

Spring 2020

## Package Conveyance Stability Project

Sadie Mensing

Central Washington University, mensings@cwu.edu

Follow this and additional works at: <https://digitalcommons.cwu.edu/undergradproj>



Part of the [Mechanical Engineering Commons](#)

---

### Recommended Citation

Mensing, Sadie, "Package Conveyance Stability Project" (2020). *All Undergraduate Projects*. 135.  
<https://digitalcommons.cwu.edu/undergradproj/135>

This Dissertation/Thesis is brought to you for free and open access by the Undergraduate Student Projects at ScholarWorks@CWU. It has been accepted for inclusion in All Undergraduate Projects by an authorized administrator of ScholarWorks@CWU. For more information, please contact [scholarworks@cwu.edu](mailto:scholarworks@cwu.edu).

# Package Conveyance Stability

By  
Sadie Mensing

## Table of Contents

1.	Introduction .....	5
a.	Description .....	5
b.	Motivation.....	5
c.	Function Statement .....	5
d.	Requirements.....	5
e.	Success Criteria .....	5
f.	Engineering Merit .....	5
g.	The scope of effort.....	5
h.	Benchmark .....	6
i.	Success .....	6
2.	Design & Analysis.....	6
a.	Approach.....	6
b.	Design.....	7
c.	Benchmark .....	7
d.	Performance Prediction .....	7
e.	Description of Analyses.....	7
f.	Scope of Testing and Evaluation .....	7
g.	Analyses .....	8
h.	Parts/ Unit Components .....	8
i.	Assembly .....	8
j.	Tolerances.....	9
k.	Operational Limits.....	9
3.	Methods & Construction.....	9
a.	Methods.....	9
b.	Construction.....	10
i.	Description .....	10
ii.	Drawing Trees .....	12
iii.	Part List .....	12
iv.	Manufacturing problems .....	13
4.	Testing Method.....	13
i.	Introduction .....	13
ii.	Method/Approach .....	13

iii. Test Procedure Description.....	14
iv. Deliverables.....	14
5. Budget.....	15
6. Schedule.....	15
a. Gant Chart .....	15
b. Overview .....	18
c. Deliverables and Mile Stones .....	19
d. Estimated Total Project Time.....	19
7. Project Management .....	19
a. Risk .....	19
b. Resources .....	19
8. Discussion.....	20
a. Evolution .....	20
b. Success .....	22
c. Next .....	23
9. Conclusion.....	23
10. Acknowledgements.....	23
Appendix A - Analyses.....	25
a. Appendix A1 – Kinetic Energy of Package.....	25
b. Appendix A2 – Inertia of Package About Y-axis (Spinning).....	26
c. Appendix A3 – Rotational Moment of Package about Y-axis .....	27
d. Appendix A4 – Forces that Causes Spinning .....	28
e. Appendix A5 – Inertia of Package About X-Axis.....	29
f. Appendix A6 – Rotational Moment About X-Axis.....	30
g. Appendix A7 – Force that Causes Tumbling .....	31
h. Appendix A8 - Force on Individual Roller.....	32
i. Appendix A9 – Angle Package is Being Diverted.....	33
j. Appendix A10 – Velocity of Package after Collision.....	34
k. Appendix A11 – Force to Launch Packages.....	35
l. Appendix A12 – Contact Angle Causing Spinning .....	36
Appendix B – Drawings .....	37
a. Appendix B1 – Drawing Tree.....	37
b. Appendix B2 – Drawing of Launching Surface .....	38

c. Appendix B3 – Drawing of Guide Piece 1.....	39
d. Appendix B4 – Drawing of Guide Piece 2.....	40
e. Appendix B5 – Drawing of Angle Iron.....	41
f. Appendix B6 – Drawing of Wooden Dowel.....	42
g. Appendix B6 - Whole Assemble.....	43
Appendix C – Part List .....	44
Appendix D – Budget .....	44
Appendix E - Schedule.....	45
Appendix F- Expertise and Resources.....	46
1. Resources.....	46
Parts .....	46
Appendix G- Testing Report.....	47
Test Procedure:.....	47
Summary/overview.....	47
Step by Step Instructions .....	47
Risk/Safety .....	48
Discussion.....	48
Appendix H- Resume.....	51
Appendix J – Hazard Analysis.....	53

# 1. Introduction

## a. Description

Dematic's new model of conveyor, 9570, is a high-speed live roller take away unit that diverts different packages inside of distribution factories. This new model has been tested at one of the Dematic's testing facility with the goal of consistently diverting five or more consecutive packages onto a cross belt unit at twice the speed as the previous model, 9190. However, the testing has been unsuccessful and has changed the packages orientation. Orientation of packages in distribution factories is extremely important so that they can be properly scanned and sent to the right destination.

## b. Motivation

This project was motivated by a previous relationship with Dematic and their request for a solution to the problem, along with the desire to learn even more about Dematic and enhance the relationship.

## c. Function Statement

Divert items from 9570 on to the cross belt.

## d. Requirements

- Convey all the different types of packages/materials including cardboard boxes, plastic totes, and polybags
- Divert at least five consecutive items down the same divert
- Keep all packages orientated
- Maintain the rate of 3 m/s

## e. Success Criteria

For this project to be considered successful, it must meet all of the requirements.

## f. Engineering Merit

Engineering merit is satisfied in a couple different ways in this project. In order to find a solution, there was lots of analysis of the different sizes of packages that are being conveyed. There were calculations involving weight of packages, rates of the system, and the angles of the diverts. Not to mention, breaking down the 9570 model and analyzing individual components like roller size and distance or guardrail heights to see if they might offer a solution. The installation of the 9570 unit was completed at Central Washington University (CWU) and that has been where the testing has taken place.

## g. The scope of effort

For this project, the scope was focused on the 9570 unit and the cross belt individually in order to better understand their connection and identify how to solve the problem. Once the unit was set up and running at CWU, the focused switched to replicating the problem from the testing center. The problem needed to be replicated in order to come to an accurate solution.

#### h. Benchmark

The 9190 unit is the previous model of live roller take away but as previously stated, the 9570 operates at twice the speed, so the 9190 did not face the same problem.

#### i. Success

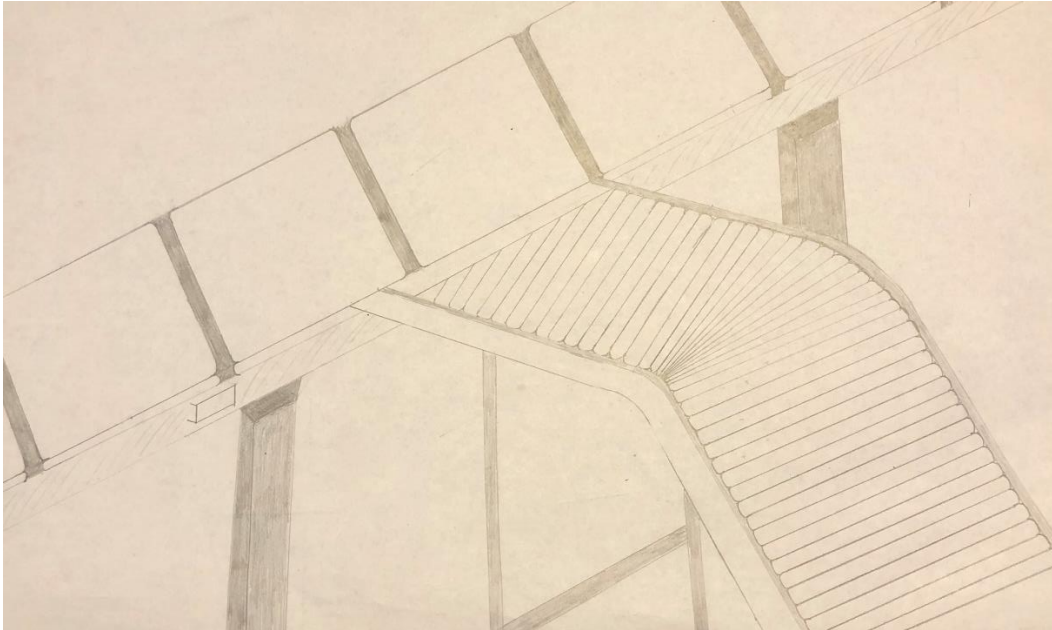
The success of this project would come in different forms. One would be based off the requirements to see five or more consecutive boxes, totes, and polybags divert down the same divert in the Dematic testing center all while retaining their orientation and the high speed of 3 m/s that the 9570 model offers. Secondly, the project would enhance engineering knowledge from completing the design, build, and test phases of a project. Lastly, it would also strengthen the relationship with Dematic and the project would be an asset that appealed to other companies in a similar field.

## 2. Design & Analysis

#### a. Approach

The idea of this design was created in order to fix the turbulence that the 9570 unit causes small packages. The turbulence and rotation were causing the packages to become disorientated. Orientation is a key factor in sorter packages inside of distribution factors so that the packages can be properly scanned and diverted to the correct destination. This project was expected to explore different solutions to this problem including a device that will guide packages along the guard rail, installing an air system to prevent turbulence, and other ideas that may come up during the build phase of this project. As the project continued, the focus shifted to testing. Initial testing of the 9570 unit was completed then the goal for the project has been to replicate the issue seen in testing videos from the tech center. Once there is a better understanding of the problem a conclusion can then be drawn from the data with the information giving insight to a solution.

## b. Design



This is a sketch of the 9570 unit connected to the cross-belt sorter.

## c. Benchmark

The 9570 unit is a newer and faster version of Dematic's 9190 unit. The 9190 unit is a great benchmark to compare the 9570 unit to.

## d. Performance Prediction

With the change to the 9570 model there will be a decrease in the tumbling and rotation of smaller packages. The orientation of these packages will be kept so that they can be properly scanned and sorted through out the process. It is predicted that multiple solutions will be tested before finding the best fit. It is also predicted that there might not be a physical solution at the end of the year but a conclusion that can be presented to Dematic.

## e. Description of Analyses

In order to come up with a solution it is important to understand all aspects of the problem. The first analysis was to calculate the Kinetic Energy of a smaller package by using the speed of the 9570 model and estimating a lightweight package (Appendix - A1). To reduce the spinning and tumbling of packages, it is important to know the force that would cause the spinning and tumbling (Appendix – A2:A7). Multiple analyses focus on how a package contacts the guardrail like the angle and speed. A couple analyses are done for recreating the cross-belt divert including, the force a package and what angle it should be launched at.

## f. Scope of Testing and Evaluation

The testing for this solution will be done at Central Washington University. The project will be evaluated by running multiple different small packages with variable lengths, widths, and weights from the cross-belt unit onto the 9570 unit. If successful, all packages will stay orientated.



### g. Analyses

The design and analysis for this project are completed using R.A.D.D. format. R.A.D.D. stands for requirements, analysis, design parameters and documentation. The project has two main requirements that are focused on. The first requirement that needed different analysis was that the 9570 unit must retain a speed of 3 m/s. It is vital that the speed of this unit be maintained and in order to better understand how speed affects packages, multiple different analyses were done involving speed. Kinetic Energy of a package was calculated to be 1.021 J (Appendix A1). Kinetic Energy is used in design parameters because knowing the kinetic energy of the packages can help predict their behavior as they travel. This calculation can be found in Appendix A1. Other documented analysis involving speed can be found in Appendix A10 where the velocity of a package is calculated after it collides with the guardrails. It is determined that after contact with the guardrail, the package experiences an increase in velocity which can affect the packages' behavior. A design parameter from this analysis would be to add more friction to the guard rail to slow down the package as it comes into contact.

The other requirement for this project is that the solution must reduce the spinning and tumbling of packages. In order to find a solution, first it is important to understand how or why that happens. The analysis involves calculating the force that causes spinning and tumbling. First the moment of inertia of a 3D object was calculated to be  $2.91 \times 10^{-3} \text{ lb}_f\text{-ft-s}^2$  about the horizontal axis and  $8.67 \times 10^{-4} \text{ lb}_f\text{-ft-s}^2$  about the vertical axis. Next, the rotational moment about each axis was calculated to be,  $8.73 \times 10^{-3} \text{ lb}_f\text{-ft}$  about horizontal axis and  $2.6 \times 10^{-3} \text{ lb}_f\text{-ft}$  about vertical axis. Finally, the force that would cause the package to tumble (over horizontal axis) was 0.053  $\text{lb}_f$  and the force that would cause the package to spin (around vertical axis) was 0.016  $\text{lb}_f$ . These analyses will play a huge roll in the design parameter for the solution to this problem because it will need to counteract these forces that are causing the problem. All analyses for this requirement can be found in Appendix A, A2-A7.

During the end of the manufacturing portion of this project, a final change in design of the launching device was made. The initial testing was not experiencing the desired results for the project. In order to better replicate the problem seen in the videos from the testing center the launcher design had to change. The cross belt, which is what the launcher is replicating, has two different velocity components. The cross belt is running at a constant speed of 2.6 m/s in the assigned x-plane and diverts packages at a speed of 2.2 m/s in the z-plane. Even though the cross belt is perpendicular to the 9570 unit that is not the angle the packages are coming into contact with the conveyor, which was how the first design of the launcher had them. The calculations done in Appendix A9 show that the guides need to be at 40-degree angle to replicate the cross belt more accurately.

### h. Parts/ Unit Components

The 9570 unit arrived at CWU in three pieces of conveyor including the angled divert piece, the corner, and a straight piece. This arrived along with a box of misc parts. It was decided to only assemble the angled piece of conveyor and the corner. The assembly included attaching the motor, belt, and tensioning pulley to the conveyor. The parts of the launcher include the wooden launching surface and guides, wooden dowels, screw eyes, and surgical tubing. An angle bracket with nuts, bolts, and washers were used to connect the launcher to the 9570 unit.

### i. Assembly

It was predicted that the majority of assembly for this project would not apply to the actual 9570 unit because it is being shipped to Central Washington University from the Dematic Tech center. However,

the state that the conveyor was shipped in still required a lot of assembly. Multiple components still needed to be mounted onto the conveyor and due to lack of guidance on how to assemble this unit, it consumed a lot of time for this project. A device was created to simulate the packages being diverted from the cross-belt unit onto the 9570 unit. This device consisted of drilling holes into a piece of wood that wooden dowels, attached to guide arms, would fit into. The assembly for this device also involved screwing in screw eyes at the front of the launching surface and tying surgical tubing to them which created a sling slot affect. If this project ends with creating a physical solution and not just drawing a conclusion, then that solution will require more assembly.

