MEC-E1060 - Machine Design

Preliminary Design Report

- Meat Chopper

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Table of contents

1. Introduction

We will design the simple knife cutting mechanism called "The Meat Chopper" for the Machine Design course. The Meat Chopper is created to be a simple, hands-free, and enjoyable way to prepare a variety of meat by emulating a knife cutting mechanism of a chef. The design is expected to be relatively compact, and mainly intended to be a novel item for homes with medium or big kitchens. Kitchens are hectic places for chefs who need to meet the customers' demands. Thus, it is essential to automate some cooking steps to increase the productivity of chefs. This automated knife mechanism aims to meet this demand by cutting materials at a push of a button. The mechanism is interesting because it has a relatively low part count but still can achieve somewhat complex planar motion for an inherently practical application. Since the seemingly routine task of cutting is automated in a novel method, it could be a great introduction to robotics for people.

Since the knife mechanism will be used in the kitchen environment, ensuring the device meets safety standards is paramount. The device has to meet the ISO Standard: SFS-EN 631-2:en as kitchenware, specifying that our device should also be made so that the construction does not alove permanent distortion of the mechanism under regular use. The standard also stipulates that the appliance should be easy to clean. The environment cannot have grease, oil or other substances which could be poisonous or carcinogenic.

The machine will also comply with standard SFS-EN 12331:2021, which means the final mechanism will have a protective cover or safety stopping mechanism. SFS-EN 1672-2:2020 also specifies that all materials must be durable and have a long cycle life. Surfaces must be smooth and cannot allow food to stay in small crevices of the material surface. The materials we have selected are Stainless Steel, plastic and wood. All material connections shall be smooth welds or flush joints.

The mentioned standards will be explored in much deeper detail in the following reports, which shall dive more profound into the operational concepts and simulations that demonstrate the viability of our mechanism.

2. Methods

The mechanism of a device will be automated, and the electric motor for the machine can be battery-powered or connected to the power outlet. For this project stage, we used the Linkage mechanism to draw out the prototype and check if the mechanism is feasible for the project. We also drew simple diagrams on paper to make initial designs for discussion with group members, which was crucial for voting on the best project to move forward in this preliminary design report. The following requirement list in Table 1 will be used as a reference in the future.

Table 1 Requirements list for the mechanism

Req	Level	Measure
Cutting force ≥ 30 N	Demand	MBS Software
Cutting Cycle < 2 s	Demand	MBS Software
Weight of product < 10 kg	Non-Demand	FEM Software
Maximum Length < 30 cm	Demand	FEM Software

The cutting force and cycle of greater or equal to 30N is chosen based on the force needed to slice through beef at 15 degree Celcius is 22.4N [5]. The cycle time of less than 2s is listed, referring to the meat slicing speed of an average home cook. The product's weight must be less than 10 kg since heavy appliances such as coffee makers are only 2 kg. Last but not least, the average cutting board is about 12 inches by 18 inches (30 cm by 45 cm); thus, the maximum length of the device is designed to be less than 30 cm.

We use Microsoft PowerPoint to draw the free-body diagrams of the mechanism to understand the forces acting on it since it has multiple diagrams for easy drawing. This will be useful for MBS simulations in the later stages of the project.

3. Results

In the preliminary report, we have sketched multiple prototypes of the knife mechanism of meat chopper as seen in Image 1. Using the prototypes, we have drawn the linkage mechanism and the free-body diagrams seen in images 6 and 7. These free-body diagrams are going to assist us in later stages when we utilize Siemens NX in order to model the mechanism.

