Chain Belt C-C Distance Calculator

AMB Calculator

This calculator determines the proper center-to-center spacing between two sprockets or pulleys, as based on the belt/chain length or an approximate center-to-center distance.

The calculator comes loaded with the standard types of belt and chain used in FRC, and their respective pitch lengths, p. If you want a non-standard pitch length, you can set that by choosing a "Custom" type. For the standard types, useful dimensions are also shown including the width, thickness, and weight. These dimensions do not affect the calculations. Suggested adders (i.e. the recommended amount to over/under tension the system) and load ratings are given for some types, though these values may vary based on the source of the belt/chain and team preference.

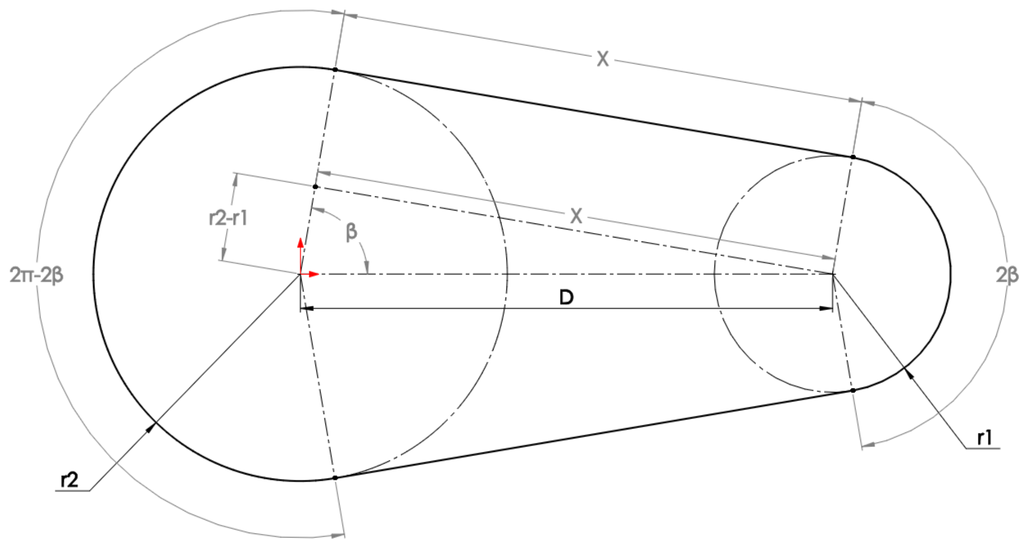
For this document we will use the nomenclature for chain, though the equations apply identically to belts.

To calculate the pitch diameter of each sprocket with n teeth, we use the formula:

$$d_p = \frac{n \cdot p}{\pi} \tag{1}$$

Halving this value gives us the pitch radius for each sprocket, $r_x = \frac{n_x p}{2\pi}$.

Defining the total chain length as L and the number of links as ℓ, we know $L = \ell \cdot p$. We can also find the total chain length geometrically using the sprocket radii and center-to-center distance D.



Adding up the various sections of the chain path, it is clear that:

$$L = 2X + r_1 \cdot 2\beta + r_2 \cdot (2\pi - 2\beta) \tag{2}$$

Using the Pythagorean theorem and trigonometry on the right triangle in the center of the diagram, we can see that:

$$D^2 = X^2 + (r_2 - r_1)^2 \implies X = \sqrt{D^2 - (r_1 - r_2)^2} \tag{3}$$

$$\beta = \cos^{-1}\left(\frac{r_2 - r_1}{D}\right) = \cos^{-1}\left(\frac{r_1 - r_2}{D}\right) \tag{4}$$

Substituting (3) and (4) into (2) gives:

$$\begin{aligned} L &= 2\sqrt{D^2 - (r_1 - r_2)^2} + r_1 \cdot 2\cos^{-1}\left(\frac{r_1 - r_2}{D}\right) + r_2 \cdot \left(2\pi - 2\cos^{-1}\left(\frac{r_1 - r_2}{D}\right)\right) \\ &= 2\sqrt{D^2 - (r_1 - r_2)^2} + 2\left(r_1 - r_2\right)\cos^{-1}\left(\frac{r_1 - r_2}{D}\right) + 2\pi r_2 \end{aligned} \tag{5}$$

Unfortunately, this equation cannot be solved analytically for D. So instead, the calculator solves it numerically using the Newton-Raphson Method. For the calculation based on number of links, our goal is $L = \ell \cdot p$ and our initial guess is $D = \frac{1}{2}L$, which would be the case if both sprockets had zero pitch diameter. For the approximate center-to-center distance calculation, our initial guess for D is the approximate distance. To get the target value, we plug in the approximate distance to (5) and find the non-integer number of links that would produce. That number is then rounded to an even multiple in the direction specified to get ℓ, and the target is $L = \ell \cdot p$. The numerical solver continues until a precision of at least 10^{-3} is reached.

The derivation of this algorithm is based on work done by Clem McKown of FRC team 1640.