#### j. Tolerances

The analyses have tolerances of +/-0.01 or +/-0.001.

#### k. Operational Limits

The main focus of this new 9570 model is retain a fast diverting speed of 3 m/s that the old 9190 unit could not accommodate. This speed must be retained with the solution in order to be successful. Other parameters include that the diameter of the rollers cannot be changed because smaller rollers are not supported by Dematic.

### 3. Methods & Construction

#### a. Methods

This project was conceived in calibration with Dematic Co. The analysis and design of the project was through CWU. There are constraints from Dematic including retaining the required speed and the diameter of the rollers cannot be decreased. The 9570 unit was estimated to need a 10' x 20' area of space. The unit uses a 480, 3 phase motor at 5-6 Amps and will require a converter in order to run at CWU. The Fluke Lab was decided to be the final destination for set up due to the available space and power connection. The launcher was made at CWU and as will any solution.

The design of the launcher was changed throughout this project. The original design was to attach clamps to the launching surface then clamp down different size pieces of guides boards for different size boxes. Screw eyes would be used to attach surgical tubing to in order to replicate the diverting cross belt but with a sling shot affect. This design was throughout construction though. Instead of attaching clamps and having different size guide boards, two guide boards were cut with wooden dowels glued into them then holes were screwed in the launching surface at distances for different size packages. This change is design required less materials and is easy to adjust to different size boxes. This launcher was then attached to an angle bracket. The design of the angle bracket was changed in order to better adjust how/where the packages are being launched onto the conveyor. Originally, the bracket was just going to be bolted to the center of the conveyor but then that would not be easily manipulated. Three different sets of holes were drilled into the conveyor to launch the packages at three different spots. The holes in the angle bracket were milled to slots to adjust the height and angle of how the packages are diverted. There were issues recreating the problem shown in the tech center videos which led to another change in the launcher design. Due to the cross belt having moving in the x-plane and diverting packages onto the 9570 unit in the z-plane, it created a resultant angle of 40 degrees that the packages are coming off the cross belt and onto the 9570 unit at when the launcher was originally "diverting" packages perpendicular to the 9570 unit. Changing this design should assist in replicating what was observed in the tech center.

While completing initial testing, it was clear that if the packages contained items that could move inside them, this was changing the packages center of gravity and the packages would experience more spinning and turbulence. This was fixed by adding paper towels into the boxes with the playdough to keep the center of mass from changing. This helped get more consistent results while launching the packages at different speeds.

## b. Construction

### i. Description

As previously stated, the 9570 unit itself will not require any construction but did require a lot of assembly. The only construction on the conveyor unit was drilling three sets of two holes into the front end of the conveyor in order to change the location that the launching device was attached at. The main construction aspect was creating the launching device. Further construction could be necessary depending on if a solution is necessary.

The construction for launching device changed throughout the project. The original design was going to consist of a large, flat, slab of wood with a smooth painted surface. Two clamps would have been attached to this launching surface on opposite sides of each other. First holes would have been drilled with a diameter of  $\frac{1}{4}$ ". After that the clamps would have been screwed down securely onto the launching surface with a screwdriver and  $\frac{1}{4}$ " screws. The clamps were to hold down different sizes of wood to guide different size packages while they were being diverted. The next step in construction of the launcher was attaching the stainless-steel screw eyes. A  $\frac{1}{4}$ " hole right in front/next to each clamp would have been drilled using an electric screwdriver. The stainless-steel screw eyes would then be screwed into the two previously created holes. Surgical tubing would then be tied through each screw eye to create a sling shot effect for launching packages.

The launcher ended up consisting of three pieces of wood, wooden dowels, surgical tubing, and screw eyes. The wood was utilized from scrap wood from the woodshop and so were the wooden dowels. The surgical tubing and screw eyes were ordered from amazon. The bottom/launching surface of the launcher started with uneven edges. A band saw was used to trim the edges giving the final length of the board to be 21.5". It is 14" wide and 1.5" thick. The two guides were cut from about a 6.5" piece of wood down to two pieces that were 18" x 3" x 0.85". Two 0.25" diameter holes were drilled using a drill press in the woodshop. They were drilled 1.5" in from the width and 3" in from each end. The piece of wood for the launching surface was previously marked for where to drill so that the guide piece could be moved in order to guide the different package sizes. The guide piece was clamped onto the launching surface and the holes lined up as closely as possible to the marks. Before drilling the holes, the desired size of package was placed in between the two clamped guides to ensure the guides would be at the correct location. Some of the holes were too close when the packages were placed in between the guides which would have caused friction to the packages so where the guides were clamped had to be adjusted which changed the location of where the holes would be drilled for the better. The holes on the launching surface were drilled through the holes on the guides to guarantee proper alignment. Two more holes were drilled on top side of the launching surface, at 0.5" distance from the front end. This is where the screw eyes were screwed into by hand and the surgical tubing tied. Four wooden dowels were cut to the length of 1.5" and were glued into the holes on the guide pieces.

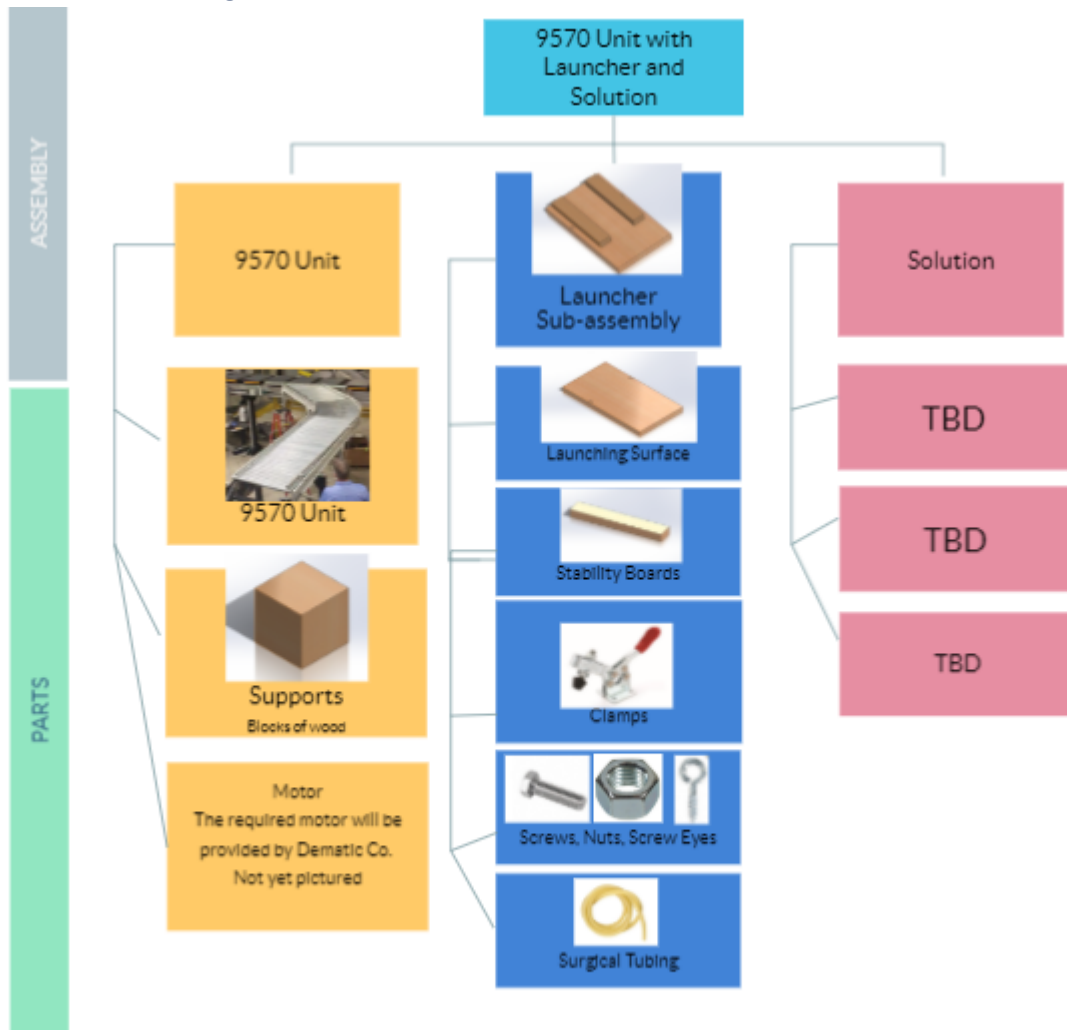
The angle iron used to attach the launcher onto the 9570 unit required construction as well. The part originally had three holes on one side that were milled in the machine lab on a mill in order to better

adjust how the launcher can be attached to the 9570 unit. Three more holes were drilled in the machine lab on a drill press with a diameter of 0.5" that would be used to bolt the angle iron to the bottom of the launcher. To do this, the angle iron was lined up to the end of the launcher and a hand drill was used to drill the screws directly through the created holes in the angle iron and into the launching surface.

The launcher was changed once more to replicate the calculated diverting angle of 40 degrees. The launching surface was marked at where the guides new location would be at. To ensure that the new holes for the wooden dowels/guides were at the correct location, the wooden dowels were drilled out of the guides with the drill press so that the new location of holes would line up with the holes in the guides. A new hole was also drilled in one of the guides because changing the angle that the guides were at on the launching surface made one of the guides hang off the edge of the launching surface. The new hole was needed in the guide because the previous location of it was off of the launching surface which left the guide with only one connecting point to the launching surface. The new hole was drilled in between the two previous holes.

The same procedure for completing the launcher before was then followed. The guides were clamped down onto the launching surface so that the new holes on the launching surface could be drilled through the ones on the guide so that they line up accurately. Before drilling the holes on the launching surface, the location that the guides were clamped was checked by placing the right size box in between the two guides to ensure the guides were one, not too tight around the box which would cause friction, and two, not too loose of a fit which would interfere with a smooth diverting process. Once the guides were clamped in the right place and the new holes were drilled, four wooden dowel pieces were cut to a length of 1.5" and glued into the guide pieces.

ii. Drawing Trees



iii. Part List

A complete parts list can be found in Appendix C but include:

For the unit:

- 9570 Unit
- Four Sawhorses
- V-belt

For Launcher:

- Launching surface
- Guide boards
- Wooden dowels
- Screws

- Nuts
- Screw Eyes
- Surgical tubing
- Angle Iron

#### iv. Manufacturing problems

This project overcame a lot of bumps in the road. A majority of those were from assembling the 9570 unit which was part of the manufacturing process, but it was just assembling so it was not exactly a manufacturing problem. Manufacturing the launcher came with its own set of problems. The holes were not marked with any additional clearance in order to not have contact force of the guides. This was an important issue to resolve because too much contact with the guides would slow down the packages. This issue was resolved by instead of drilling on the marked holes on the launching surface, the guides were placed with one of size packages in between them, then once it seemed like the packages had enough clearance to move freely in between the two guides, the guides were clamped to the launching surface. Then the holes were drilled through the already drilled holes on the guide to ensure accurate alignment. This set up even though improved accuracy of location, made using the drill press especially difficult. It was hard to line up the holes with the drill due to the size of the launching surface and the added bulk from the clamps. It became a two-person job and with the help of Professor Pringle was able to be completed.

## 4. Testing Method

### i. Introduction

The testing for this project was split up in four different sections. The first set of testing was testing the launching device. Testing was needed here in order to accurately replicate diverting from the cross-belt onto the 9570 unit as closely as possible. The second set of testing involved conveying packages of different sizes and weights to get tangible data and better understand what kind of packages experience a tumbling and or rotation for the 9570 unit to keep orientated while running at the required speed. The third round of testing was to replicate what was shown in the video from the tech center. The last round of testing will be testing that will support the conclusion that has been drawn from this project and the previous testing. The conclusion will offer a solution to finding a way to prevent the packages the were problematic from tumbling and rotating.

### ii. Method/Approach

The majority of testing for this project has been testing by trial and error. Data was collected via video and through an accelerometer. However, the data the accelerometer produced could not be properly analyzed by any parties involved in the project, so it has been sidelined for the time being. The videos have been used to establish qualitative and quantitative data by observing/describing the behavior of the packages while being launched at different velocities. The videos also provide a way to calculate velocity by observing the distance the packages travel over a certain period of time. Testing the conclusion will done with this same approach but have already fix parameters that will needed to be replicated to support this conclusion. Any solution that is created would be tested by replicating the problem and see if the solution prevents the tumbling.

### iii. Test Procedure Description

The launcher was tested in order to find the right force on the surgical band to replicate the packages velocity coming off the cross-belt. This was done by pulling back the surgical band to a measured distance then releasing and pushing a package off the launching surface. The video was put into slow motion and determined how far the package travels over a given time to find the velocity associated with the distance the surgical tube was pulled.

Once the testing of the launcher was completed, different size and weights of packages were launched onto the conveyor. Video was recorded to determine to look back at and see what size packages are having problems and understanding where and when. The current testing being done is replicating the problem seen in the tech center videos. This is done by launching the small package which is, 5" x 3.25" x 2.75" and weighs 0.112 oz empty or 0.169 oz with half a piece of play dough in it at different distance on the latest design of launcher. By analyzing the videos, it can be seen how the diverting velocity affects the packages behavior and a diverting velocity that best replicates the behavior seen in the videos.

The next set of testing will be done once a conclusion is drawn. This testing will be completed in order to support the conclusion drawn.

### iv. Deliverables

All testing has been and will continue to be documented with video. The videos are used to calculate the packages velocity at different points and provide the ability to observe the packages behavior while manipulating different aspects of the project. This provides a better understanding of what creates the tumbling and rotation of packages while the 9570 unit is running at the required speed.

