**Design Project #5: Card Flipper**

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MEE 332 Machine Design

May 11, 2021

**Introduction**

The objective of the fifth project required the team to design and produce a human-powered device that can flip a deck of cards individually using mechanical components such as cranks, cams, and gears. The team will demonstrate the performance of the device, and the goal is to flip as many cards as possible during a 30 second period.

**Basic Operation**

The team was able to utilize resources at Syracuse University’s machine shop and utilized mainly the 3D printers to produce the necessary parts for the device. The device was designed on SolidWorks, and 3D printed using ABS (Acrylonitrile Butadiene Styrene). All critical components were produced this way. For the material, ABS plastic was selected due to its ease of fabrication and sufficient material strength. A crank and a set of 1:1 ratio spur gears were utilized to easily transmit power to flip the cards. The main challenge was to design a reliable mechanism to invert the sides of the cards one at a time while extracting from the deck. To do so, the team came up with an idea to use a wheel connected to the gears by a shaft with traction mounted below a card holding pocket. The idea was to create a slit wide enough for one card to pass through, and to push the cards through with the forementioned wheel. To do so, a rubber band or a tape was to be attached around the wheel to provide the necessary grip between the wheel and the card. Once the card was pushed through the slit, it would enter a twisted enclosed path, inverting the sides of the card as it passes through. Once a card has completely passed through the slit, the wheel would push the consecutive card through the slit, pushing the card ahead of it through the path. The path twists 100 degrees along its normal axis and the card would exit half-flipped, leaving gravity to flip the card entirely as it exits and falls to the surface. This design choice was made because to invert the card 180 degrees completely, the path would have to be long enough, and the twist has to be gradual enough for the cards to push through smoothly. Producing a longer path would use more material and take longer to produce. The slit and the wheel were decided to be place on the bottom of the card holder to utilize gravity to push the cards against the wheel to provide enough grip.

**Design Analysis**

The design concept was initially drawn by hand and the final design was produced on a Computer Assisted Designing software (SolidWorks). Because the specific card dimension was given, the slit and the card holder were designed accordingly.

Some of the mechanical analysis for the selected design and material were beyond the team’s capabilities. Few components such as shafts and gears were designed accordingly with consideration of the gear ratio and desired dimensions, however because the ABS plastic performs differently from steel and other metals, the team had to rely mainly on assumptions to analyze the failure. The layered structure of FDM printed ABS plastic also made it difficult to perform a correct analysis, therefore a conservative design was required. These factors affected the selection of the concept as well, by limiting combined stresses and number of moving parts to ensure reliability.

The spur gears were designed for 1:1 ratio for the operator to easily control the speed, and it was designed utilizing the following equations:

\*check gear.SLDPRT

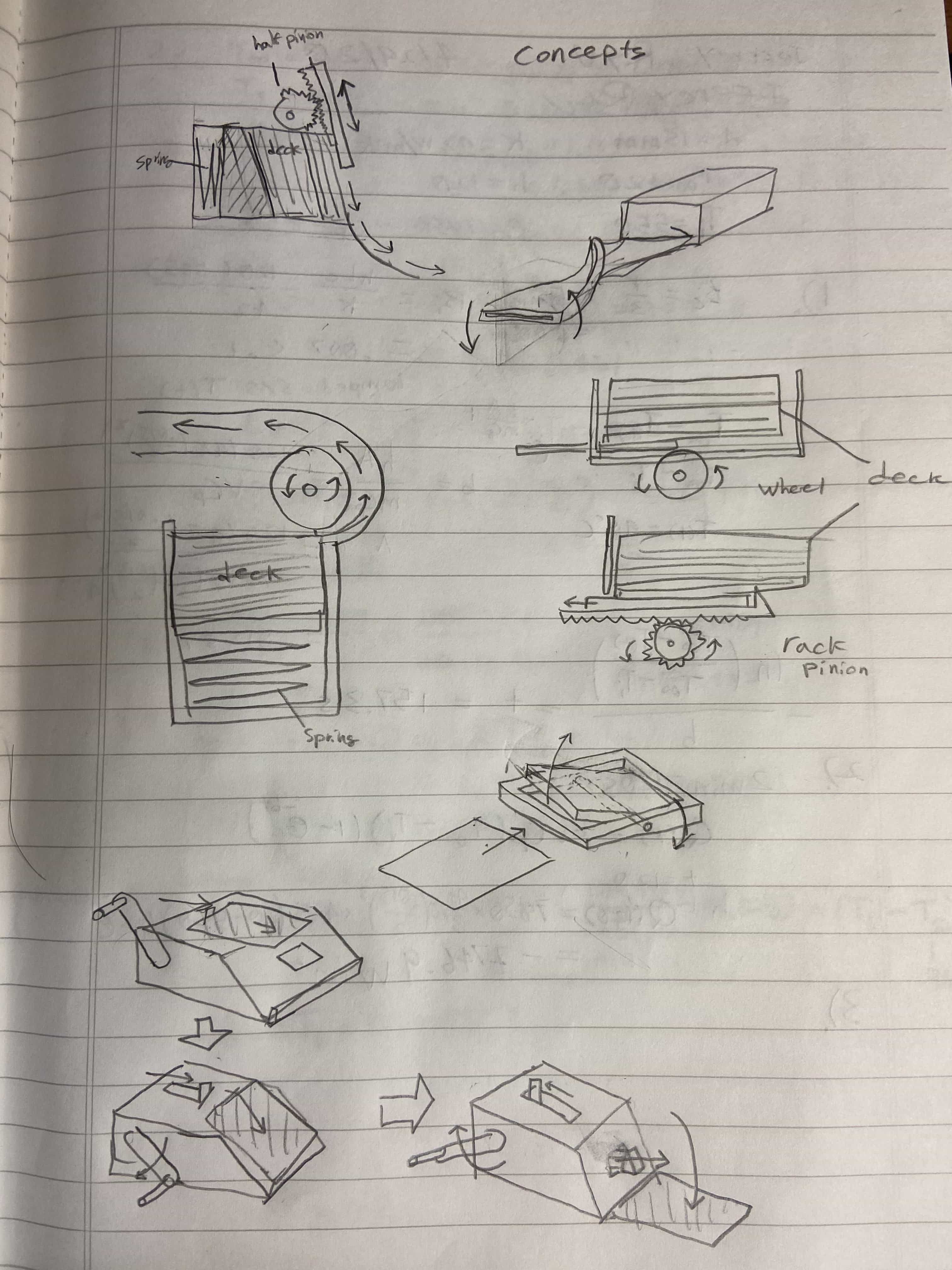
**Challenges and Possible Improvements**

Some of the main challenges of the design was the roughness of the surface and the strength of the structure. Roughness of the FDM layered structure needed to be considered especially for the twisted card-path, otherwise the card would jam due to friction while sliding through. The latter challenge as addressed previously, was taken into consideration by reinforcing the structure with generous and conservative dimensioning, but also a larger dimension will result in a longer production time, and this proved to become an issue.

During the final phase of production, a design flaw was discovered, that the wheel had to be placed closer to the slit for a smoother transition to the consecutive card and to push the preceding card successfully. The prototype was already in production by the time the team had discovered this flaw and unfortunately a solution was not reflected.

Another possible improvement would be to post-process the manufactured parts before assembly, by sanding, finishing, and lubricating the parts for a smoother operation.

**Concept Sketches**

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