Example 14-8 (From Cengel, Chapter 14

Given

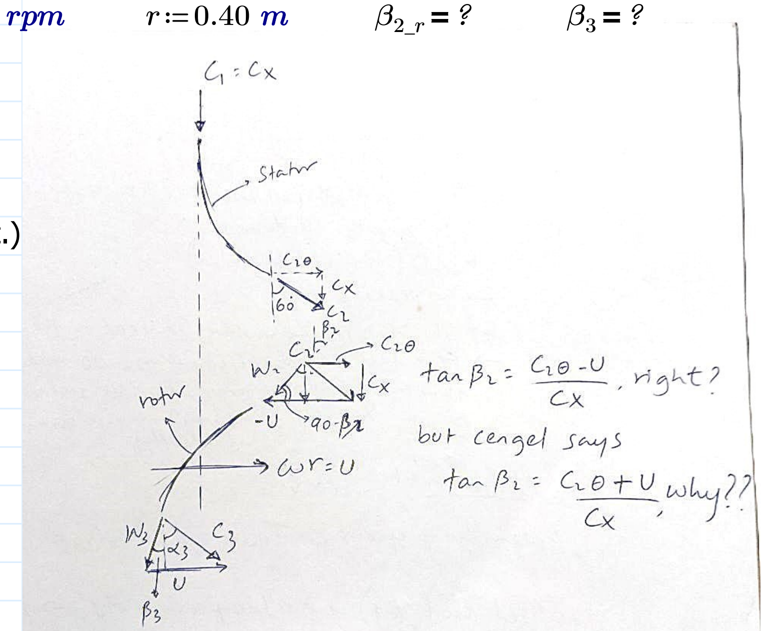
$\beta_{2\_s} := 60\ deg$ $\quad c_x := 47.1\ \dfrac{m}{s}$ $\quad \omega := 1750\ rpm$ $\quad r := 0.40\ m$

Required

$\beta_{2\_r} = ?$ $\quad \beta_3 = ?$

Assumptions:

- Flow is steady in the middle
- Incompressible flow
- Constant cross sectional area (c_x=const.)
- No whirl at exit ($\alpha_3 = 0$)



$$tan\left(\beta_{2\_r}\right) = \frac{W_{2t}}{c_x} = \frac{c_{2\theta} - U}{c_x} = \frac{c_{2\theta} - \omega \cdot r}{c_x}$$

And... $\quad \tan\left(\beta_{2\_s}\right) = \dfrac{c_{2\theta}}{c_x} \xrightarrow[]{solve, c_{2\theta} \atop float, 3} \dfrac{47.1 \cdot m \cdot \tan(60.0 \cdot deg)}{s} = 81.58\ \dfrac{m}{s}$

$$c_{2\theta} := 81.58\ \frac{m}{s}$$

$$\tan\left(\beta_{2\_r}\right) = \frac{c_{2\theta} - \omega \cdot r}{c_x} \qquad \beta_{2\_r} := \text{atan}\left(\frac{c_{2\theta} - \omega \cdot r}{c_x}\right) = 9.966\ deg$$

If we design the blades so that there's no whirl at the exit, then $c_3 = c_x$ meaning...

$$\tan\left(\beta_3\right) = \frac{\omega \cdot r}{c_x} \xrightarrow[]{solve, \beta_3 \atop float, 6} \text{atan}(14.862 \cdot rpm \cdot s) = 57.278\ deg \qquad \beta_3 := 57.278\ deg$$

Cengel's Answer:

We conclude that the rotor blade at this radius has a leading edge angle of about **73.1°** (Eq. 3) and a trailing edge angle of about **57.3°** (Eq. 4). A sketch of the rotor blade at this radius is provided in Fig. 14–65; the total curvature is small, being less than 16° from leading to trailing edge.