The deliverables of this testing included proving that the conveyor is maintaining a speed of at least 3 m/s and that the boxes stay orientated. The testing proved that the conveyor is running at a higher speed than 3 m/s as you can see from the testing data the box's speeds would exceed that requirement. The only times the box was below 3 m/s was when the box was launched at a low velocity but it would eventually reach 3 m/s as it traveled down the conveyor. The results of the testing involving the behavior of the box was not ideal. There was no consistent pattern that produced turbulence. It is positive that most the boxes stay orientated however, adjustments need to be made to produce more turbulence so that the cause of that can be pin pointed. Testing issues remain the lack of accessibility to the project. The testing procedure was given to a third party to complete onto the 9570 unit because access to the conveyor unit is limited. Due to this issue, any adjustments that needed to be made during the testing by the head engineer could not have been made. One adjustment that needed to be made through out the testing would have been to adjust the camera angle. The head engineer did request a birds eye view in order to properly see the markings made on the 9570 unit that represent the 0.5m increments however, this birds eye view made it difficult to see the type of turbulence the box was experiencing. Adjusting the camera angle to see what axis the box the rotates over will provide better qualitative data on what behavior the box experiences. Another issue that resulted from testing was that the conveyor ended after the corner. The testing showed that the boxes would not all clear the corner. This provided another deliverable that suspects if the conveyor continued after the corner the box would experience more turbulence.

## 5. Budget

A parts list is shown in Appendix C. Each part is broken down into a description, source, and cost as shown in Appendix D. The unique case of this project is the lack of parts that required purchase. The 9570 unit was donated to CWU without charge due to a current relationship with the company.

It was anticipated that a majority of this project would be donated either from Dematic or CWU with expected spending of about \$75. It turned out that even more items would be donated than what was expected. Due to the change of design in the launcher, there was no longer a need to purchase clamps because the wood pieces would stay in place with wooden dowels instead which were found in excess in the wood shop at central. The pieces of wood for the launcher were also utilized from scrap wood from the machine shop so there was no purchase necessary. The budget anticipated having to purchase screw eyes and surgical tubing, but the school was able to purchase those in bulk and donated some to this project. All nuts, bolts, and washers were donated from CWU. The only actual purchase for the project so far had been 6 individual cups of play dough that were used to change the weight of the boxes being launched. The total amount for that purchase was \$7.67. All items that relate to the conveyor were donated from Dematic. However, Dematic did not include supports or a correct size of belt for the conveyor so CWU donated 4 sawhorses for the conveyor to sit on and belt that was the correct length. This project is currently under budget with a surplus of \$67.33. This could change depending on if this project draws a conclusion that would require building a simple solution.

The materials utilized during the testing phase have not costed the project any money. The video camera was borrowed from Professor Pringle in order to capture the testing. The rest of the materials needed for testing were either donated during the manufacturing phase or borrowed from the CWU MET department. The only change in budget that has been seen throughout the testing phase of this project has been the lack of need of funding a solution. In the beginning of this project, \$100 was anticipated in the budget to create a solution. As the project has changed it has become clear that the end of this project was not creating a solution like it was originally thought. The end of this project changed to ultimately drawing a conclusion from the testing that has been done. The \$100 in the budget for a solution was no longer needed because manufacturing a solution was no longer the end goal.

## 6. Schedule

### a. Gant Chart

The scheduling of this project was project was created in the design phase which means the time for construction, testing, and finalizing the project was all estimated. A high level Gannt chart was created and can be found in Appendix E with snip of what has been completed so far shown below.

Scheduling became a huge focus when the head engineer was no longer able to access the 9570 unit to perform in person tests. The testing had to be done through a second party who also had limited access to the 9570. People were only allowed in the building two days of the week which made scheduling testing and getting everything analyzed in time a little difficult. Not being able to access the 9570 unit everyday pushed back the schedule of testing. Also, working with Dematic would affect the schedule as well. When more information would be needed about the 9570 unit or about the conditions at the tech center, it could be a problem having someone respond in a timely manner. In order to counteract these scheduling issues, the tests ran had to be prioritized. If the access was never limited, the head engineer



could be running different tests every other day. However, that was not the case so the testing had been limited in order to stay on schedule.

PROJECT TITLE: DIVERTING DECISION				Note: June x Presentation											
Principal Investigator.: SADIE MENSING				Note: June y-z Spr Finals											
TASK: ID	Description	Duration		S	October	November	Dec	January	February	March	April	May	June		
		Est. (hrs)	Actua (hrs)											%Comp.	
1	<b>Proposal*</b>														
1a	Outline	0.5	0.5	100	X										
1b	Intro	1	3	100	X										
1c	Green Sheets	12	20	100	X	X	X	X	X	X					
1d	Drawings	10	8	100	X	X	X	X	X	X					
1e	Analysis	4	4	100	X	X	X	X	X	X					
1f	Methods	2	3	100	X	X	X	X	X	X					
1g	Parts and Budget	8	6	100		X	X	X	X	X					
1h	JHA	1	0.5	100		X	X								
1i	Schedule	3	2	100		X	X	X	X	X					
1j	Test Methods	2	2	100		X	X	X	X	X					
1k	Discussion & Conclusion	1	0	100			X	X	X	X					
1l	Summary & Appx	1	0	100			X	X	X	X					
	subtotal:	45.5	49	100											
1c	Website	4	22	100	X	X	X	X	X	X	X	X	X		
2	<b>Analyses</b>														
2a	Kinetic Energy	0.5	0.25	100	X										
2b	Inertia for Spinning	0.5	3	100	X	X	X	X	X	X					
2c	Rotational Moment for Spinning	0.5	3	100	X	X	X	X	X	X					
2d	Force that causes Spinning	0.5	3	100	X	X	X	X	X	X					
2e	Inertia for Tumbling	0.5	0.5	100			X								
2f	Rotational Moment for Tumbling	0.25	0.25	100			X								
2g	Force that causes Tumbling	0.25	0.25	100			X								
2h	Velocity after Collision	0.5	0.5	100		X	X								
	Angle of Velocity Vector after														
2i	Collision	0.5	0.5	100		X	X								
2j	Force on Individual Roller	0.5	0.5	100			X								
2k	Launching Force	0.5	0.5	100			X	X							
	Contact Angle that causes														
2l	Spinning	1	1	100			X	X							
	subtotal:	6	13.3	100											
3	<b>Documentation</b>														
3a	Part 1 Roller	1	1	100	X	X									
3b	Part 2 Tapered Roller	1	1	100	X	X									
3c	Subassembly of Problem	1	1.5	100	X										
3d	Part 3 Launching Surface	1	2	100		X	X								
3e	Part 4 Stability boards	0.5	0.5	100		X	X		X						
3f	Subassembly Launcher	0.5	0.5	100			X								
3g	Assembly of Launcher	2	1.5	100				X							
3h	Conclusion	6	4	100					X						
3i	ANSI Y14.5 Compl	10	6	100	X	X	X	X	X	X					
3j	Drawing Tree	6	3	100	X	X	X	X	X	X					
	subtotal:	29	21	100											
4	<b>Proposal Mods</b>														
4a	Project Diverting Schedule	3	0	0				X							
4b	Project Diverting Part Inv.	2	0	0				X							
4c	Crit Des Review*	3	0	0				X							
	subtotal:	8	0	0											
5	<b>Part Construction</b>														
5a	Receive 9570 unit	3	12	100		X	X	X	X						
5b	Build Supports	2	0	100				X							
5c	Different size Boxes	0.5	0.5	100		X									
5d	Make Launching Surface	1	3	100			X	X			X				
5e	Make Stability Boards	0.5	1.5	100			X				X				
5f	Make Attacher	0.25	2	100			X	X	X						
5g	Buy Screw Eyes	0.25	0.25	100			X								
5h	Buy Surgical Tubing	0.25	0.25	100			X								
5i	Draw Conclusion	10	4	100				X							
5j	Manufacture Plan*	5	0.5	100			X								
	subtotal:	22.75	24	100											
6	<b>Device Construct</b>														
6a	Assemble 9570 Unit	2	11	100			X	X	X	X					
6b	Assemble Launcher	2	3	100			X	X			X				
6c	Assemble Solution 1	5	0	0											
6d	Assemble Solution 2 (if needed)	5	0	0											
6e	Take Dev Pictures	1	1	100			X	X	X	X	X				
6f	Update Website	2	6	100			X	X		X	X				
	subtotal:	17	21	66.6667											
7	<b>Device Evaluation</b>														
7a	Initial testing for 9570	10	14	100				X	X	X	X	X	X		
7b	Testing the Launcher	2	5	100				X					X		
7c	Analyze Testing Results	6	14	100				X	X	X	X	X	X		
7d	List Parameters	2	1	100				X							
7e	Design Test&Scope	3	4	100				X					X		
7f	Obtain resources	6	1	100				X							
7g	Make test sheets	2	2	100				X							
7h	Plan analyses	5	3	100				X					X		
7i	Instrument 9570	1	2	100				X							
7j	Test Plan*	10	2	100				X							
7k	Perform Evaluation	5	4.5	100				X					X		
7l	Take Testing Pics	1	0.25	100				X							
7m	Update Website	1	10	100				X	X	X		X	X		
	subtotal:	36	62.8	100											
8	<b>495 Deliverables</b>														
8a	Get Report Guide	1	1	100							X				
8b	Make Rep Outline	3	2	100							X				
8c	Write Report	12	14	100							X	X	X		
8d	Make Slide Outline	3	2	100							X				
8e	Create Presentation	12	4	100							X				
8f	Make CD Deliv. List	2	0	0							X				
8g	Write 495 CD parts	2	0	0							X				
8h	Update Website	1	2	100							X				
8i	Project Flashdrive	4	2	100							X				
	subtotal:	40	27	77.7778											

## b. Overview

The schedule was created by defining specific tasks, identifying them, and assigning times. There were weakly deadlines throughout the design phase. Overall this phase required more time than anticipated with proposal and analyses. The effort put into the proposal was underestimated and a few of the analyses had to be redone which put on additional time. The scope of this project was hard to narrow down which caused for a lot of parts in the design phase to be prolonged. It was important to allocate task dates and go in a sequence in order to be successful.

This project has experienced multiple changes in the schedule. The time that is has taken to assemble the conveyor set the whole project back a significant amount. Not to mention there was additions and subtractions to the schedule as well. Solutions to the turbulence were anticipated to start being design/manufactured 3 weeks into the quarter, after factoring in time for conveyor set up, launcher being built, and testing done. However, after the complete assemble of the conveyor, getting the unit hooked up to power, and completing the assembly and testing of the launcher was not completed until the end of the 5th week. The conveyor did not arrive until the end of the 1st week. Before the shipment from Dematic could be unpacked and laid out for assembly, a spot for where this conveyor will be ran needed to be finalized. A setback was hit at the end 2nd week when it was realized that assembling the 9570 unit was not going to be simple and Dematic had not sent very clear or straight forward drawings. The attention was then turned to beginning to manufacture the launcher while researching for better direction on how to assemble conveyor. Halfway through the 3rd week some images from the Dematic Tech center were found and then mounting all the pieces was able to be completed by the end of that week. Dematic was not able to send a correct size belt or any supports to put the unit on. This also set the schedule back because we could not measure for the length of a new belt without the motor and correct springs mounted. By the time the new belt arrived and was put into the unit, it was the end of the 4th week. Then the unit had to wait for the University Electrician to complete the connection to power and finally complete the setup of the conveyor. The launcher manufacturing, assembly and testing was able to be completed during the waiting times on the conveyor.

The schedule changed again when the launcher had to be changed. According to schedule the launcher was completed on time and by mid-January but was then redesigned at the beginning of march to better replicate the cross belt.

Most events have exceeded the predicted time once they have begun.

### c. Deliverables and Mile Stones

<b>Milestones</b>	<b>Deliverable</b>
December 2019	Proposal completed
January 2020	Analysis completed, Parts documented
February 2020	Modifications made, Parts Manufactured
March 2020	Project assembled
April 2020	Project evaluated
May 2020	Testing
June 2020	Project completed

### d. Estimated Total Project Time

The total estimated time to complete all phases of this project is 204.3 hours and the project has completed 144 hours.

## 7. Project Management

### a. Risk

Risk is a huge part of projects and project management. A huge risk this project faced was if/when the 9570 unit would arrive at Central because the project would have needed to be reevaluated without it. That would have been a huge loss of resource and would have caused problems in scheduling and budget because creating a simulation of this unit would take a lot of time and money. Risk is also present in exploring a solution. This could easily go over schedule and budget depending on how easily a solution can be design and created. There was also a risk that Central might not have the right resources to support running the 9570 unit. With the 9570 unit set up and running at CWU it created safety risks. Due to the Fluke Lab being an open and easily accessible space by anyone who enters the Hogue building, it was coned and taped off with caution tape and caution signs stating "Caution: Pinch Point, Moving Objects." A standard operating procedure (SOP) was created along with a form that needed to be signed by anyone assisting with the 9570 unit saying they have read and understand the SOP. Also, to ensure safety, a lock was placed on the knife switch so that the unit could only be turned on and ran by the approved parties.

### b. Resources

The majority of human resources for this project came from Sadie Mensing who is the principal engineer for this project. Her resume is shown in Appendix H. Supporters for this project include CWU Engineering professors and staff along Dematic employees. CWU facilities and machines are largely responsible for the manufacturing of this project. CWU has also been a financial resource by providing the power used to run the unit and donating necessary materials to get the 9570 unit running and the launcher built. Dematic Co is a financial resource for this project by providing equipment that would be

costly including the 9570 and a motor to run it. The project will be successful because of these resources.

## 8. Discussion

### a. Evolution

The principal engineer's current relationship with Dematic Co is how this project began. They were approached regarding a problem that the company has that might require further research. A couple different ideas were proposed like analyzing the material of common conveyed material, but this project was chosen for its engineering merit and the possibility of working hands on with a conveyor from Dematic. The overall idea was to have the cross-belt consecutively divert items onto the new 9570 unit while the items-maintained orientation. At first the scope of this project was too large. Dematic sent over testing videos of different size items being diverted onto the 9570 unit. Different sized items experienced different problems while being diverted like timing issues with the cross-belt. The allowed time for this project would not accommodate exploring all these problems while trying to create a solution to each. That is when the scope was narrowed down to focus on the spinning and rotating the small packages underwent while being on the 9570 unit.

The 9570 unit was at the Tech center in Michigan, so majority of the analyses were completed by using parameters giving in the unit's specification sheet or from estimating values from the videos. The difficulties this presented inspired the need to get the 9570 unit to CWU so accurate testing could be done and the unit could be manipulated to find a solution. At first testing was going to be done remotely but it became hard to be in contact with the right people who would run testing for this project. Then an onsite visit to the tech would be needed by the principal engineer but it would allow for limited attempts of testing the solution. Not to mention if the solution had to be redesigned, it is likely it would not get to be retested.

