MOST IMPORTANT EQUATION TO REMEMBER, FOR $\lambda_r \gg 1$ AND $\frac{C_L}{C_D} \gg 1$

$$\boxed{C_L \cdot G_r \cdot \lambda_r^2 = 4a(1-a)}$$

WITH $G_r = \frac{Bc}{2\pi r}$ AND $\lambda_r = \frac{r}{R} \cdot \lambda$

HOW TO REMEMBER / DERIVE ?

MOMENTUM BALANCE:

FORCE ON BLADE (AREA A_B)

$$F_B \approx \frac{1}{2} \rho A_B (\lambda_r u_\infty)^2$$

EQUALS THRUST ON ANNULUS (AREA A_A)

$$F_A = \frac{1}{2} \rho A_A u_\infty^2 \; 4a(1-a)$$

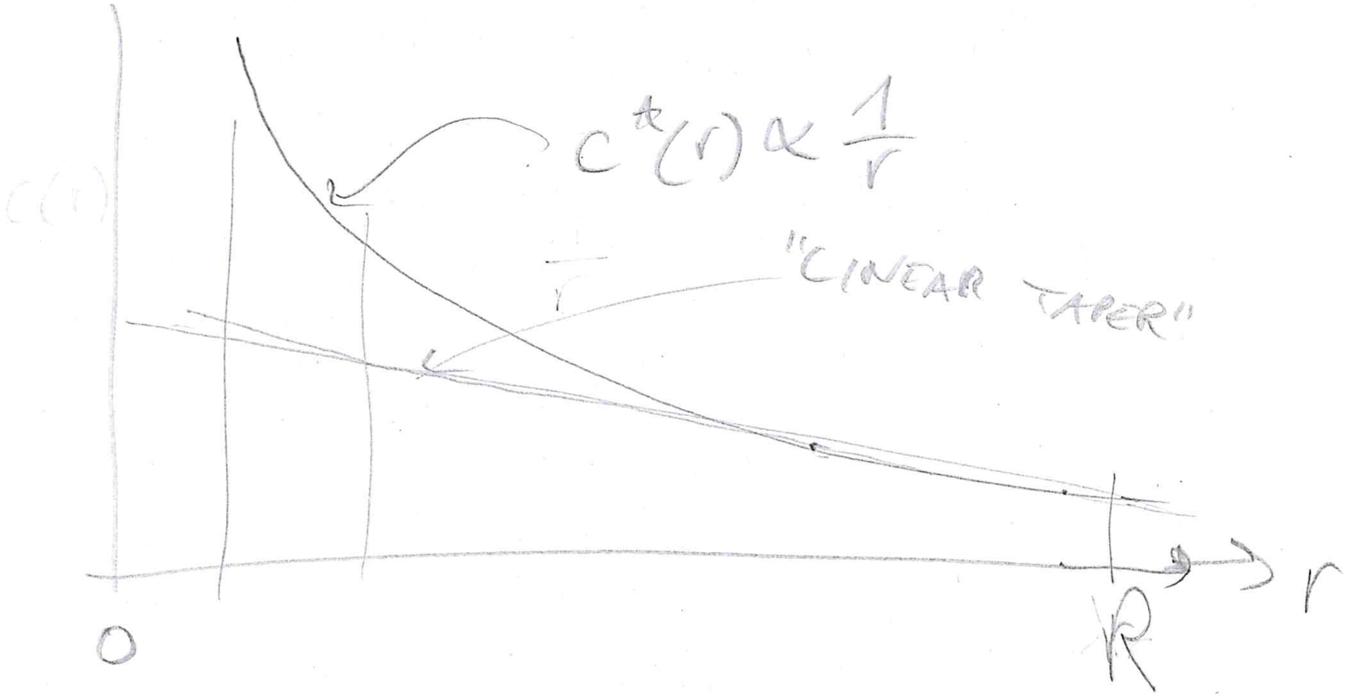
$$G_r = \frac{A_B}{A}$$

$$c = \frac{2\pi r}{B} \frac{1}{C_L} \frac{4a(1-a) R^2}{r^2 \lambda^2} \propto \frac{1}{r}$$

CHORD INVERSELY PROPORTIONAL TO RADIUS

3.4.2

IN PRACTICE, ALSO "LINEAR TAPER" IS USED



CAN INCREASE ANGLE OF ATTACK IN ORDER TO INCREASE C_L TO COMPENSATE FOR LOWER SOLIDITY, DRAG LOSSES IN INNER PART OF BLADE LESS IMPORTANT.

3.5 TIP LOSSES

AERODYNAMIC EFFICIENCY IS LOWER THAN BEM PREDICTS DUE TO "TIP LOSSES", WHICH WE DO NOT TREAT HERE

CH 4 : MECHANICS & DYNAMICS OF WIND TURBINES

LOADS/
FORCES ON WIND TURBINE & BLADES ?

SOURCES:

- AERODYNAMICS (LIFT / DRAG)
- GRAVITY (WEIGHT OF NACELLE, BLADES)
- INERTIA (GYROSCOPIC / CENTRIFUGAL)
- ELECTROMECHANICAL (GENERATOR TORQUE)
- OPERATIONAL (BRAKE, YAW & PITCH ACTUATORS)

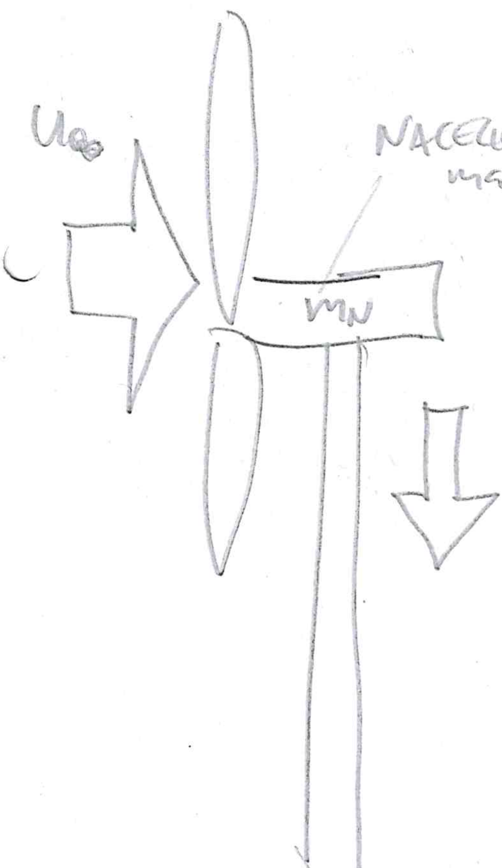
TYPES OF LOADS:

- STEADY (STATIC & ROTATING)
- CYCLIC : MULTIPLES OF ROTATION FREQUENCY (HARMONICS)
  "1P" = ONCE PER REVOLUTION, E.G. IMBALANCES OF BLADES
  "3P" = THREE TIMES PER REVOLUTION
  B·P = B-TIMES, (B = BLADE NUMBER) "BLADE PASSING FREQUENCY"

- RESONANT (VIBRATIONS OF TOWER & BLADES)
- TRANSIENT (START, STOP, YAW)
- STOCHASTIC (WIND)

4.1 STEADY LOADS IN NORMAL OPERATION

TOWER:



THRUST: $F_T \approx \dfrac{P}{\frac{2}{3} u_\infty}$

WEIGHT (GRAVITY): $F_G = m_N g$

E.G. $P = 6\ MW$, $u_\infty = 9\ \frac{m}{s}$

$m_N = 360\ t$

$F_T = 1\ MN$

$F_G = 3.6\ MN$