Sketches

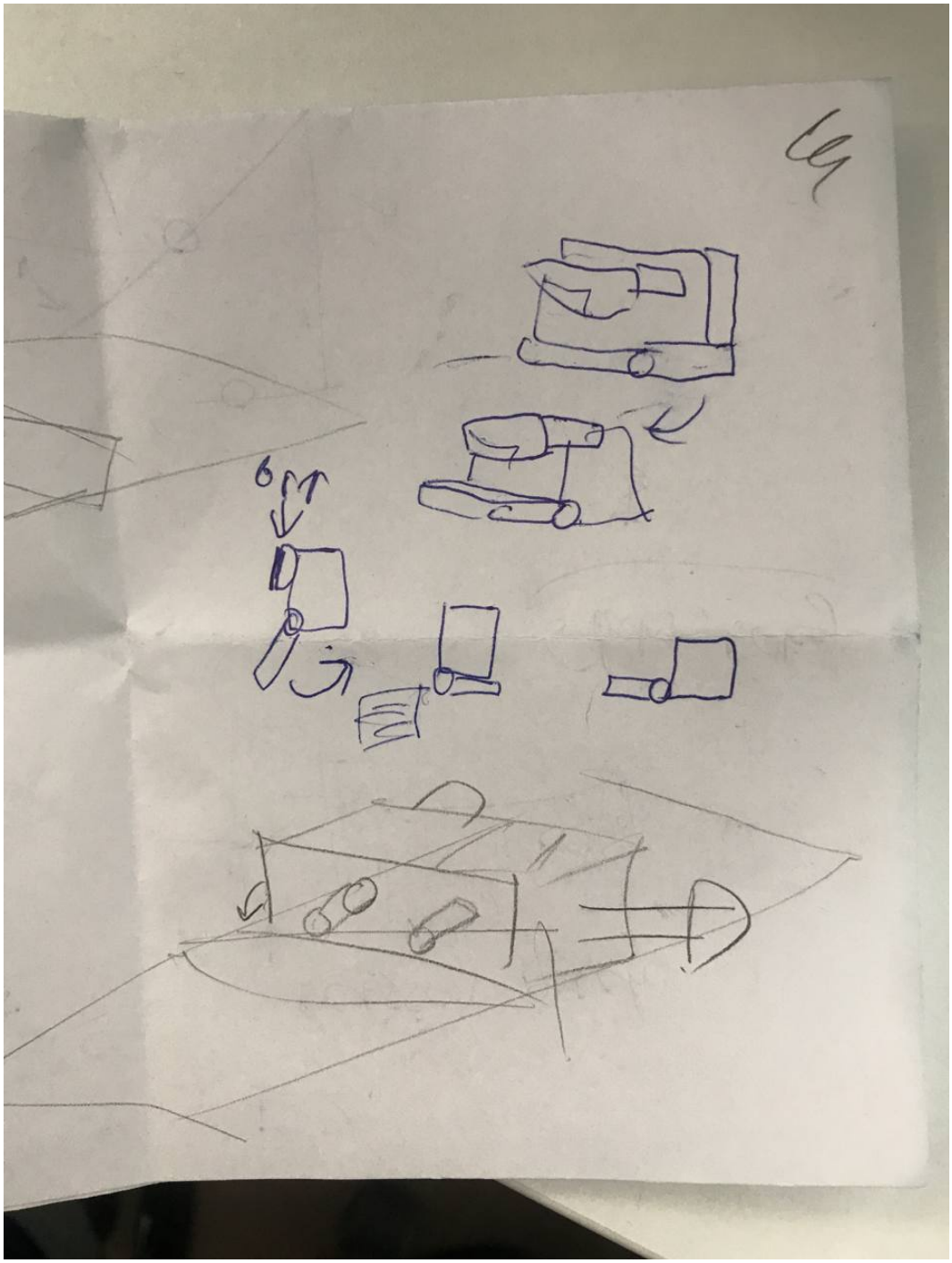
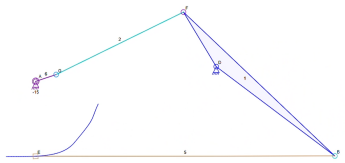
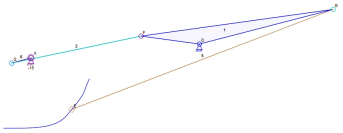
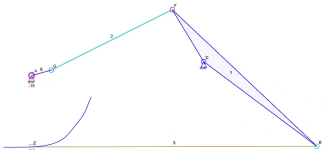


Image 1 Concept exploration sketches

One-degree-of-freedom planar linkage mechanism

Table 2 contains the Wireframe of the mechanism made with linkage at various points throughout the cycle time. Images 2 and 3 display the upwards and downwards swings.

