Our team has perceived a substantial issue with the buildup of sand in Bowie's hopper. In order to adequately design a solution to this problem, our team has created a multitude of designs that will be used in extracting our final solution. We have narrowed down the list to 3 designs that will be analysed.

1. Calvin's first design
2. Nicholas's third design
3. Chris's third design

Designs will be rated by weight of importance, using a scale from 1-3. The design with the highest points will be the global concept.

Design Criteria	Design specifications	Weight (1, 2, 3)	Design 1	Design 2	Design 3
Functional requirements	Hopper size, funnel size and volume (larger is better)	x2	2	1	3
	Least amount of 3D printable parts (replaceable parts)	x2	3	1.5	1.5
	Must evacuate and filter majority of sand/reduce congestion in filter	x3	1.5	1.5	3
	Must retain most trash and waste of existing hopper	x3	3	3	3

Constraints	Price	x2	3	2	1
	Weight	x2	3	1	2
	Biodegradable 3D plastic	x2	3	3	3
	Inclination of funnel	x1	1	3	2
	Compatibility with existing lid	x3	3	1	2
Non-functional requirements	Black coloured (absorb light energy to evaporate moisture from wet sand)	x1	3	3	3
	Durability	x1	3	2	3
	Appeals to people	x2	2	2	2
TOTAL POINTS			61.5	45.5	57

ANALYSIS:

Design 1 (Calvin):

Calvin's design was one of the first designs to be conceived. It is fairly simple in that it has two funnels, with a divider down the center of the hopper. We discovered that there was some empty space in-between the circuits and the floor of the hopper. This space can be used and is a great way of improving the hopper, without making too many drastic changes to Bowie's chassis. By including the funnel inside the chassis of Bowie, it does not change the center of mass like in Nick's third design, where the hopper was raised.

The actual hopper itself is comprised of three components, making it fairly simple to design. The three parts are: the hopper, the funnels, and the filter. We decided that two funnels were better than one since it distributes the weight of the trash, and it also allows for a second way for sand to be evacuated in case of a block-up. The filter will be set at lower height to prevent congestion in the funnels, and we also decided that having filters at the end of the exit tubes would cause congestion. So even if having a filter at the exit of the tubes would create a bit more space, it would be counterproductive since the trash would build-up.

Finally, we decided that it would be much better if the lid of the existing hopper was compatible with our hopper since we would not have to reprogram anything, and we would not have to redesign a new lid altogether. This allows us to focus more on the filter and the hopper themselves, which are the most important aspects to us.

Design 2 (Nick):

Nicholas' third design is similar to the Design 1 (Calvin's first design) in the sense that it has a hopper with a strainer as a base, which then is connected to two lateral chutes. The unwanted sand would enter the hopper, fall through the strainer/filter, and gravity would navigate the sand out of Bowie via the chutes. However, where the two designs differed, was the placement of the chutes. Design 1 featured the hopper base being attached to Bowie's frame, and the funnels being placed inside of the robot's chassis. Starting at the base of the hopper, the funnels, extend both left and right, all the way to the walls of Bowie's sides.

In comparison, Design 2 featured the hopper being elevated using plastic stands. Nicholas' aim was that by having the funnels attach to th base/filter of the hopper at a greater height away from Bowie's frame, there would be no need to alter the robot's frame in order to make entry and exit points for the chutes. Unfortunately, this change was later deemed to be inefficient as members of the team worried that the elevated hopper would result in a negative shift in weight and weight distribution. Bowie already struggles to travel at inclination of more than 15 degrees, and the addition of stands needed to raise the hopper would put further weight strain on the robot and its motors. Furthermore, having all the trash in Bowie's hopper now being elevated would lead to a significantly greater chance that Bowie tips over at any incline. Thus, Design 1 offers a lighter and more stable solution in comparison to Design 2.

Design 3 (Chris):

Design 3 incorporates an aft chute as well as two sand escapes on either side which aid in shifting the sand out of the hopper. Due to gravity the sand would be forced through the filter, removing it from the system, while leaving the trash with the hopper. The 3 chute system would distribute the weight of trash similar to the current design, maintaining the center of gravity. A three filter system does have a high likelihood of being less efficient than a system the includes just two. The 3 designs have some similarities but this design departs from the others significantly by adding a 3rd chute. While it may seem that a 3rd escape for sand would be a

great benefit, there are notable downsides. For one, a system that only has a minor effect on the amount of sand expelled but increases the weight would be a negative trade. A hopper addition that increases price and weight while adding very little addition to sand removing capabilities would violate design criteria and therefore be inadequate solution.

