# A new concept in lifting technology

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**Abstract – This publication reviews a self-conceived lifting concept, which was encountered while working out concepts for this year's Botball, and will go into detail about the mechanics, the physic concepts and the corresponding formulas, the advantages and disadvantages of the developed concept and its use cases in mechanical constructions.**

**Keywords – Nuremberg scissors, Mechanic, Constructions, Archimedes' Law of the Lever, Trigonometry**

## *I.INTRODUCTION*

In this year's brainstorming round the TLB team discovered a new lifting-concept which was not able to be built during this year's Botball because of the lack of parts that would be needed to construct it, but nevertheless it is regarded so valuable that the team continued to work on it in their spare time, which lead to some interesting discoveries. Furthermore, this paper is going to answer the question whether this concept will be able to improve many other mechanical constructions in their integrity and usability in their everyday use. Therefore, its concept will be explained in the flowing publication.

## *II. THE CONCEPT*

### *A. The Idea*

The Idea behind this concept is a mechanical construction which is compact and able to overcome as much distance upwards as possible. Of course, with this development the concept of the Nuremberg scissors (Fig. 1) plays an important role in it. After some brainstorming the following concept was found (Fig. 2), which is built with the concept of the Nuremberg scissors in mind. The biggest difference between the Nuremberg scissors and this concept is, that the axis is not connected with each other in the centre but on

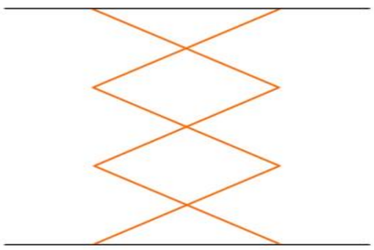

Fig.1. Nuremberg scissors
Animation:
https://logfro.de/ecer-tlb/RAN2.mp4

both ends. This wouldn't work on a normal Nuremberg scissors construct but because the new model is three dimensional it works.

Evidently, the connection points need to withstand a strong force but this can be used in favour of the friction and stability and will be explained further in the following paragraphs. In addition to the connection point, the axes move after every connector in a 90° (can be changed) turn in order to expand the Nuremberg scissors into a 3-dimensional space, which also increases its stability greatly. With the case at hand, we repeated one of these constructional supports multiple times and by that created a tower like construction, where opposing axes are connected through a diagonal telescopic part and where furthermore diagonals at the same level are connected in the middle to create a cross like platform.

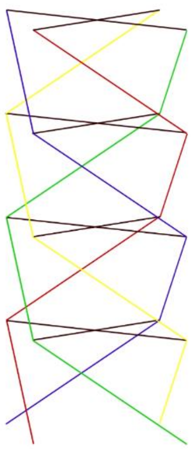

Fig.2. The Concept
Animation:
https://logfro.de/ecer-tlb/Robotik_animation.mp4

*B. Logic*

In order to go further into the logic of this concept one should be familiar with the concept of the Nuremberg scissors, in short, the Nuremberg scissors is a concept in lifting technology, which uses Archimedes' Law of the Lever in order to split the effect of forces on the axis equally. What is also special about Nuremberg scissors is its ability to lift a platform in theory parallel from the ground. To achieve this, it is built out of two axes which are connected in the middle and are fixated on both ends on a rail, that enables the axes to move and therefore change the construct's height. This concept can be modified in many ways to get a variety of interesting constructions, which makes it interesting in the concept of this publication.

Nevertheless, what role does it play in our concept. First of all, many of the formulas can be reused for this model. Furthermore, through simple transformations others can be rewritten. Second, the logic of this concept is derived from Nuremberg scissors, which makes it easier to understand it if one is familiar with it. Going further on to the concept. The increase and decrease of height, is similar to the ones of the Nuremberg scissors, the biggest difference here is the number of axes that need to be moved to get the best result. In this example, it can be achieved through direct movement of one axis and the fixation of a point, but it would be recommended to at least move two axes simultaneously (Fig. 3) for this example and fixated the vexes point of them on the ground. Of course, it would be possible to move all for axes at once (Fig. 3) and fixated the middle point, but in order to achieve this the bottom cross platform needs to be hydraulic.

*C. Upgradability*

The Logic behind this concept has great similarity with the Nuremberg scissors, but is special in its own way. Especially the improvement in stability makes this model worthwhile, but it does not end here. One could for example make the telescopic parts hydraulic, in order to help the construction, extend and decrease its height. In addition to that, it can be completely modular and be extended by adding partial bodies, a partial body defines the body between two platforms, which increase its integrity even more. After extending the construct could also be fixated through at connectors by either increasing the friction or by fixating the axes in order to disable movement, which increase the stability for longer time use cases. Of course, this concept would also work without these features, but its effectiveness can be greatly increased through these add-ons.