Table 2 Wireframe of the mechanism at various cycle time points

T = 0 s	T = 1 s	T = 2 s
		

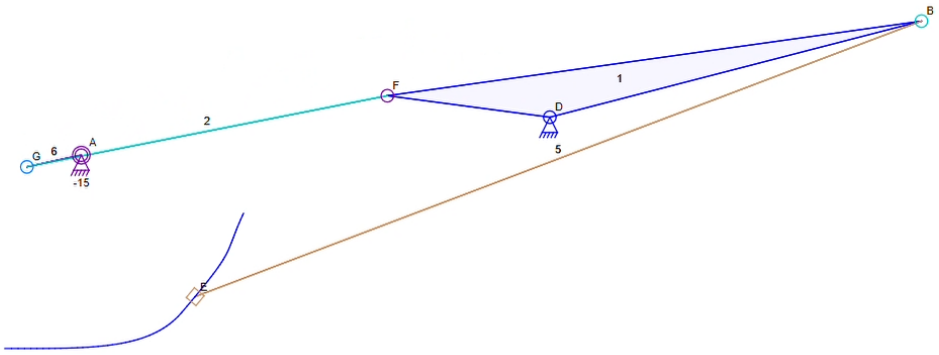


Image 2 Linkage Mechanism in Upwards Swing

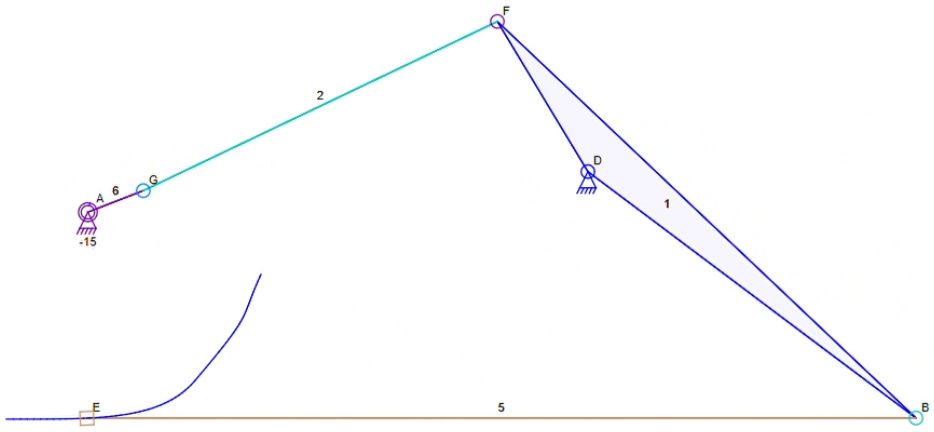
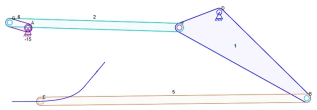
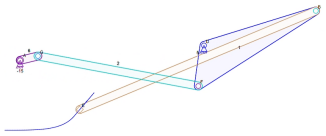
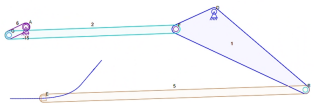


Image 3 Linkage Mechanism in Downwards Swing

Table 3 and images 4 and 5 show an improved version in which we have updated the preliminary design to reduce the height and increase the retracting speed. The table and hese images also contain the actual beams used in the mechanism.