Global concept:

In order to determine the best design and establish our global concept, we as a group decided to make a table with different design criteria and implement a weight scale based on the importance of each criteria. Ultimately, this led to the determination that design 1 is the global concept, as it narrowly edged out design 3 by 61.5 to 57. Although most design criteria were fairly similar, design 1 significantly edged out design 3 in the constraints category, with regards to price and compatibility with the existing lid. The results of the weight-scale is encouraging as it unbiasedly confirmed our initial beliefs that design 1 is the best design. Although it is a simple design, we believe it is the most efficient and the best design since it incorporates unused space in Bowie without making drastic changes to Bowie's chassis, and does not significantly impact his center of mass, because theoretically the mass of the 2 funnels will cancel each other out. An added bonus of design 1 compared to the other designs is that it is compatible with the existing hopper lid. This is a significant advantage as it allows us to focus on solving the main issues at hand, rather than reprogramming a functioning lid. In the end, it was clearly visible through bias and unbiased opinion that design 1 is the best design filter out the sand in Bowie's hopper.

Figure 1. Nicholas Anderson's 1st and 2nd Conceptual Designs:

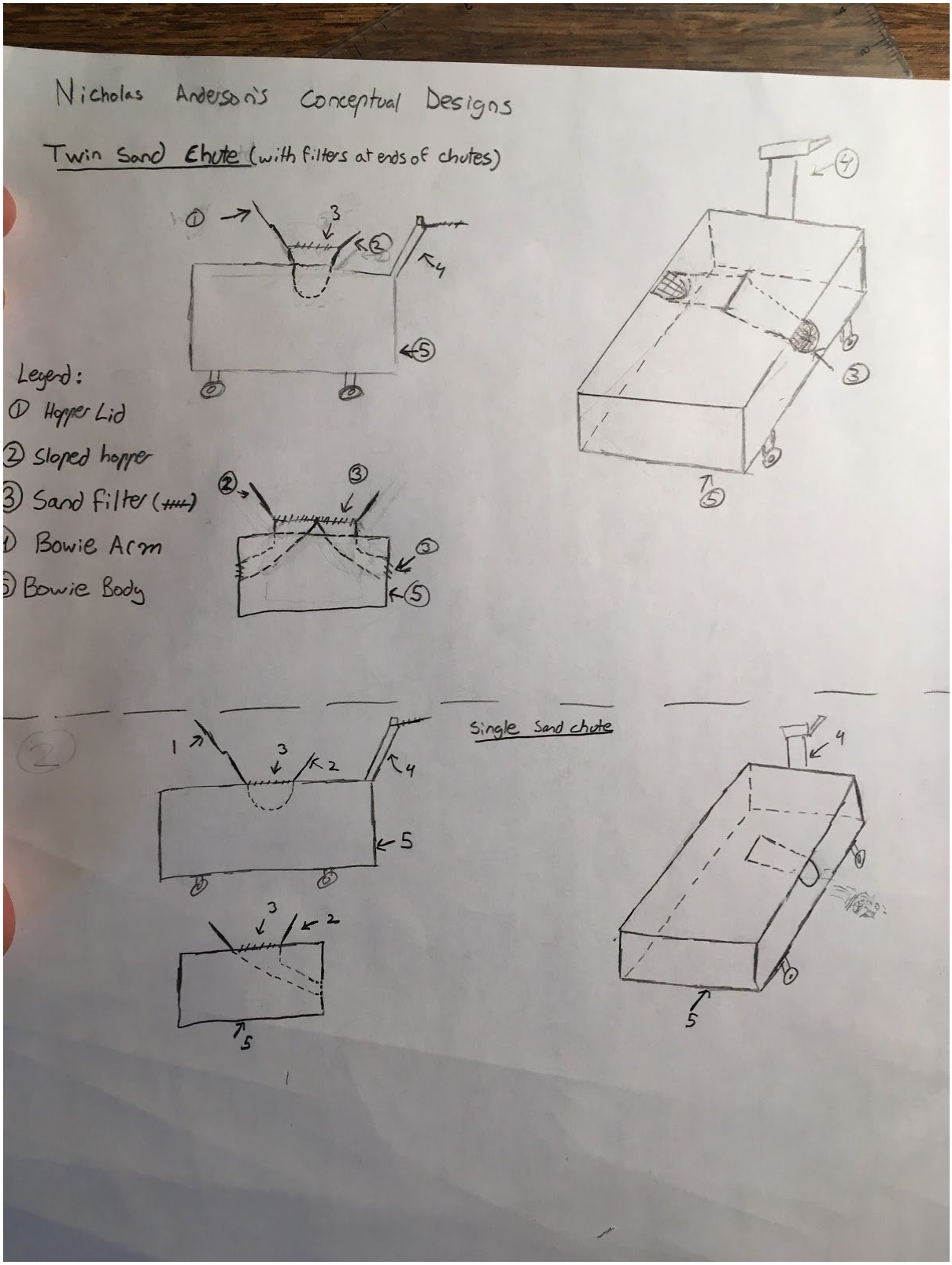

Figure 2. Nicholas Anderson's 3rd Conceptual Design :

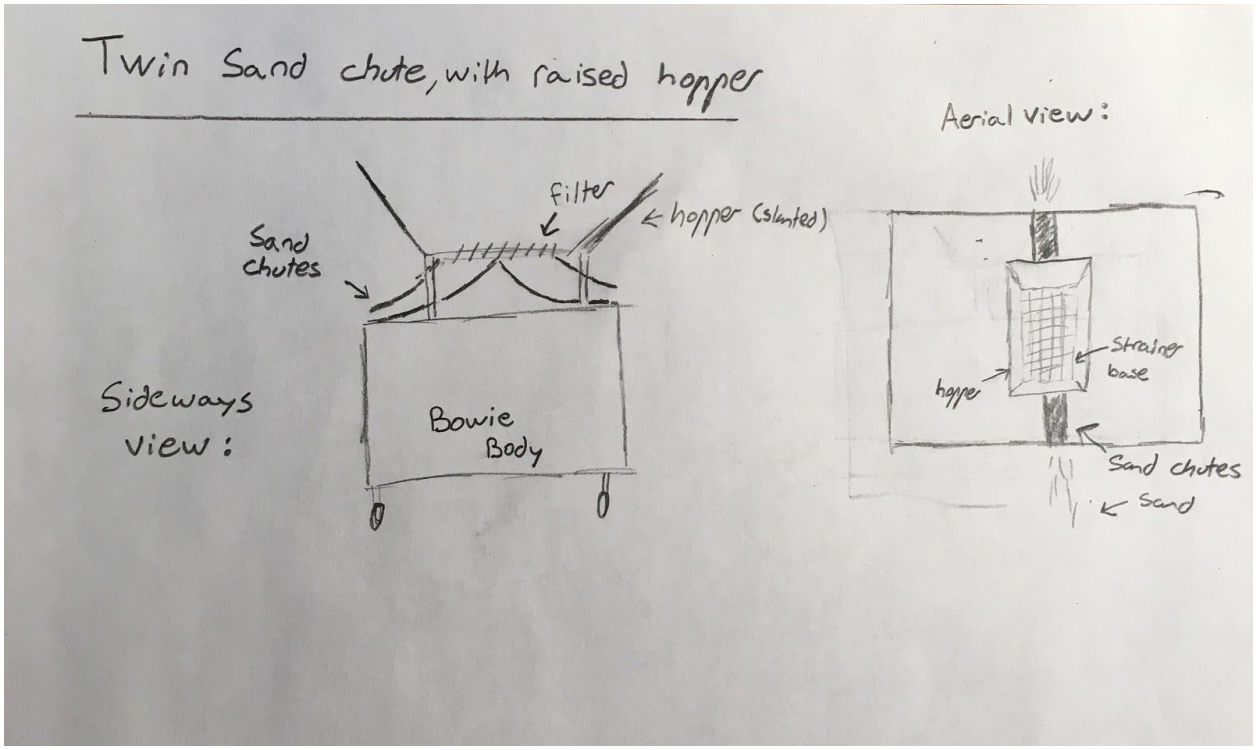

Figure 3. Chris Stevenson's Concept Design.

