1}{2}\rho U_\infty A} \qquad C_L \equiv \frac{L}{\frac{1}{2}\rho U_\infty A}$$

$$C_L + C_D = \text{fcn}(\text{RE}, \text{GEOMETRY}, \ldots)$$

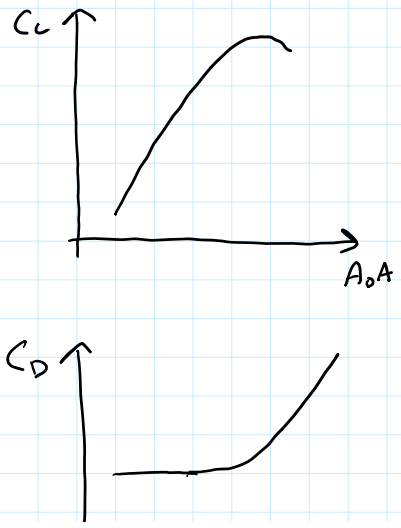
AIRFOILS

↳ TO CREATE LIFT + MINIMIZE DRAG



USE TABLES FOR C_L, C_D

FOR A GIVEN RE, AIRFOIL, M



RELATIVE VELOCITY

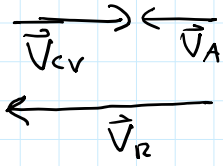
$$\vec{V}_A = \vec{V}_R + \vec{V}_{CV}$$

ABSOLUTE VELOCITY
↳ VELOCITY OF THE FLUID BASED ON A FIXED REFERENCE FRAME
(WIND)

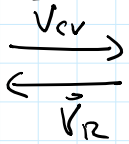
RELATIVE VELOCITY
↳ VELOCITY THAT THE OBJECT "FEELS"
(IMPORTANT ONE!)

CONTROL VOLUME VELOCITY
↳ MOTION OF THE CONTROL VOLUME
(YOU ON THE TURBINE BLADE)

HEAD WIND



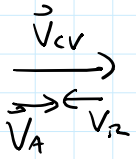
ZERO WIND



TAIL WIND

$\vec{V}_{CV}$

TAIL WIND



VECTOR