When the 9570 unit began the process to be sent to CWU, a device to replicate the cross-belt was now needed. At first it seemed like it would be a complicated device but after discussion with Dr. Johnson, CWU Professor, it was concluded that the launcher could be a simple design with a sling shot effect.

This project has faced a lot of issues. Even though the 9570 unit was not "manufactured" in this project, assembling the unit came with a lot of setbacks. These issues were resolved by the involved parties being resourceful and creative. The drawings that came with the unit were not very clear. An installation manual was able to be tracked down through Dematic. This manual had better explanation of how to assemble the unit but was still unclear as to where each part went onto the conveyor. However, a Dematic employee was able to track down pictures from a 9570 unit that was previously set up in the Dematic tech center. These pictures were key because then the unit at CWU was able to be set up just by replicating the images in this picture. The pictures also revealed that Dematic sent more parts that what were needed which added to the confusion. Without using the resource of Dematic it is likely that the set up would have taken even longer.

Even though Dematic sent extra parts, they did not send two key aspects of running the unit. Dematic was unable to send supports for the 9570 unit. This was an issue because the motor on the unit is mounted below the conveyor so it would be impossible to run it on the floor. Creativity was needed to resolve this issue. The solution came to be ordering four sawhorses to put the unit on. The other

equipment that was missing was a belt. The one belt provided would only fit on the discharge/end unit when that is the only unit not necessarily needed. In the end it was decided to not set up that piece of the unit to save space and time. In order to know what size belt to order, a piece of string was set up where the belt would be and then measured with a tape measure. There were no belts that were close to that exact size but luckily the 9570 unit has adjustable pieces, so a larger belt was ordered and was able to fit.

Manufacturing the launcher did not come with many issues thanks to the simplicity of the design. However, when it was being measured and marked for where to drill different holes for different size packages, the holes were marked so that guide pieces would have been snug onto the packages. The holes were not marked with any additional clearance in order to not have contact force of the guides. This was an important issue to resolve because too much contact with the guides would slow down the packages. This issue was resolved by instead of drilling on the marked holes on the launching surface, the guides were placed with one of size packages in between them, then once it seemed like the packages had enough clearance to move freely in between the two guides, the guides were clamped to the launching surface. Then the holes were drilled through the already drilled holes on the guide to ensure accurate alignment.

Once the new belt arrived, more obstacles were faced attaching it to the 9570 unit. Attaching the belt consisted of a lot of loosening, tightening, and adjusting different parts of the unit. It appeared that during the shipment of the unit there had been damage to one of the pulleys in the motor, but the belt was still able to fit around it. With the belt in place the unit was ready to be flipped onto the sawhorses and was ready to be hooked up to power. There was a small delay having to wait for the university electrician to complete the wiring but then the 9570 unit was finally running.

While waiting for the electrician, adjustments were made to the angle iron that would mount the launcher onto the conveyor. The previous holes were milled with the milling machine so that the height the launcher is at can be easily adjusted. Then three new holes were drilled on the other side of the angle iron to attach it to the bottom of the launcher. Once it was attached the launcher, it was time to attach the angle iron and launcher to the conveyor. Sets of holes were drilled in three different locations at the front of the conveyor so where the packages are coming onto the conveyor can be changed.

Once the unit got hooked up to power, it only ran for a short period because the belt slipped off the broken pulley and began to shred in the motor. The pulley would not stay onto its bearing due to the damage. The extra pieces Dematic sent came in handy because there was an extra pulley about the same size. The bearing for the pulleys were popped out and the correct bearing was then pressed into the new pulley and was put into the motor. This was the final step in the long process of setting up the 9570 unit and getting it to run.

The next step in the project was to complete initial testing. Different size and weight of packages were launched onto the conveyor at different velocity to observe their behaviors. The scope of testing was then narrowed when it came to replicate what was in the tech center videos. Only the small box was tested at very light weight, but the project was still not producing the desired results. That was when the launcher was changed to launch the packages at a 40-degree angle onto the 9570 unit because that better simulates how the cross belt behaves. The new design of the launcher should help recreate the video from the test center and create a more realistic data.

However, changing the angle of the launcher did not result in more consistent data. The results from the first round of testing of the new angled launcher showed that the conveyor met the requirement of the unit needing to maintain a speed of at least 3 m/s except for when the box was launched at a distance of 2 inches where the average speed was only 2.67 m/s. The requirement of the packages maintaining orientation was not met. Unfortunately, there was no consistency in the behavior of packages. The box was launched at different distances on the new angled launcher to see how the package behaved while being diverted onto the 9570 unit at different speeds. Some speeds experienced tumbling while others did not but there was no pattern. That leads to the conclusion that the diverting speed is not associated with the turbulence the packages experience. A new variable is going to be manipulated and tested to see what could create the consistent turbulence the packages experienced while in the tech center.

The average speed of the box while on the conveyor, including all launching distances, was 3.66 m/s. This exceeds the minimum rate of 3 m/s by a substantial amount. It leads to question that this could be why the boxes are not experiencing the same behavior that Dematic had shown in their test center videos. Unfortunately, Dematic did not donate a variable frequency drive with the 9570 so that the speed could be easily manipulated. Before completing more tests with different variables changed, the head engineer requested that the belt be loosen, if possible, on the 9570 unit in hopes of slowing down it's speed. Not only was the overall average speed of the box significantly higher than the requirement at 3.66 m/s, the speed of the box while being launched at 5 and 6 inches was averagely over 4 m/s. It led to the question, if launching at those distances should be eliminated then as well. However, a previous analysis done on the launching speed showed that launching the box at 5 and 6 inches, best represents the desired diverting speed from the cross belt that was 3.41 m/s. The launcher analysis showed that when the box was launched at 5 inches the average speed was 3.2 m/s and when it was launched at 6 inches, the average speed was 3.5 m/s. This proves that the head engineer should continue running the future test at those launching distances and it could be beneficial to just slow the speed of the conveyor down.

#### b. Success

A huge success of this project was being able to complete the 9570 unit and get it running for testing. This gave the project more data and the ability to manipulate the conveyor for different reasons. This also provided the opportunity for the principle engineer to get hands on experience with a piece of equipment from their future employer.

Due to the ongoing pandemic this project has faced new problems. With restrictions on travel and social interaction the head engineer for this project cannot physically work on the conveyor and conduct test. Despite the deficit of not be able to change things on the fly or manipulate the testing in the precise way desired, the head engineer has still been able to complete testing and get data with the help of the CWU MET staff completed the tests as directed. This project would not be successful as it is without the support of the staff.

### c. Next

The next step for this project will be replicating the spinning and tumbling seen in the tech center video with the 9570 unit at CWU. Once this is replicated, different variables can be manipulated in order to stop the spinning and tumbling. A possible conclusion that will be explored will be changing the diverting velocity of different weighted packages to match or exceed the speed the 9570 unit is running.

## 9. Conclusion

The 9570 unit has identified and analyzed for the spinning and tumbling of small packages while meeting all the function requirements. All aspects were evaluated to keep the unit running at the required 3 m/s. Lots of data has been collected and analyzed from initial testing to better understand how different diverting velocity's affect the behavior of packages. The conveyor was able to be assembled and ran in the Fluke Lab at CWU thanks to the donations from Dematic and CWU. The Diverting Decision is now set up to continue testing in a more accurate way and then successfully draw a conclusion from the new testing as to how to keep the orientation of smaller boxed packages while on the 9570 unit. A solution, if built, will be sure meet all the function requirements as well still allow for all the different types of packages/materials including cardboard boxes, plastic totes, and polybags to be conveyed and would not prevent the diverting of 5 or more consecutive items. All of these requirements apply to conclusion that will be drawn as well. This project provided the perfect opportunity for the principle engineer to have hands on experience with a piece of Dematic conveyor which has helped them better understand the equipment the work with.

This project meets the following requirements to be a successful senior project:

- Having substantive engineering merit
- Size and cost within the parameters of resources
- Is of interest to the principal engineer

## 10. Acknowledgements

This Project would not have been successful without the help and support of CWU staff and facility along with Dematic Co and their staff. Would like to thank the following entities for as followed:

- Dematic Co inspired and sponsored this project
- CWU sponsored this project by providing a place and power for the 9570 unit. The facilities and donated resources were a huge part of this project's success.
- Charles Pringle, CWU, mentored this project and offered guidance and assistance when needed. Professor Pringle was a huge help in design and manufacturing my launcher, and also assisted in assemble of the 9570 unit and some of the testing completed.
- Matt Burvee, CWU, mentored this project and offered guidance and assistance when needed. Matt Burvee was huge help when it came to the assemble and running the 9570. He donated his time to assist in testing as well.
- Rowdy Sanford, CWU, offered his assistance with the accelerometer
- Craig Johnson, CWU, mentored this project and offered guidance and assistance when needed
- John Choi, CWU, mentored this project and offered guidance and assistance when needed
- Alex Fedewa, Dematic, mentored this project and offered guidance and assistance when needed





## Appendix A - Analyses

### a. Appendix A1 – Kinetic Energy of Package

Given: Speed of object =  $3\text{ m/s}$

Find: Kinetic Energy of object

Assume:  $\frac{1}{2}\text{ lb}$

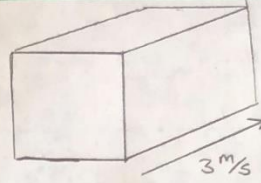
Method: Convert units  
 $E_k = \frac{1}{2}mv^2$

Soln:  $\frac{1}{2}\text{ lb} \times \frac{0.4536\text{ kg}}{1\text{ lb}} = 0.2268\text{ kg}$

$$E_k = \frac{1}{2}(0.2268\text{ kg})(3\text{ m/s})^2 = 1.021\text{ J}$$

Answer:  $1.021\text{ J}$

Tolerance  $\pm 0.01$



b. Appendix A2 – Inertia of Package About Y-axis (Spinning)

Spinning  $\frac{1}{3}$

Given: length = 9"  
width = 4"

Find: Inertia of package  
about y-axis

Assume: Package weighs  $\frac{1}{2}$  lbs

Method:  $m = \frac{w}{g}$  in  $\rightarrow$  ft

$$I = m \frac{1}{12} [l^2 + w^2]$$

Soln:

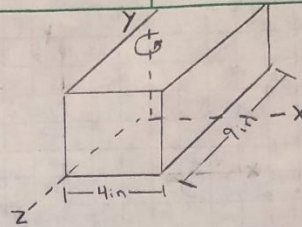
$$\text{Length} = 9 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = .75 \text{ ft}$$

$$\text{width} = 4 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = .33 \text{ ft}$$

$$m = \frac{0.5 \text{ lbf}}{32.2 \frac{\text{ft}}{\text{s}^2}} = 0.0155 \frac{\text{lbf} \cdot \text{s}^2}{\text{ft}}$$

$$I = 0.0155 \frac{\text{lbf} \cdot \text{s}^2}{\text{ft}} \times \frac{1}{12} [(0.33 \text{ ft})^2 + (0.75 \text{ ft})^2]$$

$$I = 8.67 \times 10^{-4} \text{ lbf} \cdot \text{s}^2 \cdot \text{ft}$$



c. Appendix A3 – Rotational Moment of Package about Y-axis

Spinning  $\frac{2}{3}$

Given: Inertia of package =  $8.67 \times 10^{-4} \text{ lb}_f \cdot \text{s}^2 \cdot \text{ft}$  about y-axis

Find: Rotational Moment about y-axis

Assume:  $\omega = 1.5 \text{ rad/s}$   
change of time =  $0.5 \text{ s}$  > from videos

Method:  $\alpha = \frac{\Delta\omega}{\Delta t}$   
 $M = I\alpha$

Soln:  $\alpha = \frac{1.5 \text{ rad/s}}{0.5 \text{ s}} = 3 \text{ rad/s}^2$

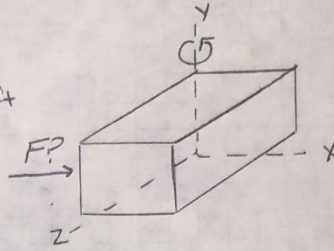
$$M = (8.67 \times 10^{-4} \text{ lb}_f \cdot \text{s}^2 \cdot \text{ft}) (3 \text{ rad/s}^2)$$
$$= 2.6 \times 10^{-3} \text{ lb}_f \cdot \text{ft}$$

d. Appendix A4 – Forces that Causes Spinning

Spinning  $\frac{3}{3}$

Given: Rotational Moment  
about y-axis =  $2.6 \times 10^{-3} \text{ lb}_f \cdot \text{ft}$

Find: Force it takes for  
package to spin



Assume: Spinning is about y-axis  
• neglect other forces  
• Package travels 2" during rotation (from video)

Method: in  $\rightarrow$  ft  
 $M = Fd$   
 $F = M/d$

Soln:  $2 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = 0.1667 \text{ ft}$

$$F = \frac{M}{d} = \frac{2.6 \times 10^{-3} \text{ lb}_f \cdot \text{ft}}{0.1667 \text{ ft}}$$

$$F = 0.0156 \text{ lb}_f$$

e. Appendix A5 – Inertia of Package About X-Axis

Tumbling  $\frac{1}{3}$

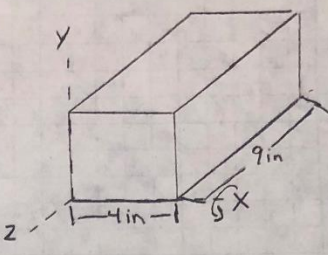
Given: length = 9"  
width = 4"

Find: Inertia of package rotating over front edge, x-axis

Assume: Package weighs  $\frac{1}{2}$  lb

Method:  $m = \frac{w}{g}$  in  $\rightarrow$  ft  
 $I = \frac{1}{3} ml^2$

Soln: Length:  $9 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = 0.75 \text{ ft}$   
 $m = \frac{w}{g} = \frac{0.5 \text{ lb}_f}{32.2 \frac{\text{ft}}{\text{s}^2}} = 0.0155 \frac{\text{lb}_f \cdot \text{s}^2}{\text{ft}}$   
 $I = \frac{1}{3} (0.0155 \frac{\text{lb}_f \cdot \text{s}^2}{\text{ft}}) (0.75 \text{ ft})^2$   
 $= 2.91 \times 10^{-3} \text{ lb}_f \cdot \text{ft} \cdot \text{s}^2$



f. Appendix A6 – Rotational Moment About X-Axis

Tumbling  $\frac{2}{3}$

Given: Inertia of package =  $2.91 \times 10^{-3} \text{ lbf} \cdot \text{s}^2 \cdot \text{ft}$  about x-axis  
(front edge of package, see tumbling  $\frac{1}{3}$ )

Find: Rotational moment about x-axis

Assume:  $\omega = 1.5 \text{ rad/s}$   
change of time =  $0.5 \text{ s}$   $\rightarrow$  estimated from videos

Method:  $\alpha = \frac{\Delta \omega}{\Delta t}$   
 $M = I \alpha$

Soln:  $\alpha = \frac{1.5 \text{ rad/s}}{0.5 \text{ s}} = 3 \text{ rad/s}^2$

$$M = (2.91 \times 10^{-3} \text{ lbf} \cdot \text{s}^2 \cdot \text{ft})(3 \text{ rad/s}^2)$$
$$= 8.73 \times 10^{-3} \text{ lbf} \cdot \text{ft}$$

g. Appendix A7 – Force that Causes Tumbling

Tumbling 3/3

Given: Rotational Moment about  
x-axis =  $8.73 \times 10^{-3} \text{ lbf} \cdot \text{ft}$

Find: Force it takes for package  
to tumble over axis

Assume: Tumbling is about x-axis  
• Neglect other forces  
• Force is applied 2" from edge/axis

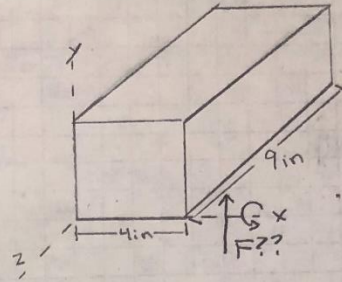
Method: in  $\rightarrow$  ft  
 $M = Fd$   
 $F = \frac{M}{d}$

Soln:

$$2 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = 0.1667 \text{ ft}$$

$$F = \frac{M}{d} = \frac{8.73 \times 10^{-3} \text{ lbf} \cdot \text{ft}}{0.1667 \text{ ft}}$$

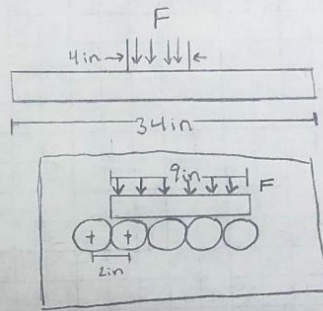
$$F = 0.0527 \text{ lbf}$$





h. Appendix A8 - Force on Individual Roller

Given: width = 4"  
Package = length = 9"  
mass = 1/2 lb  
Roller = 34" long  
1.9" diameter  
Center to center = 2"



Find: Force on individual roller

Assume: x-y Plane only  
Perfectly distributed load

Method:  $F = mg$   
Individual  $F = \frac{F}{\# \text{ of rollers}}$

Soln:  $F = \frac{1}{2} \text{ lb} \times 32.17 \frac{\text{ft}}{\text{s}^2} = 16.08 \text{ lbf}$

$$\frac{16.08 \text{ lbf}}{4.5 \text{ rollers}} = 3.57 \text{ lbf}$$

Min Force on roller for small packages = 3.57 lbf

i. Appendix A9 – Angle Package is Being Diverted

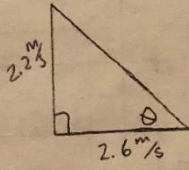
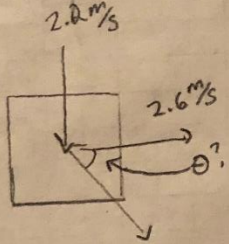
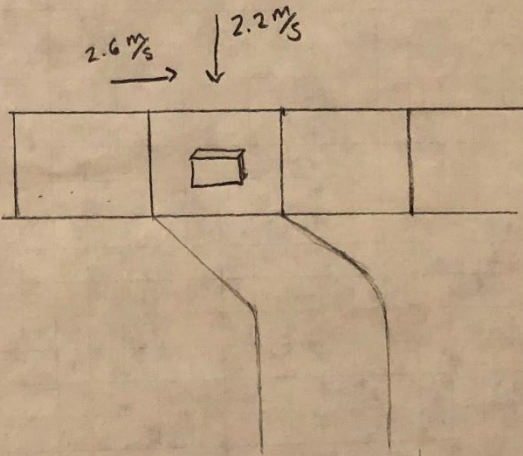
Given: Cross-belt speed =  $2.6 \text{ m/s}$   
Cross-belt lateral carrier speed (divert speed) =  $2.2 \text{ m/s}$

Find: Angle of velocity vector

Assume:

Method: FBD  
trigonometry  
 $\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right)$

Soln:


$$\theta = \tan^{-1}\left(\frac{2.2}{2.6}\right) = 40^\circ$$

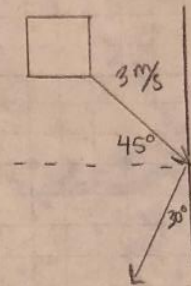
$40^\circ$

j. Appendix A10 – Velocity of Package after Collision

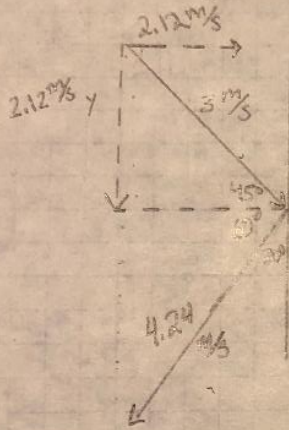
Given: Initial velocity =  $3 \text{ m/s}$   
Angle of contact =  $45^\circ$   
Mass =  $1 \text{ lb}$

Find: Velocity after collision

Assume: Angle off guard rail =  $30^\circ$   
Package hits at flat side  
(not corner)



Method: FBD  
Momentum vectors  
trigonometry

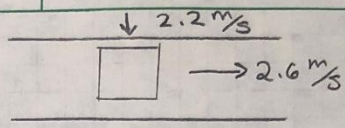
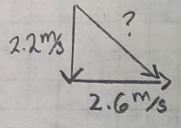


$$\sin 45 = \frac{y}{3 \text{ m/s}}$$
$$y = 3 \text{ m/s} \sin 45$$
$$y = 2.12 \text{ m/s}$$

$$\cos 60 = \frac{a}{h}$$
$$h = \frac{2.12 \text{ m/s}}{\cos 60}$$

$$= 4.24 \text{ m/s}$$

k. Appendix A11 – Force to Launch Packages

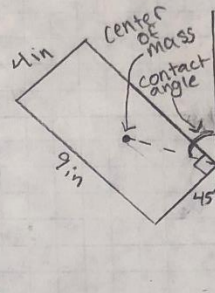
Launching Force	
<p>Given: crossbelt speed = 2.6 m/s diverting speed = 2.2 m/s mass = 1/2 lb (package)</p>	
<p>Find: Force it would take to replicate a package diverting from x-belt (cross belt)</p>	
<p>Assume: Neglect friction : Diverts in 1/3 s</p>	
<p>Method: <math>a^2 + b^2 = c^2</math> <math>m \rightarrow ft</math> <math>a = \frac{\Delta v}{\Delta t}</math> <math>F = ma</math></p>	
<p>Soln:</p>	
	$a^2 + b^2 = c^2$ $c = \sqrt{a^2 + b^2} = \sqrt{2.2^2 + 2.6^2}$ $c = 3.41 \text{ m/s}$
$3.41 \text{ m/s} \times \frac{3.28 \text{ ft}}{\text{m}} = 11.17 \text{ ft/s}$	
$a = \frac{\Delta v}{\Delta t} = \frac{0 - 11.17 \text{ ft/s}}{0 - 0.333 \text{ s}} = 33.52 \text{ ft/s}^2$	
$F = ma$ $(0.5 \text{ lb})(33.52 \text{ ft/s}^2) = 16.76 \text{ lbf}$	

# I. Appendix A12 – Contact Angle Causing Spinning

## Contact Angle

Given: length = 9 in  
width = 4 in

Find: Contact angle that would cause package to spin

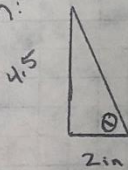


Assume: • Center of mass = 2 in, 4.5 in  
• Everything in picture is true  
• No spinning if center of mass is aligned with contact point  
• Angle less than contact angle = safe  
• Angle greater than calculated = spinning

Method:  $\tan \theta = \frac{y}{x}$

$90 - \theta + 45 = \text{contact angle}$   
angle > contact angle = spinning

Soln:



$$\tan \theta = \frac{y}{x} = \frac{4.5}{2}$$

$$\tan^{-1}\left(\frac{4.5}{2}\right) = 66.04^\circ = \theta$$

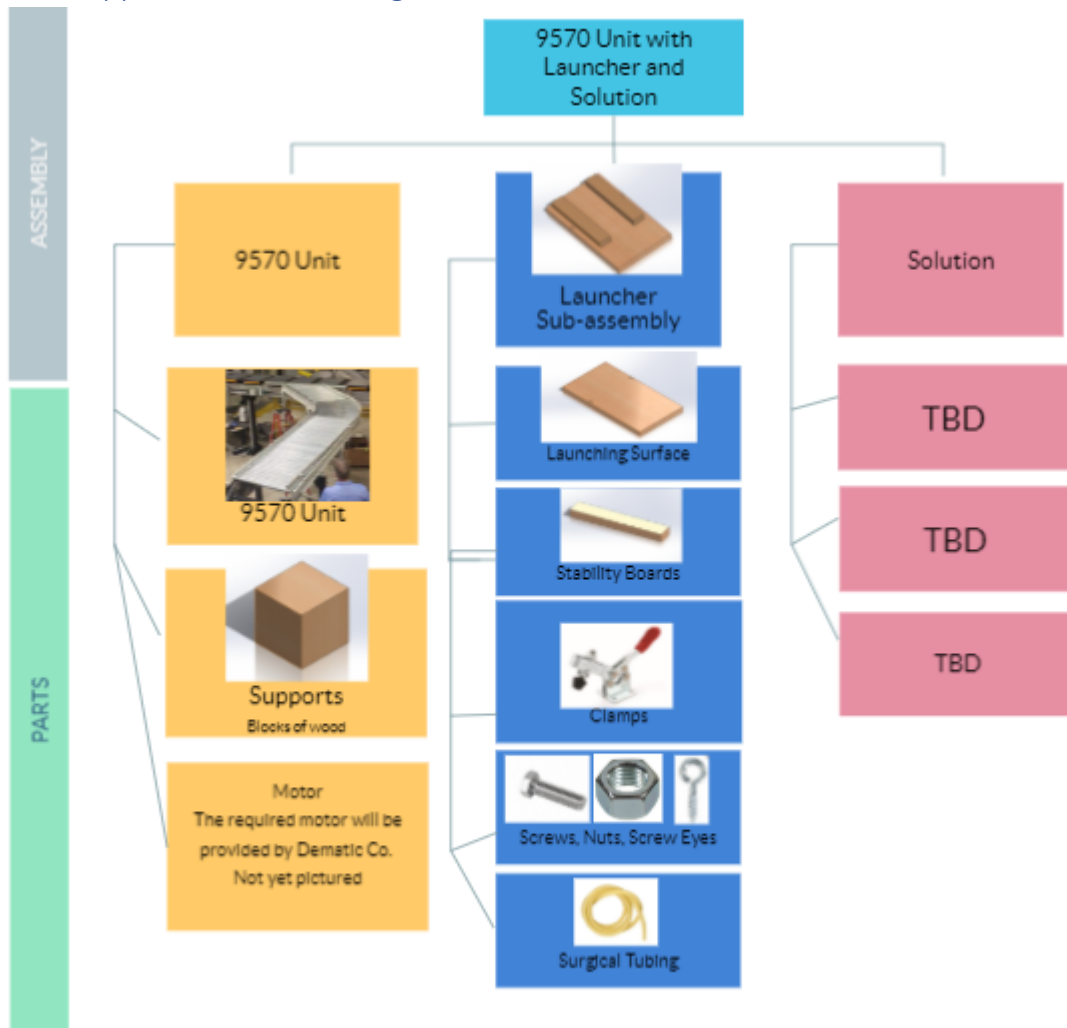
$$90 - 66.04^\circ = 23.96^\circ$$

$$23.96^\circ + 45^\circ = 68.96^\circ$$

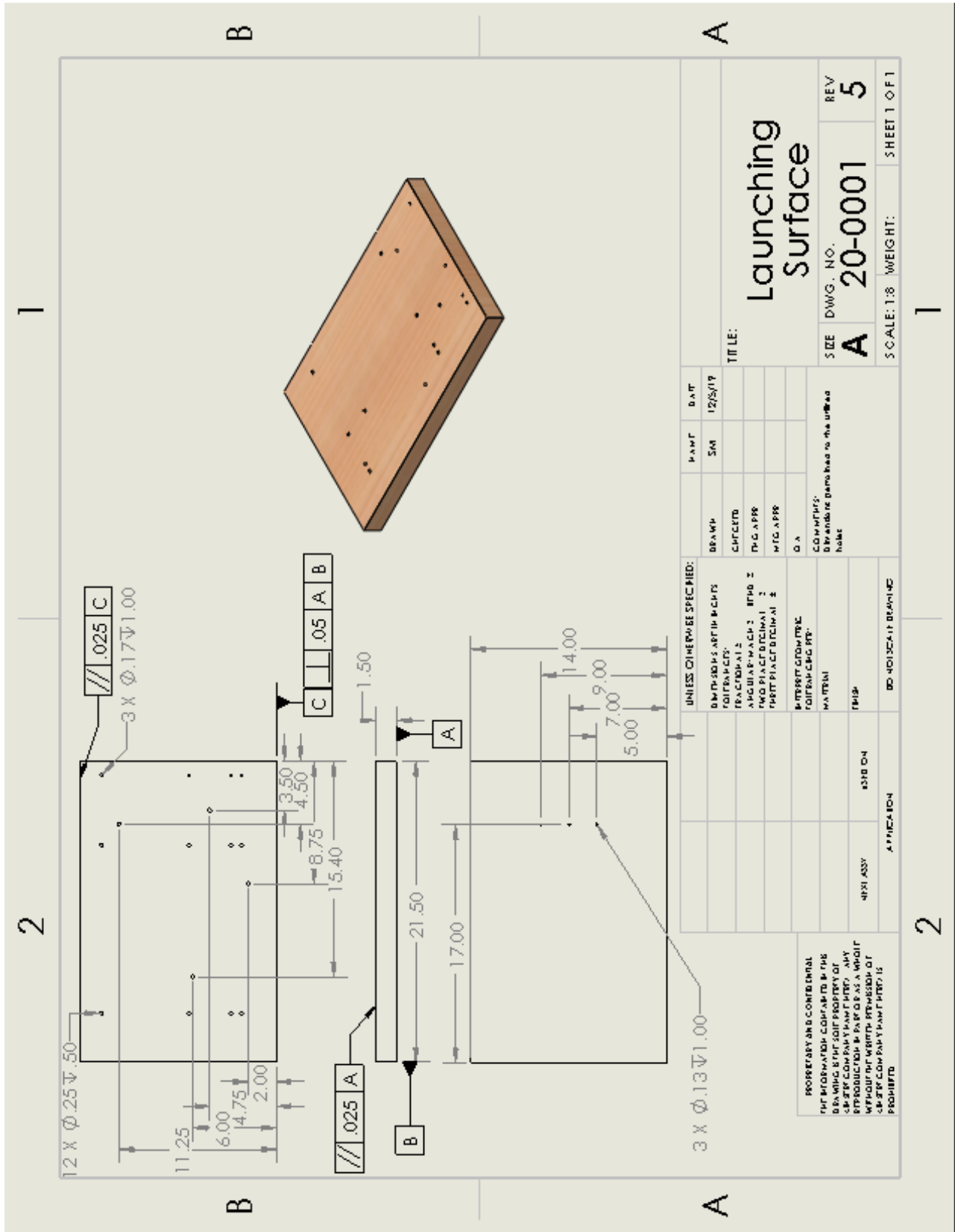
Angle > 68.96° causes spinning

## Appendix B – Drawings

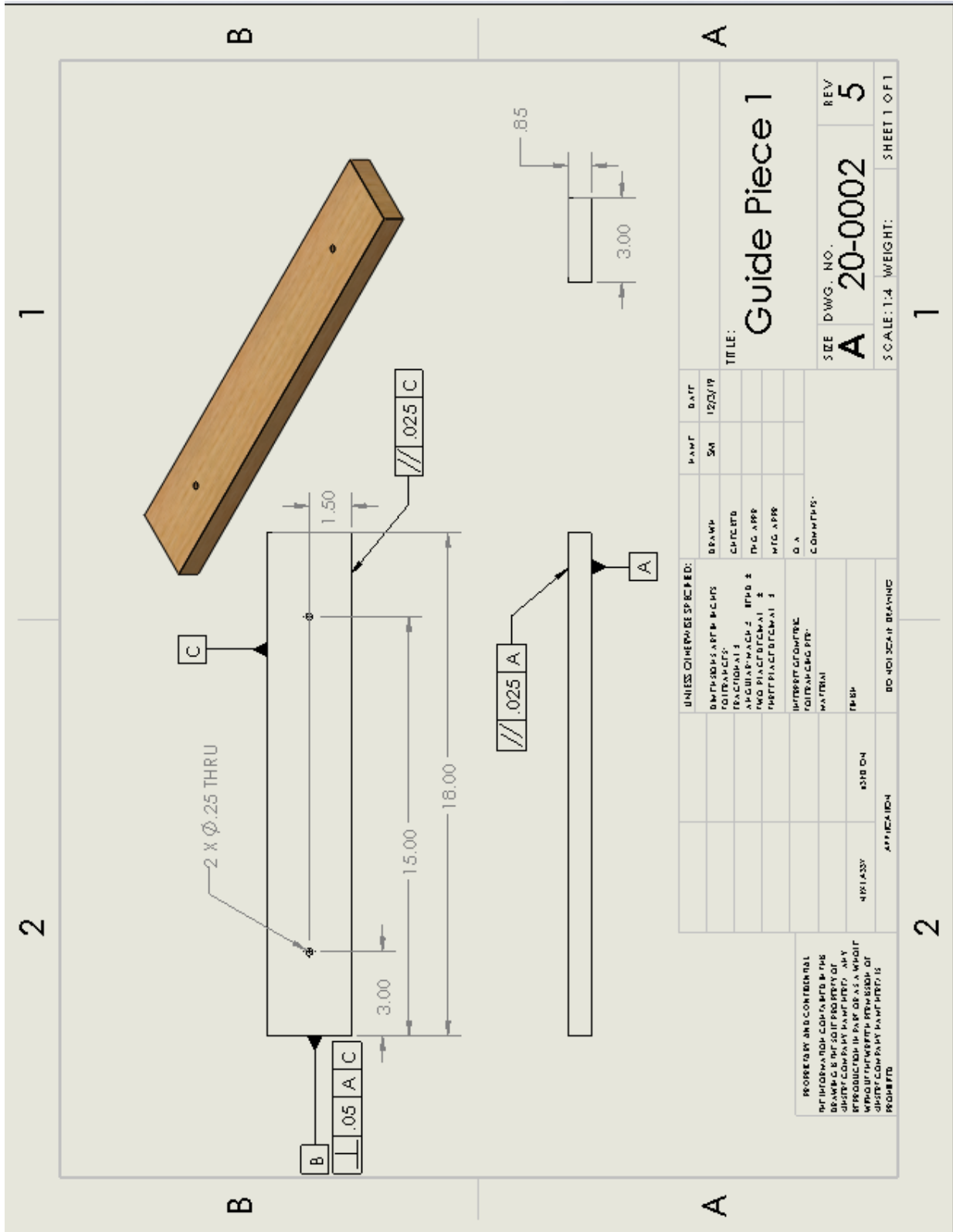
### a. Appendix B1 – Drawing Tree



b. Appendix B2 – Drawing of Launching Surface



c. Appendix B3 – Drawing of Guide Piece 1





d. Appendix B4 – Drawing of Guide Piece 2

**2** **1**

**B** **A**

3 X  $\Phi$ .25 THRU

3.00

1.50

9.00

15.00

18.00

.85

B .05 A C

.025 A

A

**A** **B**

UNLESS OTHERWISE SPECIFIED:  
 DIMENSIONS ARE IN INCHES  
 FRACTIONS: 1/2 BEND 1  
 ANGULAR TOLERANCE: TWO PLACE DECIMAL 1  
 HOLE POSITION: THREE PLACE DECIMAL 2  
 UNLESS OTHERWISE SPECIFIED:  
 DIMENSIONS ARE IN INCHES  
 FRACTIONS: 1/2 BEND 1  
 ANGULAR TOLERANCE: TWO PLACE DECIMAL 1  
 HOLE POSITION: THREE PLACE DECIMAL 2  
 UNLESS OTHERWISE SPECIFIED:  
 DIMENSIONS ARE IN INCHES  
 FRACTIONS: 1/2 BEND 1  
 ANGULAR TOLERANCE: TWO PLACE DECIMAL 1  
 HOLE POSITION: THREE PLACE DECIMAL 2

PROPRIETARY AND CONFIDENTIAL  
 THE INFORMATION CONTAINED IN THIS  
 DRAWING IS THE SOLE PROPERTY OF  
 CRYSTAL COMPANY NAME HERE. ANY  
 REPRODUCTION OR TRANSMISSION  
 WITHOUT THE WRITTEN PERMISSION  
 OF CRYSTAL COMPANY NAME HERE IS  
 PROHIBITED.

NAME	DATE	DRAWN	CHECKED	ENC APPR.	MTC APPR.	O.A.	COMMENTS:
SJM	9/7/020						

TITLE: **Guide Piece 2**

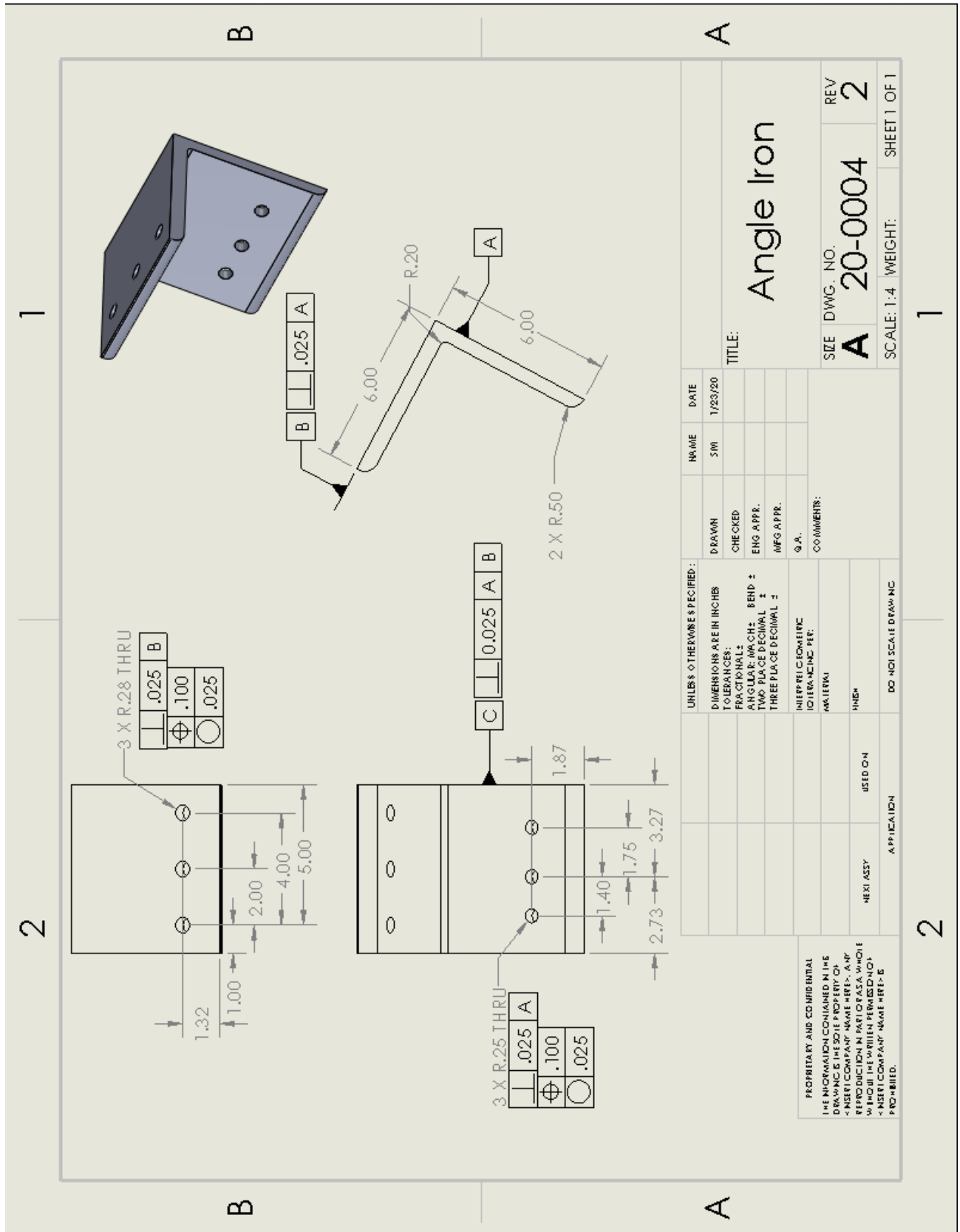
SIZE: **A** DWG. NO.: **20-0003** REV: **1**

SCALE: 1:4 WEIGHT: SHEET 1 OF 1

APPLICATION: **2**

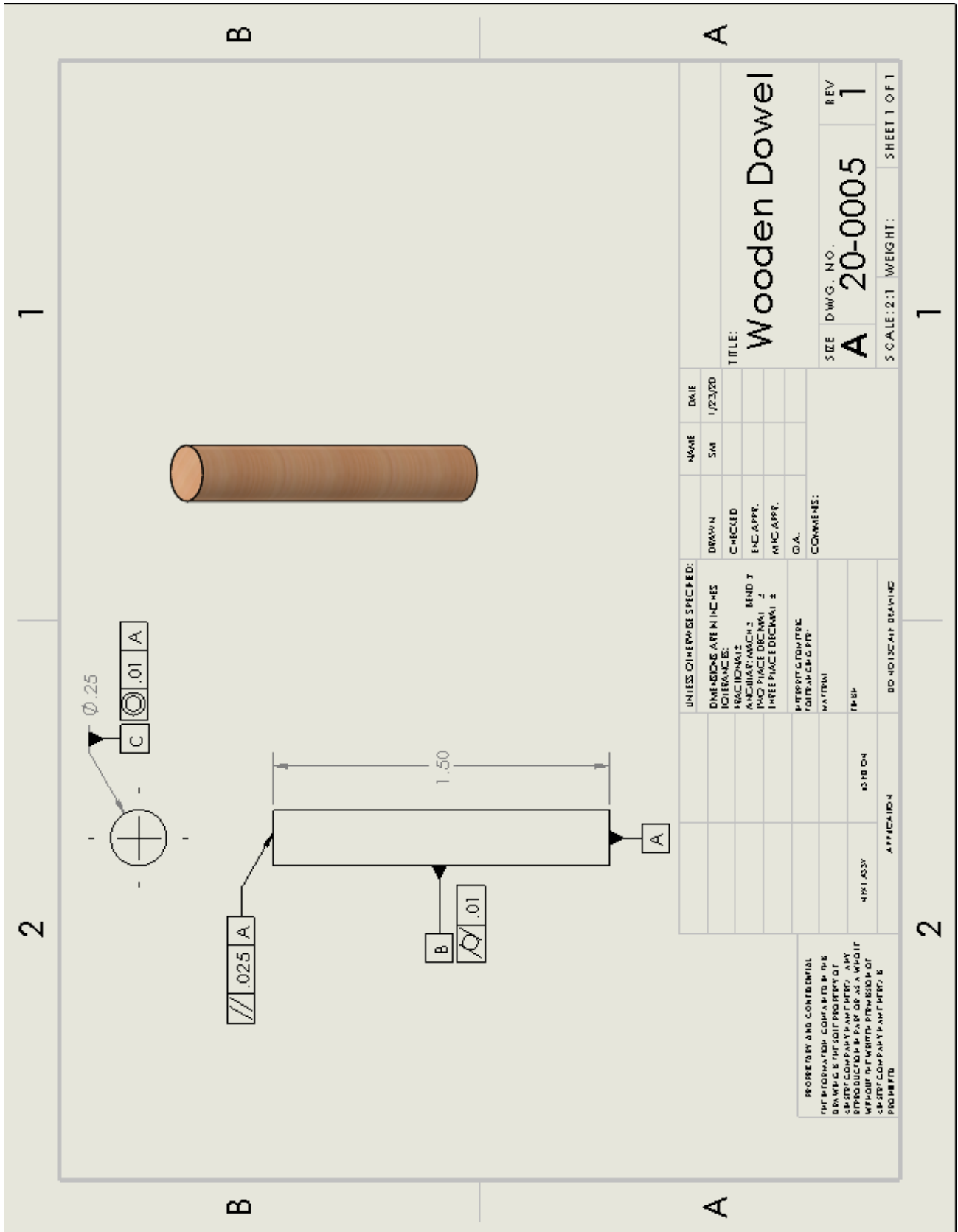
DO NOT SCALE DRAWING

e. Appendix B5 – Drawing of Angle Iron

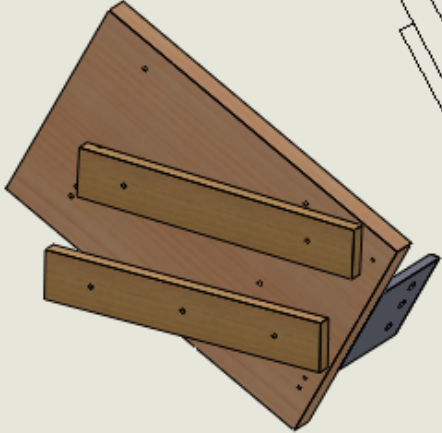
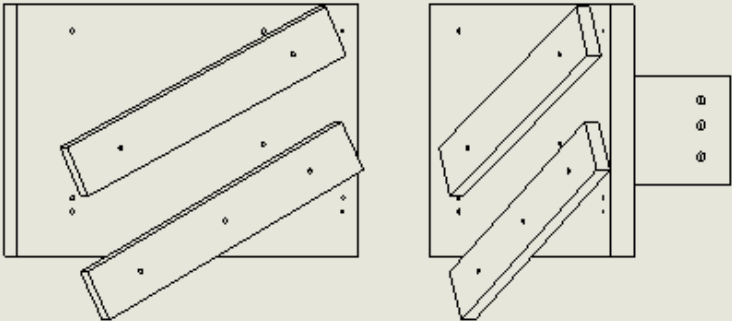


PROPRIETARY AND CONFIDENTIAL  
 THE INFORMATION CONTAINED IN THIS  
 DRAWING IS THE SOLE PROPERTY OF  
 <INSERT COMPANY NAME HERE>. A RE-  
 PRODUCTION IN PART OR AS A WHOLE  
 WITHOUT THE WRITTEN PERMISSION IS  
 <INSERT COMPANY NAME HERE> IS  
 PROHIBITED.

f. Appendix B6 – Drawing of Wooden Dowel



g. Appendix B6 - Whole Assemble

2	1	B	A
B	A	 	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS: ± .001 DECIMALS: ± .001 HOLE DIMENSIONS: ± .001 HOLE LOCATIONS: ± .001 HOLE DIAMETERS: ± .001 HOLE SPACINGS: ± .001 HOLE DRILLING: ± .001 HOLE FINISH: ± .001		DRAWN CHECKED ENG/APP. MFG/APP. D.A. COMMENTS:	NAME SM DATE 3/16/20
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS: ± .001 DECIMALS: ± .001 HOLE DIMENSIONS: ± .001 HOLE LOCATIONS: ± .001 HOLE DIAMETERS: ± .001 HOLE SPACINGS: ± .001 HOLE DRILLING: ± .001 HOLE FINISH: ± .001		TITLE: <h2 style="text-align: center;">Launcher Assembly</h2> SIZE DWG. N.O. <h1 style="text-align: center;">A 10-0001</h1> R REV <h1 style="text-align: center;">1</h1> SCALE: 1:8 WEIGHT: SHEET 1 OF 1	MATERIAL FINISH DRILL SCALE BEARING
PROPERTY AND CONFIDENTIAL THIS DRAWING IS THE PROPERTY OF THE COMPANY AND IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, WITHOUT THE WRITTEN PERMISSION OF THE COMPANY. PROHIBITED		PART ASSY APPLICATION	2 1

## Appendix C – Part List

Part ID #	Description	Quantity	Buy or Mfg
1	9570 unit	1	Buy
2	Motor	1	Buy
3	Supports	4	Mfg
4	Launching Surface	1	Mfg
5	Stability Boards	6	Mfg
6	Toggle Clamps	2	Buy
7	Screws	8	Buy
8	Hex Nuts	8	Buy
9	Screw Eyes	2	Buy
10	Surgical Tubing	1	Buy
11	Cardboard Boxes	4	Buy

## Appendix D – Budget

PARTS LIST AND BUDGET								
SENIOR PROJECT TITLE ___ Diverting Decsion								
						Cost:		
ITEM ID	ITEM Description	Item Source	Model/SN	Price/Cost (US Dollars) (\$ / hour)	Quantity (or hrs)	Subtotals	Actual \$	
1	9570	Dematic Co	N/A	4,000	1	4000	0	Donated
2	Motor	Dematic Co	N/A	1,000	1	1000	0	Donated
3	Slabs of Wood	Lowes						
	.5"x6"x24"		P 12X6 2 POPBD	4.64	2	9.28	0	Donated
	1"x6"x24"		P 1X6 2 POPBD	5.3	2	10.6	0	Donated
4a	Screws	Grainger	36LM52	1.92	4	7.68	0	Donated
4b	Hex Nut	Grainger	22UK70	3.09	1	3.09	0	Donated
4c	Scew Eyes	Grainger	1WBE7	2.19	1-20pck	2.19	0	Donated
5	Play Dough	Dollar Tree	N/A	1	5	5.5	5.5	
6	Surgical Tubing	AMI Ventures	5161201	11.24	1	11.24	0	Donated
7	Solution	N/A	N/A	100	1	100	100	
						Tot Est.\$	5149.6	105.5
								Tot Act. \$

# Appendix E - Schedule

PROJECT TITLE: DIVERTING DECISION				Note: June x Presentation											
Principal Investigator: SADIE MENSING				Note: June y-z Spr Finals											
TASK ID	Description	Duration Est. (hrs)	Actual % Comp. (hrs)	October	November	Dec	January	February	March	April	May	June			
1	<b>Proposal*</b>														
1a	Outline	0.5	0.5	100											
1b	Intro	1	3	100	X										
1c	Green Sheets	12	20	100	X	X	X	X	X	X					
1d	Drawings	10	8	100		X	X	X	X	X					
1e	Analysis	4	4	100		X	X	X	X	X					
1f	Methods	2	3	100		X	X	X	X	X					
1g	Parts and Budget	8	6	100		X	X	X	X	X					
1h	JHA	1	0.5	100		X	X								
1i	Schedule	3	2	100		X	X	X	X						
1j	Test Methods	2	2	100		X	X	X	X						
1k	Discussion & Conclusion	1	0	100		X	X	X							
1l	Summary & Appx	1	0	100		X	X								
	subtotal:	45.5	49	100											
1c	Website	4	22	100	X	X	X	X	X	X	X	X	X	X	X
2	<b>Analyses</b>														
2a	Kinetic Energy	0.5	0.25	100	X										
2b	Inertia for Spinning	0.5	3	100	X	X	X	X	X	X					
2c	Rotational Moment for Spinning	0.5	3	100	X	X	X	X	X	X					
2d	Force that causes Spinning	0.5	3	100	X	X	X	X	X	X					
2e	Inertia for Tumbling	0.5	0.5	100		X									
2f	Rotational Moment for Tumbling	0.25	0.25	100		X									
2g	Force that causes Tumbling	0.25	0.25	100		X									
2h	Velocity after Collision	0.5	0.5	100		X	X								
	Angle of Velocity Vector after					X	X								
2i	Collision	0.5	0.5	100		X	X								
2j	Force on Individual Roller	0.5	0.5	100		X									
2k	Launching Force	0.5	0.5	100		X	X								
	Contact Angle that causes					X	X								
2l	Spinning	1	1	100		X	X								
	subtotal:	6	13.3	100											
3	<b>Documentation</b>														
3a	Part 1 Roller	1	1	100	X	X									
3b	Part 2 Tapered Roller	1	1	100	X	X									
3c	Subassembly of Problem	1	1.5	100		X									
3d	Part 3 Launching Surface	1	2	100		X	X								
3e	Part 4 Stability boards	0.5	0.5	100		X	X								
3f	Subassembly Launcher	0.5	0.5	100		X									
3g	Assembly of Launcher	2	1.5	100			X								
3h	Conclusion	6	4	100			X	X	X	X					
3i	ANSI Y14.5 Compl	10	6	100	X	X	X	X	X	X					
3j	Drawing Tree	6	3	100		X	X								
	subtotal:	29	21	100											
4	<b>Proposal Mods</b>														
4a	Project Diverting Schedule	3	0	0			X	X	X						
4b	Project Diverting Part Inv.	2	0	0			X	X							
4c	Crit Des Review*	3	0	0			X	X							
	subtotal:	8	0	0											
5	<b>Part Construction</b>														
5a	Receive 9570 unit	3	12	100		X	X	X	X						
5b	Build Supports	2	0	100		X	X	X	X						
5c	Different size Boxes	0.5	0.5	100		X									
5d	Make Launching Surface	1	3	100		X	X								
5e	Make Stability Boards	0.5	1.5	100		X	X								
5f	Make Attacher	0.25	2	100		X	X	X							
5g	Buy Screw Eyes	0.25	0.25	100		X									
5h	Buy Surgical Tubing	0.25	0.25	100		X									
5i	Draw Conclusion	10	4	100		X	X	X	X	X					
5j	Manufacture Plan*	5	0.5	100		X									
	subtotal:	22.75	24	100											
6	<b>Device Construct</b>														
6a	Assemble 9570 Unit	2	11	100		X	X	X	X						
6b	Assemble Launcher	2	3	100		X	X								
6c	Assemble Solution 1	5	0	0		X	X	X	X	X					
6d	Assemble Solution 2 (if needed)	5	0	0		X	X	X	X	X					
6e	Take Dev Pictures	1	1	100		X	X	X	X	X					
6f	Update Website	2	6	100		X	X								
	subtotal:	17	21	66.6667											
7	<b>Device Evaluation</b>														
7a	Initial testing for 9570	10	14	100		X	X	X	X	X	X				
7b	Testing the Launcher	2	5	100		X	X	X	X	X					
7c	Analyze Testing Results	6	14	100		X	X	X	X	X	X				
7d	List Parameters	2	1	100		X									
7e	Design Test & Scope	3	4	100		X	X								
7f	Obtain resources	6	1	100		X									
7g	Make test sheets	2	2	100		X									
7h	Plan analyses	5	3	100		X									
7i	Instrument 9570	1	2	100		X									
7j	Test Plan*	10	2	100		X									
7k	Perform Evaluation	5	4.5	100		X									
7l	Take Testing Pics	1	0.25	100		X									
7m	Update Website	1	10	100		X	X	X	X	X	X				
	subtotal:	36	62.8	100											
8	<b>495 Deliverables</b>														
8a	Get Report Guide	1	1	100						X					
8b	Make Rep Outline	3	2	100						X					
8c	Write Report	12	14	100						X	X	X	X		
8d	Make Slide Outline	3	2	100						X					
8e	Create Presentation	12	4	100						X	X	X	X		
8f	Make CD Deliv. List	2	0	0						X					
8g	Write 495 CD parts	2	0	0						X					
8h	Update Website	1	2	100						X					
8i	Project Flashdrive	4	2	100						X					
	subtotal:	40	27	77.7778											

## Appendix F- Expertise and Resources

### 1. Resources

Central Washington University MET Professors

Sadegh, Ali M., and William M. Worek. *Marks Standard Handbook for Mechanical Engineers*. McGraw Hill Education, 2018.

Parts

<https://www.woodcraft.com/products/wooddriver-low-silhouette-toggle-clamp-6-x-1-3-4-200-lb-capacity?via=573621f469702d06760016cd%2C576328a869702d20ec000b2f>

[https://www.grainger.com/product/36LM52?gclid=CjwKCAiAlajvBRB\\_EiwA4vAqiC5Cu\\_tVQ\\_LyfRfx0pKaqYIUdvL2Oyd7G8y7ZXbEBv4jt7Ms3plGahoCAXIQAvD\\_BwE&cm\\_mmc=PPC:+Google+PLA&ef\\_id=CjwKCAiAlajvBRB\\_EiwA4vAqiC5Cu\\_tVQ\\_LyfRfx0pKaqYIUdvL2Oyd7G8y7ZXbEBv4jt7Ms3plGahoCAXIQAvD\\_BwE:G:s&s\\_kwcid=AL!2966!3!281733020621!!!g!400034971163!](https://www.grainger.com/product/36LM52?gclid=CjwKCAiAlajvBRB_EiwA4vAqiC5Cu_tVQ_LyfRfx0pKaqYIUdvL2Oyd7G8y7ZXbEBv4jt7Ms3plGahoCAXIQAvD_BwE&cm_mmc=PPC:+Google+PLA&ef_id=CjwKCAiAlajvBRB_EiwA4vAqiC5Cu_tVQ_LyfRfx0pKaqYIUdvL2Oyd7G8y7ZXbEBv4jt7Ms3plGahoCAXIQAvD_BwE:G:s&s_kwcid=AL!2966!3!281733020621!!!g!400034971163!)

<https://www.grainger.com/product/FABORY-1-4-20-Hex-Nut-22UK70?internalSearchTerm=1%2F4%22-20+Hex+Nut%2C+Plain+Finish%2C+18-8+Stainless+Steel%2C+Right+Hand%2C+ASME+B18.2.2%2C+PK50&suggestConfigId=8&searchBar=true>

[https://www.grainger.com/product/1WBE7?gclid=CjwKCAiAlajvBRB\\_EiwA4vAqiF\\_WHntlv5bv9BAWJ8F9gR7izpuEi8jDP35wYMjj9c559LQwdF80xoCwzcQAvD\\_BwE&cm\\_mmc=PPC:+Google+PLA&ef\\_id=CjwKCAiAlajvBRB\\_EiwA4vAqiF\\_WHntlv5bv9BAWJ8F9gR7izpuEi8jDP35wYMjj9c559LQwdF80xoCwzcQAvD\\_BwE:G:s&s\\_kwcid=AL!2966!3!264955915880!!!g!439223734983!](https://www.grainger.com/product/1WBE7?gclid=CjwKCAiAlajvBRB_EiwA4vAqiF_WHntlv5bv9BAWJ8F9gR7izpuEi8jDP35wYMjj9c559LQwdF80xoCwzcQAvD_BwE&cm_mmc=PPC:+Google+PLA&ef_id=CjwKCAiAlajvBRB_EiwA4vAqiF_WHntlv5bv9BAWJ8F9gR7izpuEi8jDP35wYMjj9c559LQwdF80xoCwzcQAvD_BwE:G:s&s_kwcid=AL!2966!3!264955915880!!!g!439223734983!)

<https://www.grainger.com/product/CALBRITE-1-4-20-36LM52?searchBar=true&searchQuery=36lm52>

<https://www.walmart.com/reviews/seller/916?offerId=71EA54E912214DB4AF514ADD8A97ACB5>

## Appendix G- Testing Report

### Test Procedure:

#### Summary/overview

This procedure is put in place to test the requirement that the boxes must maintain a minimum speed of 3 m/s while keeping orientation on the 9570 unit. This procedure will involve video recording to get qualitative and quantitative results from. The video camera needs to be set up in order to have the full conveyor in view. Starting from the launcher end, marks will be made on the edge of the conveyor every 0.5 m. Once the testing has begun, the box will be pulled back onto the launcher at different distances to launch the box at different velocities. At each 0.5 m increment the velocity of the box will be calculated from watching the recording and seeing the time it took the box to travel that distance. The videos will also be used to describe the behavior of the box between each 0.5 m increment. See Appendix for how to describe the boxes behavior.

The testing will be completed on 4/20/20 will take 3 hours to complete. This will take place at the Hougue Technology building in the Fluke Lab. Required resources include the 9570 unit, the launcher, the small box, video camera (webcam on tripod), ruler/meter stick, marker, and a laptop.



#### Step by Step Instructions

1. Read and sign the Standard Operating Procedure (SOP) posted around the 9570 unit for proper safety while using machine. SOP includes start up and take down instructions as well (see appendix).
2. Use the meter stick and marker to mark every 0.5 m on the conveyor starting from the launcher end. Make sure the marks are noticeable enough to be seen in the videos
3. Plug the webcam into the laptop in order to see it's view, then position the webcam to include the whole conveyor in it's view. (With the previously made marks visible)
4. Ensure the small box is on the launcher and ready for testing.
5. Refer to the SOP for proper start up procedure and complete it.
6. Once the 9570 unit has warmed up, start the video camera and begin testing
  - a. Indicated to the camera, rather it be visually or verbally, what distance the box is being launched at. The testing starts at 2 in and goes up to 6 in.
  - b. The small box is placed in between the two angled boards on the launcher. With the surgical tubing wrapped around the back of the box (aka the side farthest from the 9570



- unit) the front of the box will be pulled back to the 2 in mark indicated on the launcher between the two boards.
- c. Release the box from the desired distance and observe the box as the box travels down the conveyor and then return the box to the launcher.
  - d. Launch the box at least two more times (at least three times total) from the same 2 in mark on launcher.
  - e. Stop the video camera.
7. Repeat all steps for Step 6 at the launching distance 3 in, 4 in, 5 in, and 6 in.
  8. Refer to SOP for proper shutdown procedure of the 9570 unit.

### Risk/Safety

Risk of safety while working with the 9750 include items or personal being sucked in between the rollers or the belt so it is important that all long hair must be pulled back and there is no loose clothing or jewelry near the unit. Closed toed footwear and safety glasses must be worn as PPE. It is important that the conveyor is clear of all objects before powering on and no one can go under the conveyor while the conveyor is running. While completing the testing it is important to be cautious of pinch points and flying objects. Anyone assisting in catching boxes must stand behind the blue line at the end of the conveyor.

### Discussion

Due to COVID-19 this testing cannot be completed by the lead engineer on this project because the pandemic has restricted travel and accessibility. More discussion to come after testing.

## Standard Operating Procedures

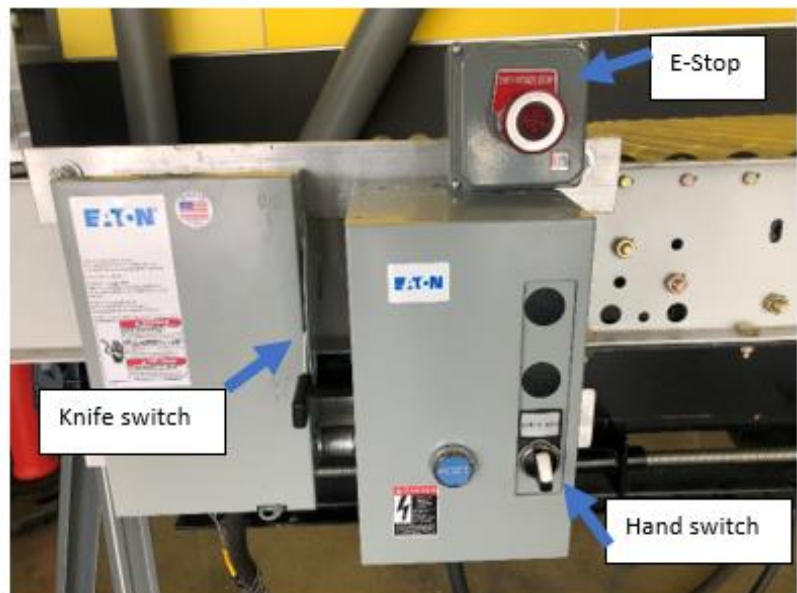
### General Safety

1. All long hair must be pulled back
2. No loose clothing or jewelry, closed toed footwear
3. No one will go under the conveyor while it is running
4. Conveyor is clear of objects before powering on
5. Be cautious of pinch points and flying objects
6. Anyone assisting in catching boxes must stand behind the blue line at the end of the conveyor while the unit is running

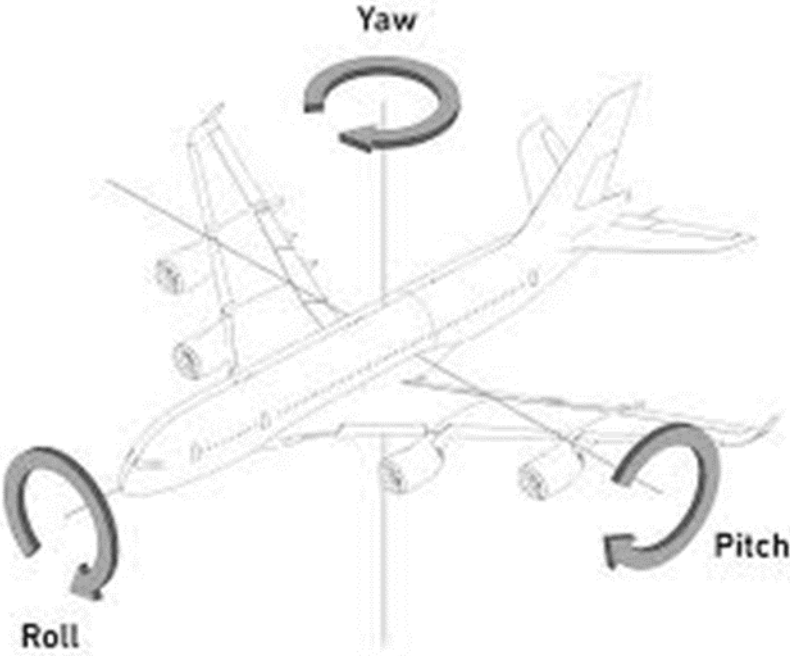
### SOP

1. Plug the conveyor into power
2. Unlock the knife switch
3. Ensure the emergency power button is pulled out
4. Switch the knife switch to "On."
5. Turn the switch to "HAND" to run the conveyor
6. Turn the switch back to "O" to turn off the conveyor.
7. Flip the knife switch back to "Off" to power down and lock the switch in place
8. Unplug the conveyor to complete the shutdown

\*\*In case of emergency push the red emergency button to immediately stop the conveyor\*\*



Describe Boxes Behavior



## Appendix H- Resume

# SADIE MENSING

2210 N Clearview Drive, Ellensburg, WA 98926

(425) 446-2676 | [sadiemensing@gmail.com](mailto:sadiemensing@gmail.com)

## EDUCATION:

**Bachelor of Science in Mechanical Engineer Technology** anticipated June 2020  
Central Washington University, Ellensburg, WA  
GPA: 3.77

## Leadership/Achievements/Activities

Dean's List	2015-Current
CWU Women's Basketball Team Captain	2018-2019
Academic All-Conference Team	2016-2019
Student Athlete-Advisory Committee	2015-2019
Hall of Fame Endowment Recipient	2017-2018

## Relevant Coursework

SolidWorks, Engin Proj Cost Analysis, Statics, Thermodynamics, Strength of Materials, Fluid Dynamics, Dynamics

## SKILLS:

Computer: SolidWorks, Word, Excel, PowerPoint

## EXPERIENCE:

**Solution Design Engineer Intern, Dematic** June -Sept. 2019

- Used software to provide a design and price for customers based off Requests for Proposals
- Assisted head engineers on their projects
- Lead my own project for a traditional non-sort distribution factory

**Beverage Cart and Pro Shop Employee, Sun Country Golf Course** June 2018 -May. 2019

- Assisted customers by answering questions, responding to inquiries and handling telephone requests.
- Resolved guest complaints quickly and efficiently.
- Trusted to open and close the Pro Shop daily
- Handled money, balanced tills, processed credit card payment batches and prepared bank deposits, maintaining efficient accuracy.

**Events Staff, Swift Water Cellars** May – Sept. 2017

- Set up event facilities and equipment, cleaned areas and organized supplies.
- Performed post-event tasks such as breaking down areas, removing trash and cleaning facilities.
- Provided exceptional customer service to all guests and escalated concerns where needed.

## VOLUNTEER EXPERIENCE:

**Mid-Columbia Fisheries, Ellensburg, WA** Oct. 2018

- Installed over 300 plants

**Mt. Stuart Elementary, Ellensburg, WA** 2016-2018








- Assisted in different events including silent auctions and played with children at recess. |

## Appendix J – Hazard Analysis

### **JOB HAZARD ANALYSIS** **Assembling and Running the 9570 unit**

Prepared by: Sadie Mensing	Reviewed by:  Approved by:
-------------------------------	----------------------------------

Location of Task:	Fluke Lab/TBD
Required Equipment / Training for Task:	
Reference Materials as appropriate:	Dematic Installation Manual

<b>Personal Protective Equipment (PPE) Required</b>						
<small>(Check the box for required PPE and list any additional/specific PPE to be used in "Controls" section)</small>						
						
Gloves	Dust Mask	Eye Protection	Welding Mask	Appropriate Footwear	Hearing Protection	Protective Clothing
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.						

PICTURES (if applicable)	TASK DESCRIPTION	HAZARDS	CONTROLS
	Installing the Conveyor	Crushing fingers while mounting pieces or pushing the parts together	Be aware of the hazard and practice with care
	Preparing for operation near drive station, belts, and pulleys	Parts of the body, hair and clothes being drawn-in between the equipment	Only wear closely fitted clothing, no jewelry, pull back hair. Attach protective plates after installation over the exposed drive station.
	Working near the rollers/ conveyor while they are running	Shearing of fingers/hands between unit load and carrier rollers	Only persons who have been instructed on this unit may work on or near conveyor. Wear closely fitted clothes.
	Contact with moving power transmission belt	Could result in minor friction burn	Avoid contacting the power transmission belt during operation.








	<b>Running the conveyor</b>	<b>Conveyor is really loud and exposure to elevated sounds can damage hearing</b>	<b>Equipment operating environment should be reviewed, and hearing protection provided if needed</b>
	<b>Connecting power</b>	<b>Danger of electric shock</b>	<b>Verify proper electrical grounding.</b>
	<b>Lifting heavy objects</b>	<b>Back and/or foot injury</b>	<b>Bend knees and lift with legs. Use others for help. Make sure your grip is secure before moving the object. Make sure there is a clear path the final destination.</b>

## JOB HAZARD ANALYSIS

### Operating the Band Saw

Prepared by: Sadie Mensing	Reviewed by:  Approved by:
-------------------------------	----------------------------------

Location of Task:	Woodshop
Required Equipment / Training for Task:	Proper operation of Band saw
Reference Materials as appropriate:	JHA Berkeley

Personal Protective Equipment (PPE) Required						
(Check the box for required PPE and list any additional/specific PPE to be used in "Controls" section)						
						
Gloves	Dust Mask	Eye Protection	Welding Mask	Appropriate Footwear	Hearing Protection	Protective Clothing
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.						

PICTURES (if applicable)	TASK DESCRIPTION	HAZARDS	CONTROLS
	Align materials flat on table.	Pinching fingers or hands	Keep fingers and hands away from pinch points.
	Start blower and saw	Cutting fingers and hands	Keep fingers and hands away from blade. Use push bar for smaller materials
		Injuries from flying sawdust	Wear safety glasses or face shield.










## JOB HAZARD ANALYSIS

### Operating the Drill Press

Prepared by: Sadie Mensing	Reviewed by:  Approved by:
-------------------------------	----------------------------------

Location of Task:	Woodshop and Machine Shop
Required Equipment / Training for Task:	Proper operation of Drill Press
Reference Materials as appropriate:	JHA Berkeley

Personal Protective Equipment (PPE) Required						
(Check the box for required PPE and list any additional/specific PPE to be used in "Controls" section)						
						
Gloves	Dust Mask	Eye Protection	Welding Mask	Appropriate Footwear	Hearing Protection	Protective Clothing
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.						

PICTURES (if applicable)	TASK DESCRIPTION	HAZARDS	CONTROLS
	Load the vise	Finger pinching while sliding the vise	Do not let your fingers get in between vise and keep eyes on task
	Lock the table in place	Back Strain	Don't lean over the table
	Load the bit	Hand injury	Do not hold the end of the bit.
	Feed the drill with the feed	Injury cause by breaking the bit	Feed with the appropriate pressure. Use the appropriate bit for the material. Wear eye protection.
	Clean the table	Eye injury from debris	Wear eye protection and do not use compressed air.