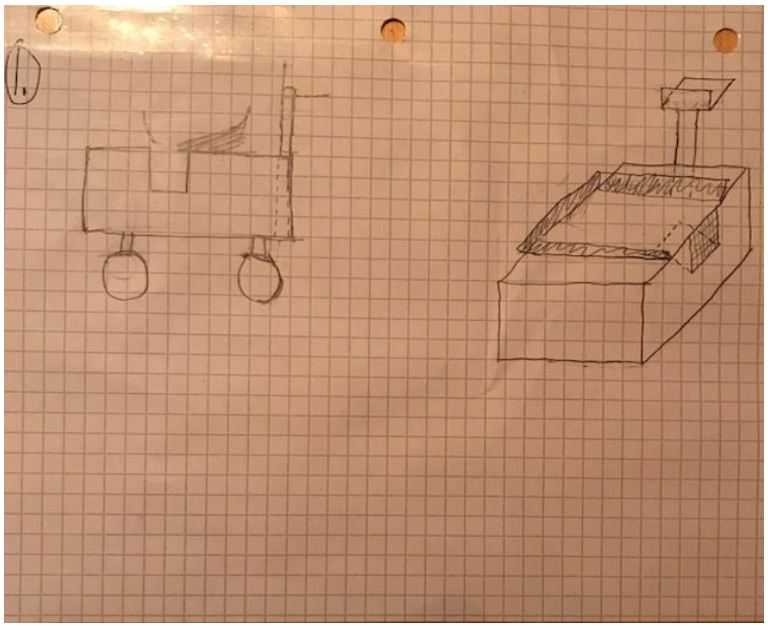

Figure 4. Chris Stevenson's Concept Design.

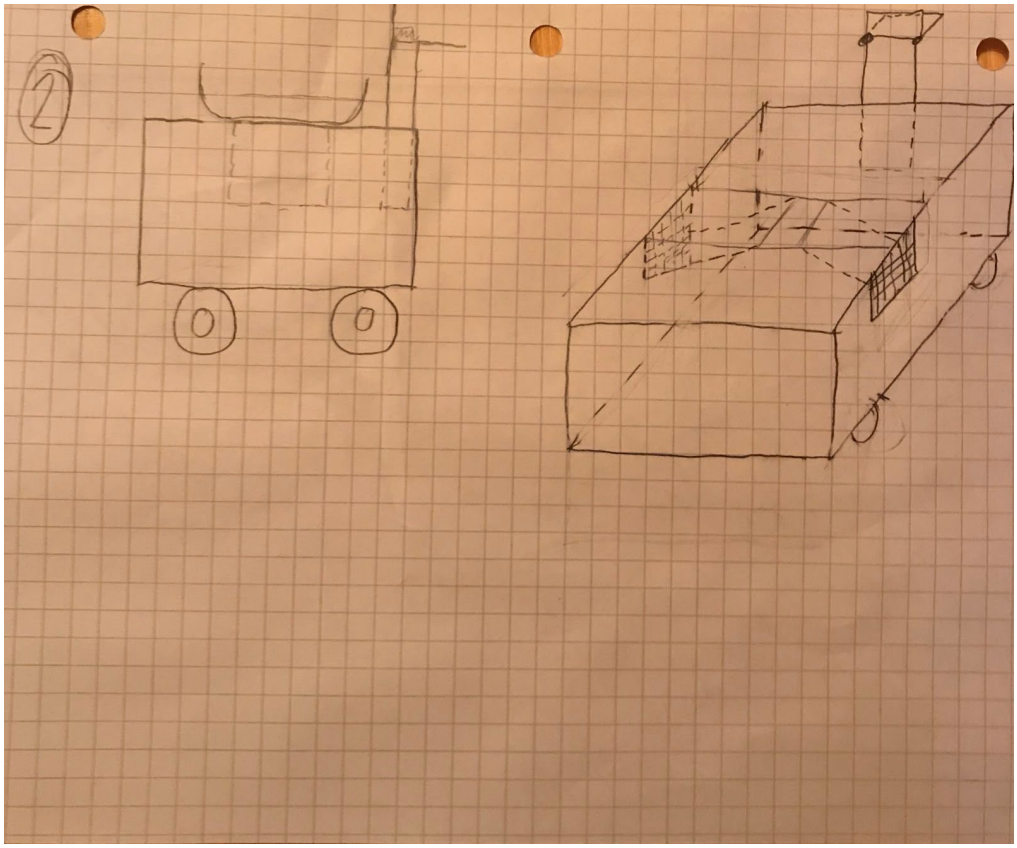

Figure 5. Chris Stevenson's concept design.

