Gears:

Exercise 1: Presizing

Even in the exam for gears we need to be able to presize.

Spur gear since there is no axial component.

$a = 120 \pm 5mm$

$u = 2$

$\alpha = 20^\circ$

Pinions need higher since they are smaller so they suffer more cycles.
Both are ductile since $A > 2\text{-}3\%$

We take U_L^* as 80 since we have no reason to do otherwise, so we choose in the middle, if it later fails we take a higher value.

We take k^* from the table at the current layout, we have a range of 5.6 and 10, as a first trial we take 7,5 MPa.

$$dp_1 = \frac{2a}{u+1} = 80mm$$

$$dp_2 = u \cdot dp_1 = 160mm$$

$$b = \frac{1}{k^*} \cdot \frac{2C_1}{dp_1^2} \cdot \frac{u+1}{u} = 5mm$$

→ We know C_1 we have already designed the shaft and have C_1.

→ Face width of our pinion.

→ We shouldn't be happy. Usually we use the same b for all gear wheels. In this case we will have a gear with $d_p = 160mm$ and $b = 5mm$, this is disproportional & risks breaking.

engineering rule: We take this value if it is at least 1/10 of the d_p of the biggest gear. So in this case we will assume 16 mm rather than 5.

$$m = \frac{T}{b \cdot U_L^*} = 1{,}56mm \xrightarrow[\text{module}]{\text{standard}} 2mm$$

We don't go to 1,5mm for safety even though we already went from $b=5$ to $b=15mm$

$$z_1 = \frac{dp_1}{m} = 40 \quad (z_1 > 17 \Rightarrow \text{no undercut with } \alpha = 20°)$$

$$z_2 = u\, z_1 = 80 \xrightarrow[\text{prime to each other}]{z_1 \,\&\, z_2} z_2 = 81 \Rightarrow dp_2 = 162$$

↳ we can also change zp_1 to 39 or 41 → In many cases this is the point we can most easily make changes.

$u_{final} = \frac{81}{40} = 2{,}025$ ✓

$a_{final} = 121\,mm$ ✓

$dp_1 = 80$, $dp_2 = 162$

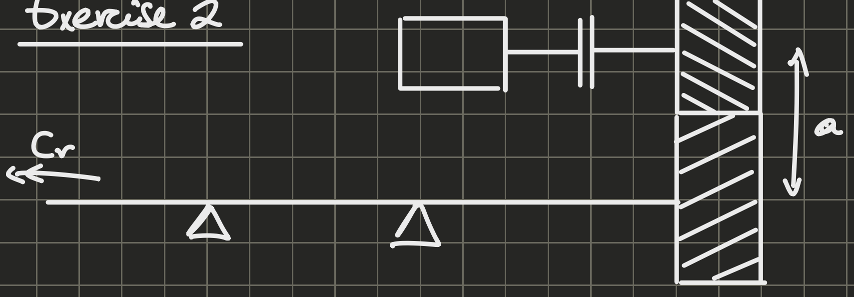
$\alpha = 20°$

We can derive the many values.

$m = 2mm$

$b = 16mm$

Exercise 2



$U_L^* = 100$ $\quad a = 120 \mp 5mm$

$k^* = 5$ $\quad \tau = 0{,}2\ (\mp 2\%) \Rightarrow u = 5$

$C_r = 810\ Nm$ $\quad \alpha_n = 20°$

$\beta = 11°$

$c = 200mm$

$$d_{p1} = \frac{2a}{u+1} = 40\,mm$$

$$C_1 = \frac{C_r}{u} = 162$$

$$b = \frac{1}{U^*} \frac{2C_1}{d_{p1}^2} \cdot \frac{u+1}{u} = 48{,}6\,mm$$

$$F_t = \frac{2C_1}{d_{p1}} = 8100\,N \rightarrow m_n = \frac{F_t}{U_L^* \cdot b} = 1{,}67$$

↳ we increase b to 54mm so we can bring m_n to 1,5mm

$$m_t = \frac{m_n}{\cos\beta} = 1{,}53\,mm \rightarrow z_1 = \frac{d_{p1}}{m_t} = 26{,}2 \rightarrow 26 \text{ teeth}$$

$> z_1$ ✓

$z_2 = 130 \rightarrow 131$

$d_{p1} = 37{,}73$

$d_{p2} = 200{,}18$

$\tau = .1985$ ✓

$a = 119{,}95$ mm ✓

$F_t \cong 8100\,N$

$F_r \cong 3000\,N$

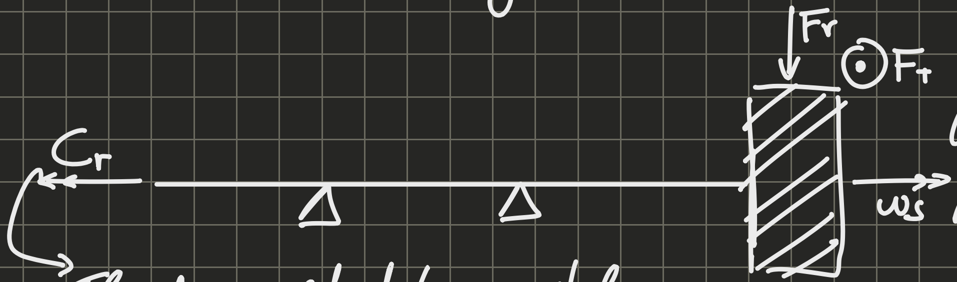
$F_a \approx 1575\,N$ (*)

For the shaft we don't know anything, so we have to build it up.

Part of the pre-sizing we usualy need to choose where to put rollers and hinges.

In this case if the force of the helical gear is compressive we want the hinge on the left so more of the shaft is under compression. If it's tensile we put it on the right to reduce the section under tensile load.

Therefore first thing to do before we design the shaft is finding the direction of F_a.

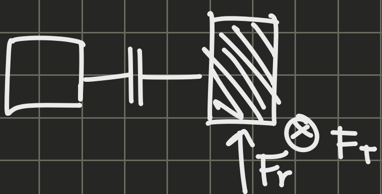


We need to define the magnitude (*) and directions of the forces.

This is a resistent torque, it has a tendency to rotate in the opposite direction

F_r is always onto the shaft

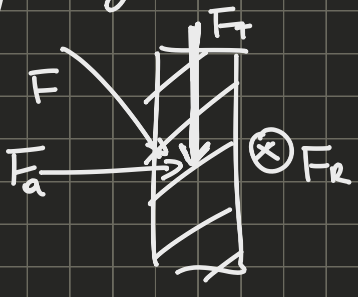
$\vec{\omega}_s = -\vec{\omega}_r$



F_T needs to be out of the board to realise $\vec{\omega}_s$

The direction of F_a depend on the directions of the teeth and if we are looking at the driven or driving wheel:

A trick is to look at the top or bottom of the wheel depending where F_T is acting.



All the forces are connected through F which they are the projections of, therefore for how F is applied F_a must act in the direction which helps F_T push the tooth

After this the pre-sizing and checks are all the same.

Gears are not usually not checked using FEA.
↳ But if we do we find the two critical areas for bending and the pitting.