Table 3 Improved model of the mechanism at various cycle time points

T = 0 s	T = 1 s	T = 2 s
		

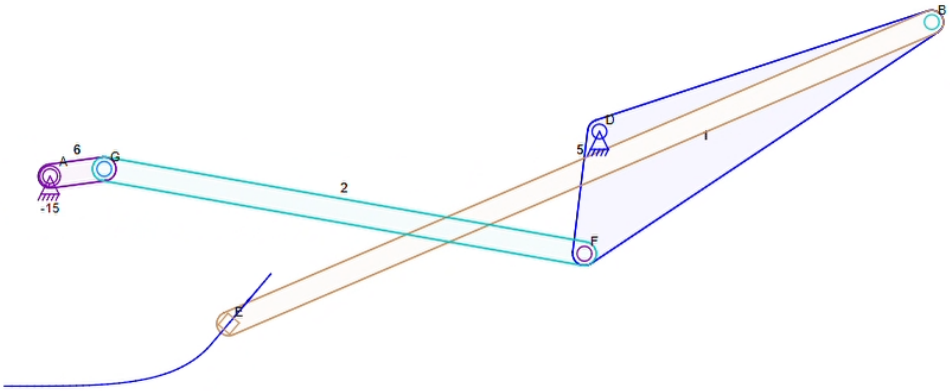


Image 4 Linkage Mechanism in Upwards Swing

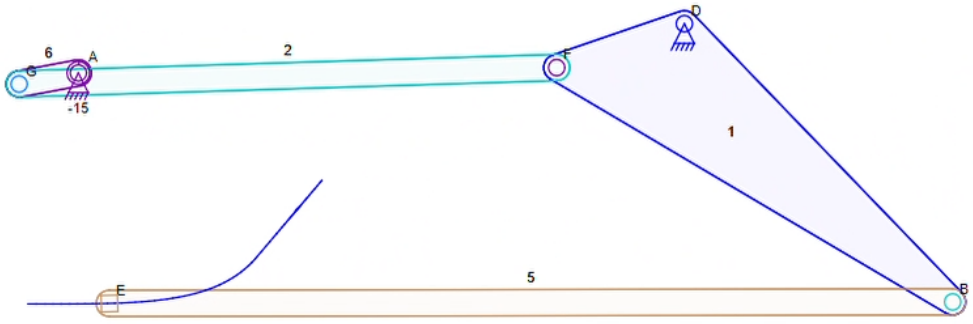


Image 5 Linkage Mechanism in Downwards Swing

Free-body diagrams

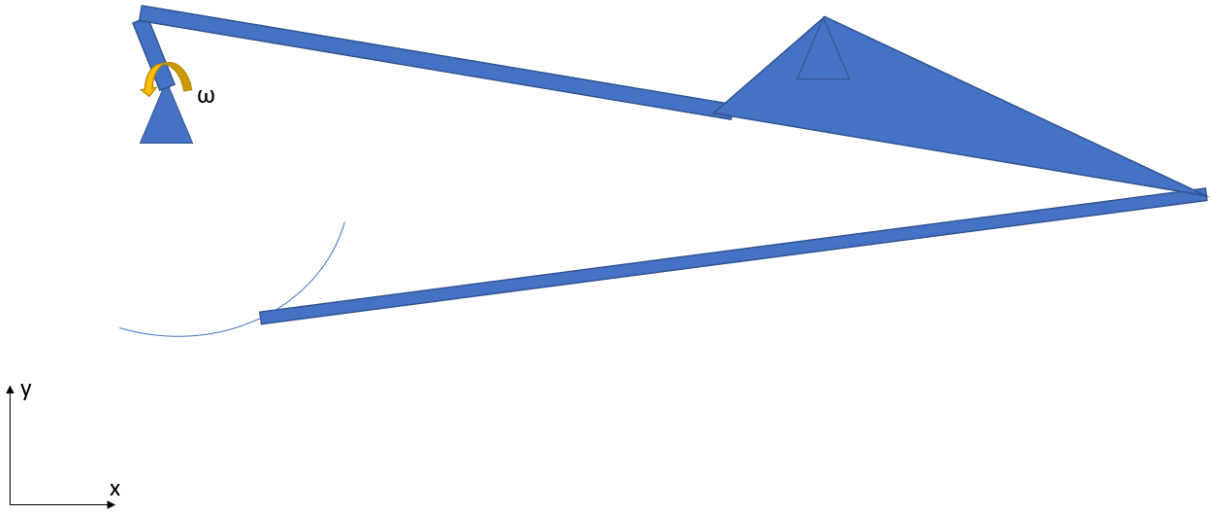


Image 6 Structural diagram

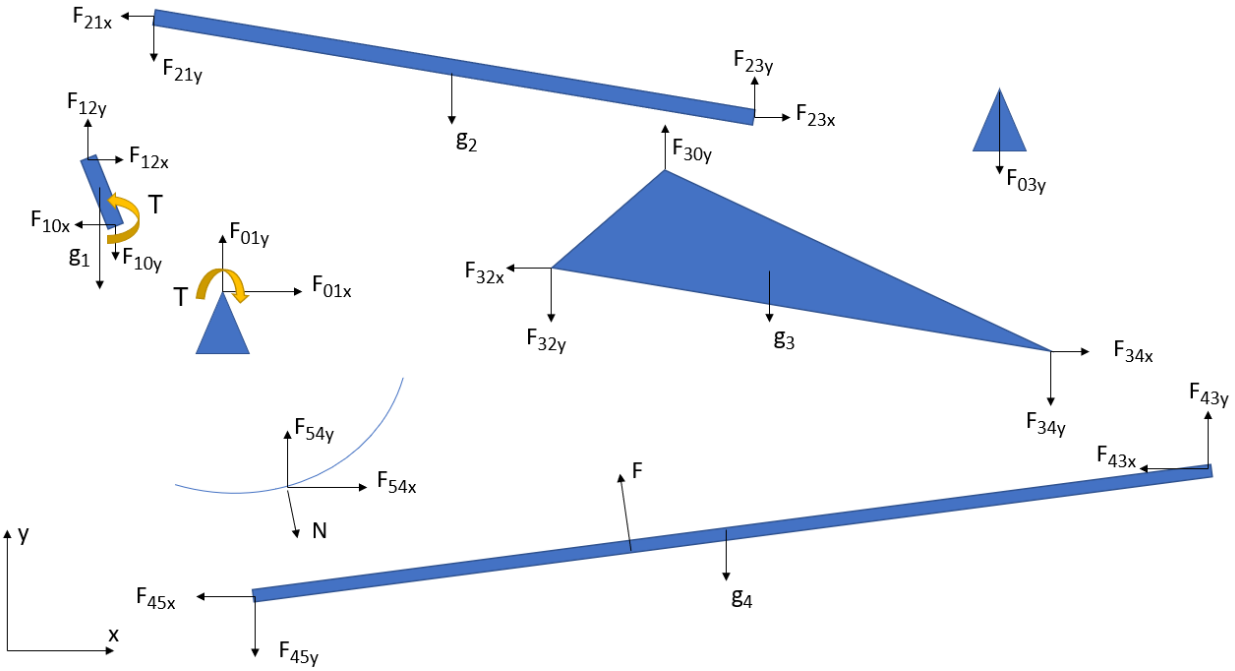


Image 7 Free-body diagram without friction

The project aims to create a cutting mechanism to make chopping meat such as beef easier, decrease the workload, and increase the productivity of a professional chef by automating the mundane chopping of meat.

4. Discussion

In this first stage of the project, we learnt how to use the Linkage software to model the mechanism for easy understanding and whether the proposed mechanism is likely to work or not. We also learnt to discuss choosing the optimal design for this project among group members and what is needed to succeed. At this stage, we are not familiar with using Siemens NX and Teamcenter, but we hope to learn how to utilize them in later weeks.

In this first week, we successfully delegated initial tasks among teammates and in helping one another as necessary. We also held group discussions for brainstorming and voting purposes and asked the tutors meaningful questions about free-body diagrams and the feasibility of the mechanism for later weeks. In the coming weeks, we can ask for even more feedback to maximize the report's overall quality.