## *III. PHYSICS AND FORMULAS*

*A. The Physics*

The physics of this concept are simple. In order to fully comprehend it one must understand Archimedes' Law of the Lever, Trigonometry and Newton's second law of the Forces. At the top of the concept the force of the load influences the structure. This load needs to be eliminated by an engine or a hydraulic press, the counterforces that is needed here can be calculate with Archimedes' Law of the Lever, the formula that is needed to do this is listed further below. Also, the needed counterforce changes with the setup of the structure because the load arm is the width of the construction and the height of a partial body is the power arm. Therefore, does this relation changes with the degree of turn of the axes. What we can also conclude through this, is that the change of height is not linear and can also be calculated. In addition to that, it can be made linear with the use of a speedup formula. The force of the load which affects a structural support, depends on the amount of them. In addition to that equals the force inflecting a connecter the force of the structural support and the force of the connected motor. The bottom area of the structure is also influenced by the setup, therefore is it important to not extend the construction too far.

*B. The Formulas*

Most of the abbreviations used for the formulas can be seen in the upcoming picture (Fig.3).

The first formula has great importance for the rest of them, it calculates the force which is impacting the ground($F_G$) with the force of the load($F_L$) and the forces of the structural support.

$$F_G = F_L + F_S$$

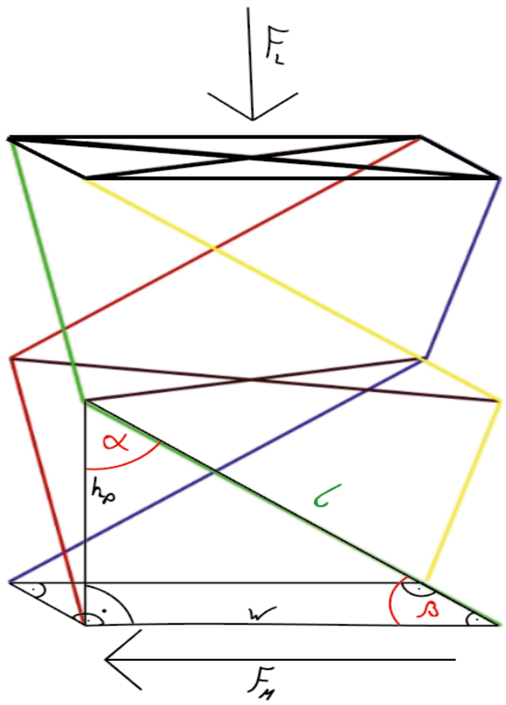


Fig.2. abbreviations

The second on is to calculate how strong a hydraulic press must ($F_E$) be, to lift a load at a certain angle. If multiple engines are used the needed force can be divided equally for every structural support, that is supported by an engine. Of course, can it be remodelled to calculate the min possible degree of turn with a given load and engine or the max load with a given engine and angle.

$$F_H = F_G * \cot(\beta) = F_G * \tan(\alpha)$$

The next formula is to calculate the height of the structure with a given angle and the length of an axis(l) and the amount of repetitions of partial bodies($n_p$). This formula is useful to calculate how high the structure is minimal and maximal with a certain angle.

$$h = \sin(\beta) * l * n_p$$

The last formula work like the third, but instead of calculating the height it calculates the bottom area(B). This one is important, because the angle influences the stability. Therefore, the higher its height is the lower it’s stability becomes.

$$G = (\cos(\beta) * l) \wedge 2$$

With these formulas one can now calculate the forces that are affecting the connectors($F_C$), because these are as mentioned before the most affected parts. This is therefore from great importance, because the connectors should probably be built from a different material as the axes and have also the biggest break risk. To calculate this, you also need the amount of structural supports($n_s$).

$$F_C = F_M + F_G / n_s$$

## *III. USE CASES IN MECHANICAL CONSTRUCTIONS*

### *A. Cranes*

After coming to the conclusion, that the parts are under a high pressure, why would one think this concept can be used in something like a crane cranes. The answer is quite simple, this construction can work as a kind of framework, which is modular an can be therefore changed for any suitcase, partial parts can be custom chosen, and the construct extends with the top of the crane mounted on. After this happened the framework gets fixated on multiple stress points, for example the connectors, to grant stability over a longer time period. The greatest advantage, of this concept here would be the renounce of a telescopic crane and therefore a faster build up, the biggest problem in this use case would be the inferior stability to a tower crane and the more expensive cost.

### B. Lifting Platforms

Lifting Platforms seem like the ideal use case for this concept, because they are barley concerned by the disadvantages of this concept, like minimum flex, an would be able to use the advantages to nearly full extend, like less resource cost as a Nuremberg scissors. Even its modularity could find a use case here, even if it comes with higher expenses.

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