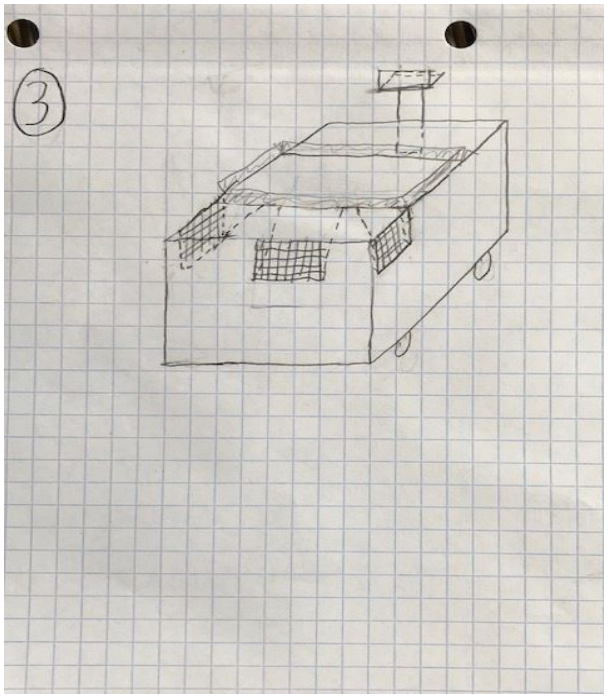
3

Figure 6. Calvin Hooton's Concept Designs:

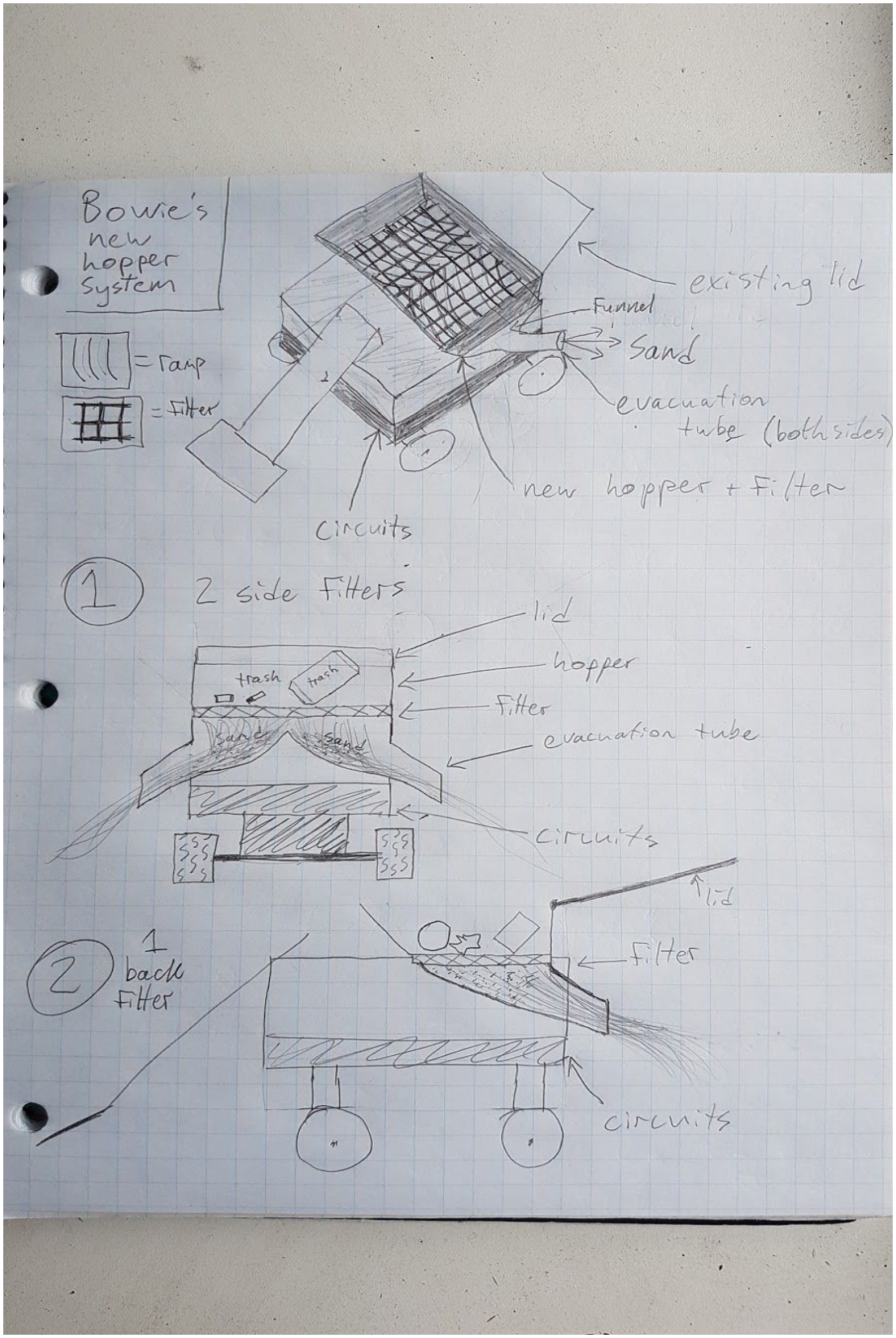

Figure 7. Steven Li's First Conceptual Design :