We started the week by each proposing a solution mechanism and then proceeded to vote on the best option in a meeting held at Startup Sauna. Then we attended the assignment session on Thursday, 8.9 and made the majority of the report with the help of advice from the tutors and teachers. Then we conducted the overall finishing touches of the report on the weekend. We will have a rotating role of main secretary for the report, who will be responsible for the report's layout. This week our report's main secretary was Min Hein Htike. Next week Elias Puolakka is going to serve as the main report secretary.

Since we have accomplished all the necessary descriptions, diagrams and the requirement lists for this project and included a great deal of further high-quality effort, like researching standards and presenting many detailed descriptions of different aspects of our solution, we expect to receive a commendable grade of 5.

5. References and Sources

1. *123rf; Cutting meat with knife. (n.d.).* Retrieved September 8, 2022, from *https://www.123rf.com/photo_71234931_stainless-steel-butcher-knife-cut-meat.html*
2. *Hertzmann; Knife Anatomy, Materials, Use, and Care*. (n.d.). Retrieved September 8, 2022, from http://www.hertzmann.com/articles/2001/knives/
3. DI Editorial Team & Writers. (2022, February 9). *Cutting Board Sizes (Dimensions Guide)*. Designing Idea. Retrieved September 10, 2022, from https://designingidea.com/cutting-board-sizes/
4. *Tuote*. (n.d.). Retrieved September 10, 2022, from https://sales.sfs.fi/en/index/tuotteet/SFS/CEN/ID2/1/957147.html.stx
5. Brown, Tim & James, Stephen & Purnell, Graham. (2005). Cutting forces in foods: Experimental measurements. Journal of Food Engineering. 70. 165-170. 10.1016/j.jfoodeng.2004.09.022.