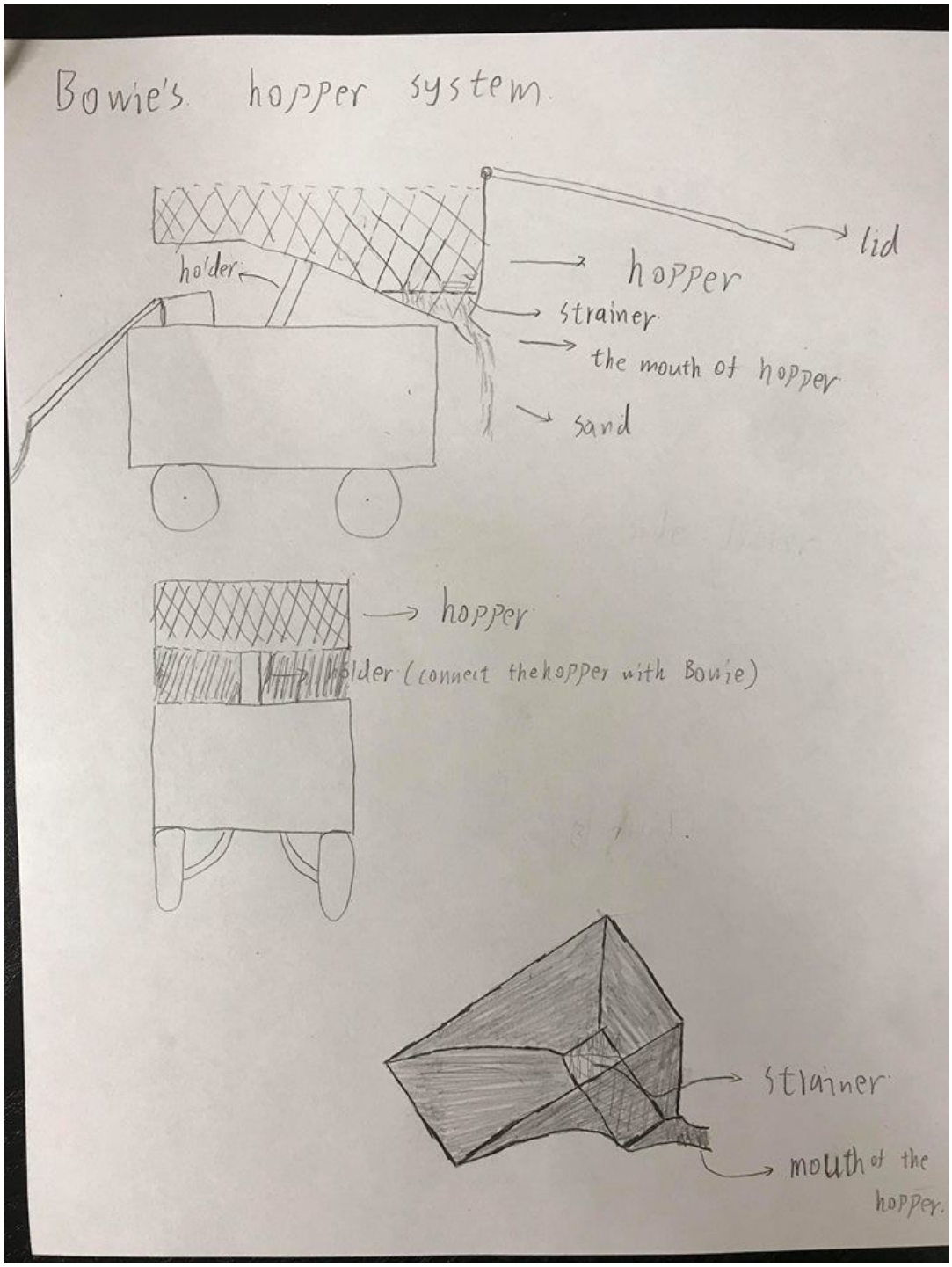

Figure 8. Steven Li's Second Conceptual Design:

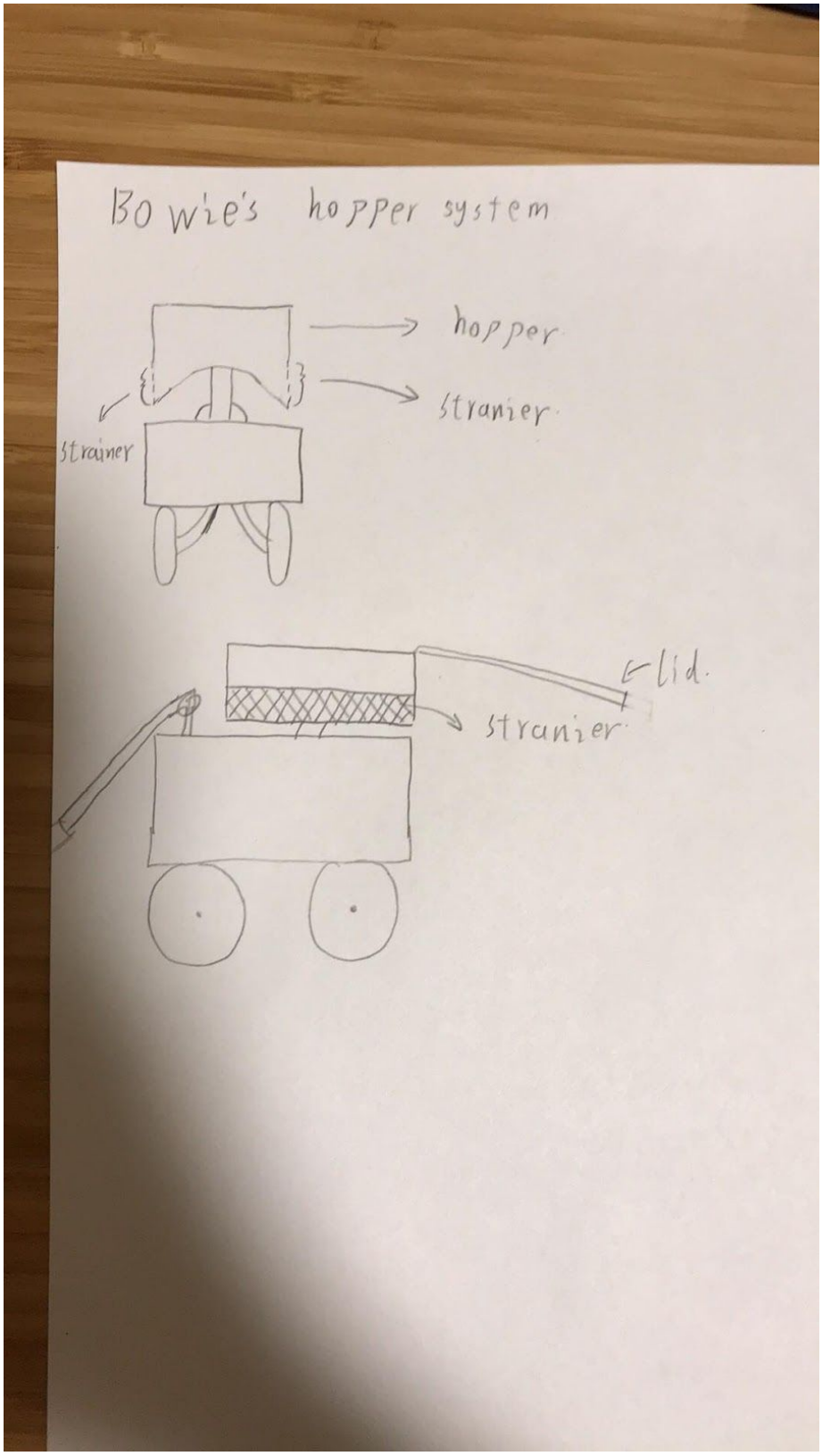

Figure 9. Mofijioluwa's Conceptual Design #1:

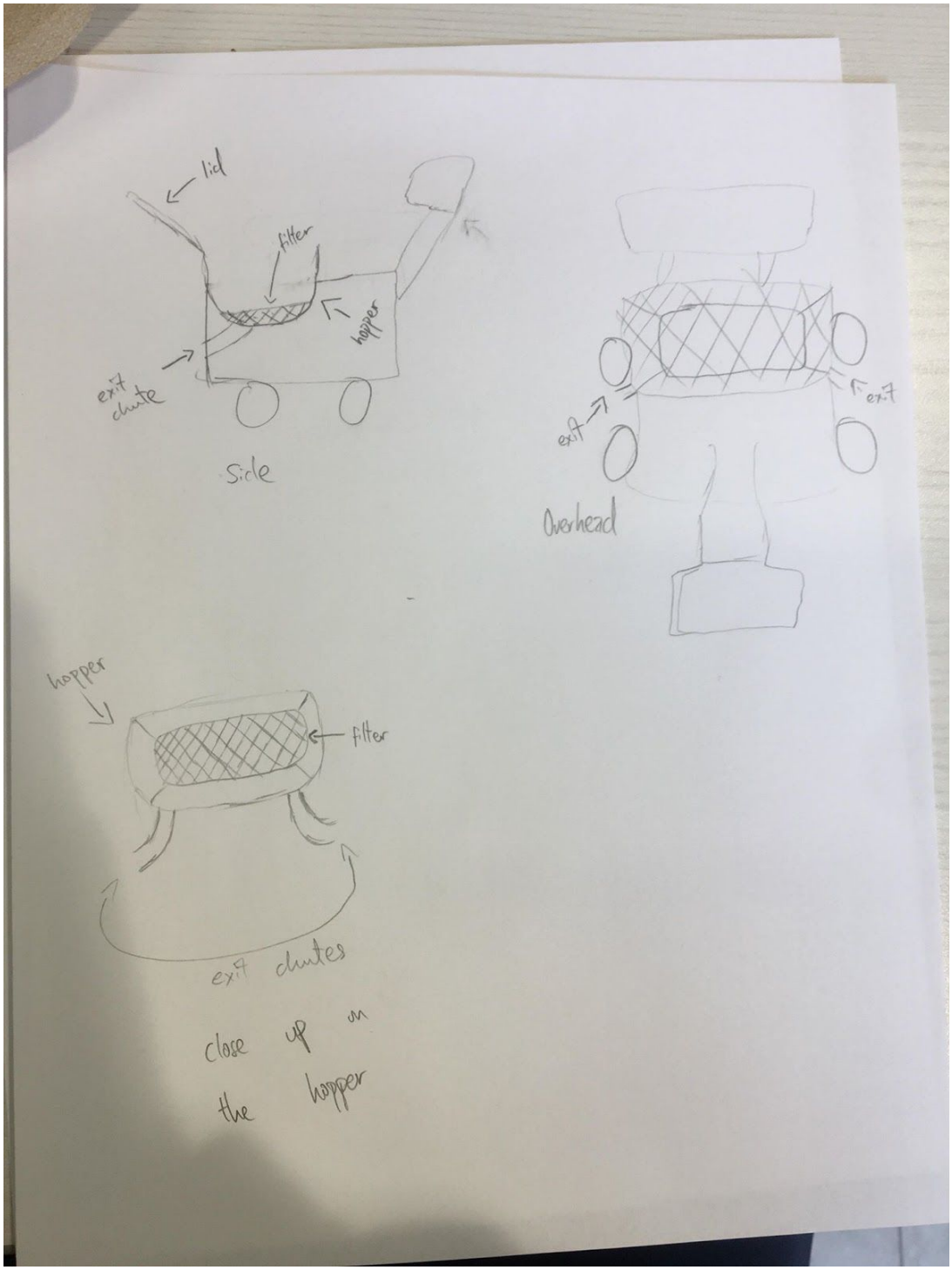

Figure 10. Mofijioluwa's Conceptual Design #2: