The 11th Man: An Automated Softball Practice Machine

by

ERIC HUHN II

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Signature of Author ______________________
Mechanical Engineering Technology

Certified by ______________________
Muthar Al-Ubaidi, PhD,
Thesis Advisor

Accepted by ______________________
Dr. Muthar Al-Ubaidi, Department Head
Mechanical Engineering Technology

Abstract

While practice machines have come a long way, the market still offers nothing that will allow an individual player to sharpen their defensive skills. The 11th Man is the first product to offer fully automated motion, gravity fed helical hopper, variable speed release mechanism, and a flexible directional chute. These features allow for full range defensive practice from popup to grounder and first to third base.

A survey was conducted to determine whether this application would be accepted by sports enthusiasts. Both current and retired players were surveyed. The survey supplied information used to create the house of quality. Results determined that the motion and the automatic feeder were the most important customer requirements.

This report covers in depth survey results, research, design, build and testing. Testing of the 11th Man met all the customer requirements. The motion was linkage driven, therefore eliminating costly electrical components, and making it more robust. A helical hopper was designed to insure no jamming while in operation.

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Introduction

Problem Statement

Softball enthusiasts have no way to go out to the field and practice defensively by themselves. No machines on the market today can automatically throw softballs to different positions on the field. Machines can throw pop flies, grounders, and pitch. However, you need a minimum of two people in order to practice. These machines are not designed to throw a softball into the outfield or move by themselves. Buying a machine on the market requires a person to manually feed the balls into the machine. The person loading the balls would also have to reposition the machine manually for defensive practice. Therefore, it would not be cost effective to buy a machine and try to use it for defensive practice. The Machine is easily replaced by a friend hitting the balls to you.

Scope of Product

The 11th Man is designed to be the extra player needed to practice by yourself or as a team. It can represent a batter at home plate, or a pitcher on the mound. The design also gives the user continuous practice. Two significant problems need to be solved to make The 11th Man possible. The first problem was making a machine that has the ability to hit balls in a range from foul line to foul line, and pop-fly to grounder. The second problem was to determine how to feed balls automatically. Ball feeding was a challenge since balls had to feed a moving machine. Ball feeding had to be variable since the release time between hitting and fielding is different.

The 11th Man's success is dependent on several variables. The 11th Man must be able to throw a ball into the out field. Its motion must cover foul line to foul line, and pop-up to grounder. The ball feeder must have a minimum capacity of 30 balls to insure continuous practice. The 11th Man must be able to run off standard 110v AC power, and be guarded for safety.

Customer Perspective of the Problem

The 11th Man can be a great addition for a high school or college softball team. It allows the team to have the variety of practice that represents real game situations. This practice removes the coach from behind the plate and puts the coach in the field with the players. This type of coaching should allow for better development of the player. The 11th man also increases the amount of hit balls to each player. During a typical 1 hour practice players would probably get 20-30 balls hit to him/her in the field. The 11th Man can deliver 10 times that amount.

There are approximately 687 high schools in Ohio[4] and 17175 High schools in the United States [1] .On the college level there are 907 [5] women's softball teams and 864 men's baseball teams in the United States. There are also 30 [6] professional baseball teams and 161 minor league teams. These are all potential users of The 11th Man and this roughly equals 36,216. These numbers do not include the number of organized softball teams both men and women that play throughout the summer.

A spreadsheet (Figure A 1-Competitor Comparison) shows all of the available machines on the market. Seen in Figure A 1-Competitor Comparison there are a total of 11 [2, 3, 7, 8, 9] machines that are closely related to The 11th Man. Jugs and ATEC are the only two manufactures of these machines on the market.

The 11th Man has two major components, the automatic motion and the ball feeding mechanism. When assembled The 11th Man is mounted to a frame and pulled by hand or with a small vehicle. The overall footprint is roughly 4'W x 6'L x 7'H, my portion of this project consisted of a footprint of 2'W x 4'L x 7'H which is mounted to the frame, and Tim's portion consists of a footprint of 4'W x 6'L x 2'H.

The 11th Man is a fully working prototype machine. Meaning all of the desired motions, pitching, infield, outfield, whole team, and single position practice situations. The 11th Man can not throw trick pitches. Meaning it will not throw a curve ball, knuckle, slider, or sinker. The reason is due to the single wheel design, it takes two wheels to throw the trick pitches.

Customer Needs & Prototype Objectives

Customer Needs

In order to validate the need for the 11^{th} Man, a survey of ball players was conducted. The primary objective of the survey was to determine what features players would like to see in a practice machine.

The results from the survey indicated several things. First, the majority of players responded that the motion both horizontal and vertical were the most important features. Secondly, the ability to control the speed of the thrower to vary ball speeds for different skill levels and practice situations. Lastly, the ball feeder was important to allow for continuous practice. Survey results can be seen in appendix B.

Prototype Objectives

The purpose of building a fully functional prototype is to determine whether the objectives can be met. The objective for my portion of the project is the feeder. The feeder needs to be capable of delivering a continuous flow of balls to the thrower. This feeder also needs to be adaptive for the time change needed to convert from pitching practice to outfield practice. The prototype must also be designed for hours and hours of continuous practice. Due to the continuous nature, a simple yet robust design must be created.

Design Solution

To avoid any confusion, the design was split into two portions. My partner designed the motion and the main frame while the ball feeder and thrower was under my control.

Building a successful prototype starts with a successful design. To determine the design, customer surveys were totaled and placed in to the QFD (Quality Functional Deployment) model. The QFD defines the best solution to a customer need.

Design 1 (as shown in Figure 1-Alt. Design 1) utilizes a flexible hose coiled up inside a hopper. This design will prevent any jamming, but it will reduce the number of balls that can fit into the hopper.

Design 2 (as shown in Figure 2-Alt. Design 2) is a separate unit that works like a chute. This design is the best on weight, but its down sides are the limited amount of balls it can handle, and it needs to be set up separate from the main machine.

Design 3 (as shown in Figure 3-Alt. Design 3) is a basic hopper. While it can hold the greatest amount of balls, there is a high probability that a ball will jam causing not only an inconvenience to the customer, but also a safety issue.

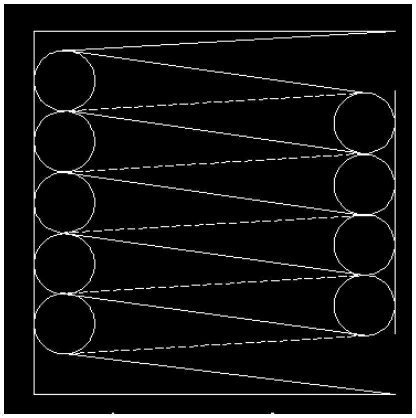
Figure 1-Alt. Design 1

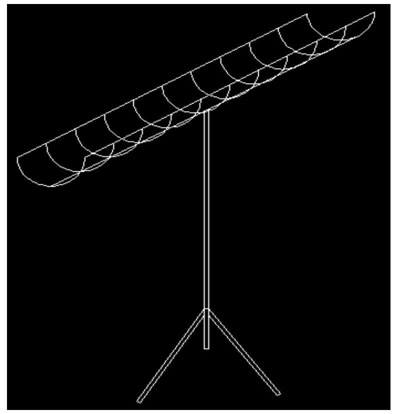
Figure 2-Alt. Design 2

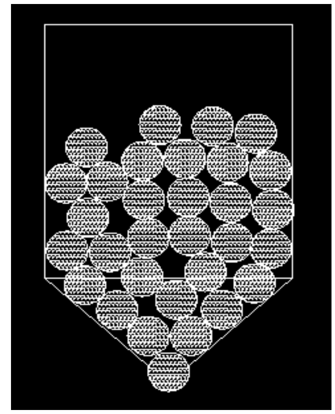
Figure 3-Alt. Design 3

These three designs were used to perform the Weighted Objective Method. The Weighted Objective Method determined that design 1 was the best design for the application.

To insure design 1 would meet the requirements of the customer and the environment a pre-prototype was developed. The pre-prototype was a cardboard box with a hose coiled inside it. This simulated the basic hopper, and a test was performed to see if balls would feed without jamming. The testing was a success. This pre-prototyping was the best way to determine how the feeder was going to be designed and built. It was an inexpensive means to a solution that would be robust.

After pre-prototyping, the design concept was transferred into SolidEdge version 14. SolidEdge is a solid modeling package, and was chosen because of the animation package available to the students. Once the design was modeled, calculations were performed to determine factor of safeties on each critical component. These calculations can be seen in Appendix C.

Prototype Fabrication

Material & Component Availability

The intent while building the 11th Man was to use low cost materials and components that were readily available or obtainable within 5 working days. Since this project was self-funded and a prototype, this philosophy yielded desirable results at a low cost. Raw materials required for fabrication of the feeder consisted of standard cold rolled steel. The framework and support system were also built using cold rolled steel. The steel was purchased from a scrap yard. Specialty items needed to construct the feeder and thrower were bearings, 2 DC motors, 2 bridge rectifiers, and 2 variable speed drives. The motors, rectifiers, and variable speed drives were located at Mendelson's Liquidation Outlet. The rest of the components were ordered from McMaster-Carr.

Assembly

Assembly methods to build The 11th Man consisted of basic welding, drilling and a few machining of slots or grooves. Assembly Tolerances were plus or minus ¼ inch, except for the thrower wheel. The thrower wheel assembly had to be balanced in order to keep vibration to a minimum. Also the tolerances had to be plus or minus 0.005 inches, to keep the shaft, bearings, and supporting steel in line.

The shaft assembly for the pitching wheel consisted of a shaft and a hub. These two components had to be welded together and then balanced on a lathe. The reason for balancing was no matter how accurately the shaft was welded to the hub it would never run perfectly true and straight. Therefore, chucking the assembly up on the shaft diameter and turning the face and OD of the hub forced the assembly to be balanced to the shaft, ensuring minimal vibration. Once the shaft assembly was completed it then had to be installed on to the framework through the bearings. The bearings had to be installed parallel to the motor to insure proper alignment. The bearings selected allowed enough movement to align the shaft to the motor and then be properly secured.

To insure proper feeding of the balls it was determined that the angle of the hose was critical. To accomplish this four 5/8 inch threaded rod were attached the ball feeder frame. Each rod was positioned at a quadrant point on the coil. Then a thin hard board floor was cut out and positioned in the helical angle desired to support the hose. On each of the threaded rods a support bracket was sandwiched between two 5/8-inch bolts. This support bracket style allowed for easy assembly that could be adjusted. The reason for using the threaded rod was to allow adjustments after assembly. The adjustments are necessary due to the ridges in the hose that could not be accounted for during design. The ridges in the hose had a tendency to stop the balls after they had been stacked up in the hopper. Additional angle in the hopper resolved the problem, but trial and error was necessary.

Testing

The 11^{th} Man was tested for distance, reliability, and safety. To test for distance the 11^{th} Man was setup in defensive mode at the maximum trajectory position. In this position it fired 30 balls into the outfield. Each one of these balls was in a range of 250 to 275 feet. This met the design criteria for the product. The test for reliability was to load the hopper with 30 balls and insure there were no jams. This test was conducted 5 times and there was not a jamming issue during these tests.

Also for safety considerations The 11th Man is wrapped in a Mesh guarding to keep users from getting in the machine on accident and also to protect it from any ball being hit at it during batting practice. Also for safety there is a remote control added to allow the user to get into position before the machine begins to throw balls. The remote allows the user to turn off the ball feeder motor while in the field. There is a light attached to this for visual verification. The 11th Man was built as a fully functional full-size working prototype to perform the above testing procedures.

Conclusion

Throughout the design, build and testing of The 11th Man the concept was always thought to be innovative and leading edge technology. The 11th Man did not disappoint in any regards. The testing was 100% successful. All the objectives to throw the ball anywhere and be able to practice with it were successful. The 11th Man provides a complete work out for softball enthusiasts. The machine can pitch, throw grounder anywhere in the infield, and throw balls into the out field in any region. Basically The 11th Man is the ultimate hitter for defensive practice. It is also the ultimate pitcher, it has the variability of a good pitcher. With these feature the users' skills can be honed and formed by The 11th Man.

Recommendations

The 11th Man was a prototype, therefore as always changes can be made to make it better. One thing that should be changed immediately would be the motor for the release mechanism. The motor that was use lacks the optimum torque required to easily advance balls when the time interval is dropped below 15 seconds. The motor exists but not purchased due to budget constraints. Other things that could be changed would be the frame and the wiring. The frame could be made out of aluminum rather than steel, this would make the entire assembly lighter and easier to move. The wiring could be incorporated into a single electrical box rather that 2.

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Appendices

Appendix A – General References

Figure A 1-Competitor Comparison

Manufacture	Model	Automatic Motion	Variable Speed	Cost	Weight	HP	Balls Type	Transport Wheels	Pop Flies	Grounders	Feeder Included	Feeder Compatible	Vertical Pivot	Horizontal Motion	# Of Wheels
ATEC	Hitting Streak	No	No	$399.99	27	1/4	foam only	No	Yes	Yes	No	No	Yes	Yes	1
Jugs	Toss Machine	No	No	$349.99	13	0	Any	No	No	No	No	No	No	No	0
Jugs	Super Softball	No	Yes	$1,899.99	75	1/4	Any Softball	No	Yes	Yes	No	Yes	Yes	Yes	1
Jugs	Combo Baseball/Softball	No	Yes	$2,499.99	145	1/4	Any	No	Yes	Yes	No	Yes	Yes	Yes	2
ATEC	Casey Pro	No	Yes	$2,199.99	105	1/4	Any Softball	No	Yes	Yes	No	Yes	Yes	Yes	2
ATEC	Casey	No	Yes	$1,999.99	115	1/4	Any Softball	No	Yes	Yes	No	Yes	Yes	Yes	2
ATEC	Power Hummer	No	Yes	$1,799.99	115	1/4	Any Softball	No	Yes	Yes	No	No	Yes	Yes	2
ATEC	Axis	No	Yes	$1,599.99	65	1/4	Any Softball	No	Yes	Yes	No	No	Yes	Yes	1
Jugs	Jr Combo Baseball/Softball	No	Yes	$1,399.99	75	1/4	Any	No	Yes	Yes	No	Yes	Yes	Yes	1
ATEC	Rookie	No	Yes	$1,299.99	65	1/4	Any Softball	No	Yes	Yes	No	Yes	Yes	Yes	2
ATEC	Casey Jr	No	Yes	$949.99	50	1/4	Any	No	Yes	Yes	No	Yes	Yes	Yes	1
Senior Design	**Fullout**	**Yes**	**Yes**				**Any**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**1**

Figure A 2-Field Regions

Appendix B – QFD

Baseball/Softball Practice Machine Survey

I am a senior in the Mechanical Engineering program at the University of Cincinnati and I am currently working on my senior design project. The design is for a new practice machine that not only pitches, but gives defensive practice as well. The goal is simulate game time pitches and hits as realistically as possible.

*While ranking this survey 5 is the highest of importance to you

Are you currently an active baseball or softball player?	Yes	No	
Do you or your team currently own a pitching machine?	Yes	No	
If yes:			
Are you happy with it?			1 2 3 4 5
If no:			
Are you interested in purchasing one?			1 2 3 4 5
If you were to purchase a pitching machine would you be interested in it to do more than just pitching?	Yes	No	

Please rate each of the following features

Ability to automatically throw balls randomly to the entire field in order to simulate game time hits during practice	1 2 3 4 5
Ability to automatically throw balls randomly to specific regions of the field (i.e. shortstop, left field, first base, etc.) in order to simulate game time hits during practice	1 2 3 4 5
Ability to automatically vary pitches in order to simulate game time pitching practice	1 2 3 4 5
To have an integrated automatic ball feeder that hold up to 50 balls	1 2 3 4 5
Ability to adjust the time in between throws	1 2 3 4 5
Game time velocities	1 2 3 4 5
Weight	1 2 3 4 5
Size	1 2 3 4 5
Cost	1 2 3 4 5
Reliability	1 2 3 4 5
Maintenance	1 2 3 4 5
Safety	1 2 3 4 5

Any other suggestions:

___

___

___

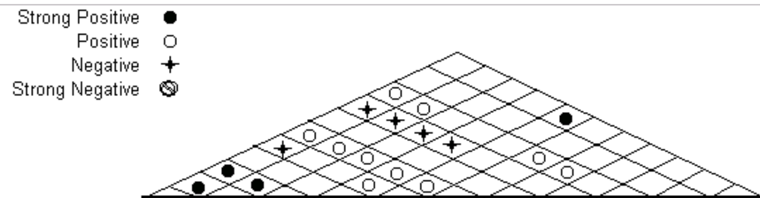
Figure A 3-Customer Needs

	Whats	Hows
1	Pop flies to Ground Balls	Vertical Motion
2	From 1st to 3rd base	Horizontal Motion
3	Pitching to fielding practice	Variable speed Thrower
4	Baseballs to softballs	Adjustable ramp plate
5	Single person operation	Automatic ball feeder
6	Size	Design
7	game time velocities	Strong enough motor
8	Cost	Low Cost Materials
9	Reliablility	Design and component selection
10	Maintenance	Design for assembly
11	Safety	Remote control

Figure A 4-Survey Results

Survey Results													
													Average
1	Currently an active player	0	0	5	0	0	0	0	5	0	5	5	36.36%
2	Own Pitching Machine	0	0	0	0	0	0	0	0	0	0	0	0.00
3	Intrested in Purchasing	3	0	0	5	5	0	0	3	5	5	3	2.64
4	More than just pitching	5	0	0	5	5	0	0	5	5	5	5	3.18
5	Randomly across entire field	5	4	5	5	5	5	4	5	4	4	4	4.55
6	Randomly to specific regions	4	4	5	5	5	5	4	5	4	5	3	4.45
7	Pitch variations	3	5	5	5	4	3	4	5	5	5	5	4.45
8	Automatic ball feeder	5	5	5	5	4	3	4	5	3	3	5	4.27
9	adjust time between throws	4	3	4	5	3	4	4	4	4	3	5	3.91
10	game time velocities	4	5	4	5	5	4	4	4	5	5	5	4.55
11	wieght	3	3	4	5	5	3	3	4	3	1	3	3.36
12	Size	3	3	4	5	5	4	3	3	3	1	3	3.36
13	Cost	5	5	5	5	4	5	4	5	3	5	5	4.64
14	Reliability	5	3	5	5	5	5	4	4	4	4	5	4.45
15	Maintence	5	5	5	5	5	4	4	4	4	3	4	4.36
16	Safety	5	5	5	5	5	5	4	5	5	2	4	4.55

Figure A 5-House of Quality



	Automatic Vertical Motion	Automatic Horizontal Motion	Variable speed Thrower	Adjustable ramp plate	Automatic ball feeder	Design	Strong enough motor	Low Cost Materials	Design and component selection	Design for assembly	Remote control	Customer Importance	Comparison Study	Planned Machine	Improvement Ratio	Sales Points	Improvement Ratio	Relative Weight
Pop flies to Ground Balls	9		3			3						4.5	1	5	5	1.5	33.4	0.17
From 1st to 3rd base		9				3						4.5	1	5	5	1.5	33.4	0.17
Pitching to fielding practice	6	6	9			3						4.3	1	5	5	1.5	32.0	0.17
Baseballs to softballs				9	3	3						3.9	3	5	1.7	1.3	8.5	0.04
Single person operation					9	9						4.5	1	5	5	1.5	34.1	0.18
Size						9						3.4	2	3	1.5	1	5.0	0.03
game time velocities			9				9					3.4	2	5	2.5	1.3	10.9	0.06
Cost								9				4.6	1	2	2	1	9.3	0.05
Reliablility									9			4.5	3	3	1	1	4.5	0.02
Maintenance									9	9		4.4	4	2	0.5	1	2.2	0.01
Safety						9				3	9	4.5	1	3	3	1.3	17.7	0.09
abs. Importance	2.6	2.6	2.5	0.4	1.7	4.4	0.5	0.4	0.3	0.4	0.8	17					191.0	1.0
Reel. Importance	0.15	0.15	0.15	0.02	0.10	0.26	0.03	0.03	0.02	0.02	0.05							
Machine now on Market			2	3	1	3	1	2	1	1	1							
Direction of Movement	+	+	+	S	+	+	+	S	+	+	+							
Target Value	5	5	4	3	2	4	2	2	3	3	4							

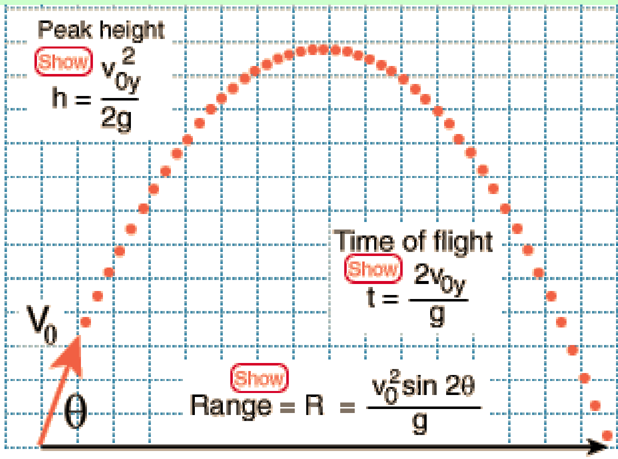
Figure A 6-Weighted Objective

Weighted Objective for Motion

Design Criteria	Weight	Design 1		Design 2		Design 3	
	W*	S	U	S	U	S	U
Automatic Vertical Motion	15	10	1.54	10	1.54	10	1.54
Automatic Horizontal Motion	15	10	1.54	10	1.54	10	1.54
Variable speed Thrower	15	0	0.00	0	0.00	0	0.00
Adjustable ramp plate	2	0	0.00	0	0.00	0	0.00
Automatic ball feeder	10	0	0.00	0	0.00	0	0.00
Design	26	7	1.83	7	1.83	10	2.61
Strong enough motor	3	9	0.27	9	0.27	10	0.30
Low Cost Materials	3	2	0.06	4	0.12	10	0.30
Design and component selection	2	4	0.07	7	0.13	10	0.18
Design for assembly	2	3	0.07	9	0.20	10	0.22
Remote control	5	0	0.00	0	0.00	0	0.00
Overall Utility			5.38		5.62		6.69

Appendix C – Calculations

Item	Calculation				
1	**Wheel Velocity**				
	Maximum Distance	R	298	ft	
	Launch Angle	θ	45	Degrees	
	Gravity	G	32.15	ft/s^2	
	Wheel Diameter	Dw	18	in	
	Wheel Circumference	Cw	56.5487	in	



	Vo = Initial Velocity			
	Vo = ((R*G)/(sin(2θ))^(1/2)			
	Vo =	97.88105	ft/s	Speed at which ball leaves Wheel
	Convert Ft/s to RPM			
	Vo =	1174.5726	in/s	
		20.771004	RPS	
		1246.2602	RPM	

Item	Calculation			
2	**Motor Requirements**			
	RPM	RPM	1246.26	rev/m
	Force to compress wheel .125in	Fc	150	lbf'
	Coef of Friction	u	0.3	

f = u * Fc	= Friction Force		
f=	45	lbf	
Total Force			
Ft = Fc + f			
Ft =	195		

	T = Ft*d	= Torque on the Motor		
	d=	9	inches	
	T=	1755		
	Weight of Wheel	W	30	lbs
	Mass of Wheel	M	0.931677	Slugs
	Energy	E	1755	in-lbs
	Output Velocity	V2	97.88105	in/s
	Assuming Wheel acts as a flywheel and applying the Energy equation			
	E=W(V1^2-V2^2)/2g			
	V1 =	99.471855	in/s	
	Convert Ft/s to RPM			
	Vi =	1193.6623	in/s	
		21.108583	RPS	
		1266.515	RPM	Required Initial RPM
	T = Jo * a	= Torque on the Motor		
	Jo = .5 * Mr^2			
	Jo =	0.262034	slug-ft^2	
	Angular Acceleration = a			
	V1 in Radians =			
	V1rsd = (V1rpm*2*PI())/60			
	V1rad =	132.6291	Rad/s	
	a = (w - wo)/t			
	wo =	0	Rad/s	
	time = t =	60	sec	
	a =	2.210486	Rad/sec^2	
	T =	0.579223	Slug ft^2/sec^2	
	Hp = T * RPM			
	RPM=	1246.26		
	Hp=	0.137		
	Safety Factor=	1.25		
	Hp=	0.172		Minimum Hp needed to throw ball 298ft
3	**Shaft Diameter**			
	Design Factor	N	2	
	Torque of Shaft	T	0.172	in-lbs

	Yield Stress of Material	Sy	71000	psi
	τd = Design Stress			
	τd = Sy/2N			
	τd =	17750.00	psi	
	Zp = Polar Section Modulus			
	Zp = T/τd			
	Zp =	0.00	in^3	
	D = Shaft Diameter			
	D = ((16Zp)/PI)^(1/3)			
	D =	0.04	in	
4	**Key Stress - Key 1 Seat**			
	Diameter of Shaft	D	0.5	in
	Torque of Shaft	T	0.172	in-lbs
	Stress Concentration factor	Kt	2	
	Yield Stress of Material	Sy	71000	psi
	Zp = Polar Section Modulus			
	Zp = (PI*D^3)/16			
	Zp =	0.02	in^3	
	τ nom = Nominal Stress			
	τ nom = T/Zp			
	τ nom =	7.00	psi	
	τ = Stress in key			
	τ = Kt*τ nom			
	τ =	14.00	psi	
	Resultant Safety Factor			
	S = Sy/τ			
	S =	5071.41		
5	**Key Stress - Key 1 Width**			
	Yield Stress of Material	Sy	51000	psi
	Width of Key	W	0.125	in
	Length of Key	L	0.75	in
	Shaft Diameter - Horizontal	D	0.5	in
	Torque of Shaft	T	0.172	in-lbs
	Assumptions from Machinist Handbook			
	τk = Key Stress			
	τk = 2*T/(WLD)			
	τk =	7.33	psi	
	Resultant Safety Factor			
	S = Sy/τk			
	S =	6957.32		

Appendix – D- Statement of Financial Support

In order to build this machine Tim and I have secured $500.00 donation to put towards the materials. Beyond that point Tim and I will fund the project personally. We plan to build the project in Tim's garage where he has various tools to accomplish this. We will out source or locate a machine shop for any components we cannot build in my garage or use the north lab machine shop. All testing will be done at my church, which has a softball field; we will be borrowing a generator from Dion Cullum in order to run the machine in the field. When this project is finished I will maintain possession of the prototype.

Components	Quantity	Cost	Ext cost	Cash donations	Physical Donations	Eric's	Tim's
Gear motor	2	$ 225.00	$ 225.00	1	1 motor already donanted		X
Variable speed motor (1/3 hp)	1	$ 225.00	$ 225.00			X	
Variable speed drive	2	$ 95.00	$ 190.00	1		X	
Variable speed motor (small)	1	$ 70.00	$ 70.00	1		X	
Wheels	2	$ 27.00	$ 54.00				X
Steel tubing	30ft	$1 per ft	$ 30.00				X
Bearings	Unknown	$ 75.00	$ 75.00				X
Pins	8	$ 10.00	$ 10.00				X
1x.25x? (linkage) flat plate	5	$1 per ft	$ 5.00				X
8in dia 1/4 think round plates	2	$ 25.00	$ 50.00				X
Tim's Misc		$ 100.00	$ 100.00				X
Steel Tubing	12ft	$1 per ft	$ 12.00			X	
Flexible tubing	20ft	$5 per ft	$ 100.00			X	
Pillow block bearing	2	$ 15.00	$ 30.00		bearings and shaft donanted	X	
Pulley	2	$ 20.00	$ 40.00			X	
Drive belt	1	$ 10.00	$ 10.00			X	
Pitching Wheel	1	$ 65.00	$ 65.00			X	
Spring	1	$ 1.00	$ 1.00			X	
Pins	1	$ 1.00	$ 1.00			X	
2-13/16" - 3-3/4" Adjustable Hose Clamps	2	$ 1.00	$ 1.00			X	
3" PVC pipe, schedule 40	6in	$ 2.00	$ 2.00			X	
1/4" Plate	3 Square Feet	$ 25.00	$ 25.00			X	
1/8" Plate	3 Square Feet	$ 25.00	$ 25.00			X	
Pipe, 6" OUTSIDE Diameter, 1/4" thick wall	1ft	$ 50.00	$ 50.00			X	
1-1/4" Square Tubing, 1/8" thick	2ft	$ 2.00	$ 2.00			X	
1/2" x 1/2" Angle	6in	$ 2.00	$ 2.00			X	
1-1/2" x 1-1/2" Angle	3-1/4"	$ 2.00	$ 2.00			X	
Eric's Misc		$ 175.00	$ 175.00			X	
Total			**$ 1,577.00**	**$ 500.00**			

Figure A 7-Budget

Task Name	Duration	Start	Finish
Senior Design	**142 days**	**Sat 11/8/03**	**Mon 5/24/04**
Proposal	40 days	Sat 11/8/03	Thu 1/1/04
Tim's Design	**47 days**	**Thu 1/1/04**	**Fri 3/5/04**
Design	28 days	Thu 1/1/04	Mon 2/9/04
Tim's Calculations	11 days	Tue 2/10/04	Tue 2/24/04
Re-designs	9 days	Tue 2/24/04	Fri 3/5/04
Build	**41 days**	**Fri 3/5/04**	**Fri 4/30/04**
Purchase Compon	11 days	Fri 3/5/04	Fri 3/19/04
Fabricate Compon	21 days	Fri 3/5/04	Fri 4/2/04
Assembly	15 days	Mon 4/12/04	Fri 4/30/04
Eric's Design	**47 days**	**Thu 1/1/04**	**Fri 3/5/04**
Design	28 days	Thu 1/1/04	Mon 2/9/04
Eric's Calculations	11 days	Tue 2/10/04	Tue 2/24/04
Re-designs	9 days	Tue 2/24/04	Fri 3/5/04
Build	**41 days**	**Fri 3/5/04**	**Fri 4/30/04**
Purchase Compon	11 days	Fri 3/5/04	Fri 3/19/04
Fabricate Compon	21 days	Fri 3/5/04	Fri 4/2/04
Assembly	15 days	Mon 4/12/04	Fri 4/30/04
Project Assembly	2 days	Fri 4/30/04	Mon 5/3/04
Testing	11 days	Mon 5/3/04	Mon 5/17/04
Tech Expo	1 day	Mon 5/24/04	Mon 5/24/04

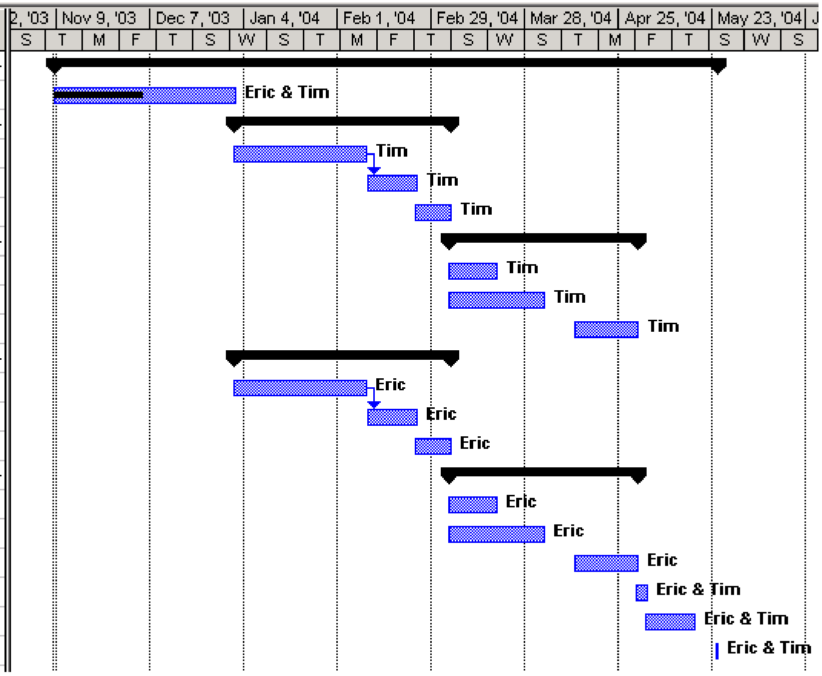


Figure A 8-Schedule

Appendix – E – Proof of Design

Appendix G

Proof of Design

The following has been agreed upon by both parties (E & T Engineering and MET Advisor – Muthar Al-Ubaidi) as critical design objectives to be verified at completion of product.

1. Automatic motion is to cover entire regulation softball field
2. Thrower must be able to throw a ball in to the outfield
3. All pinch points to be protected for safety
4. Will run off standard 110 AC power
5. Automatic feeder will supply at least 30 balls with out failure

E & T Engineering

Eric Huhn

______________________ Date 4/14/04

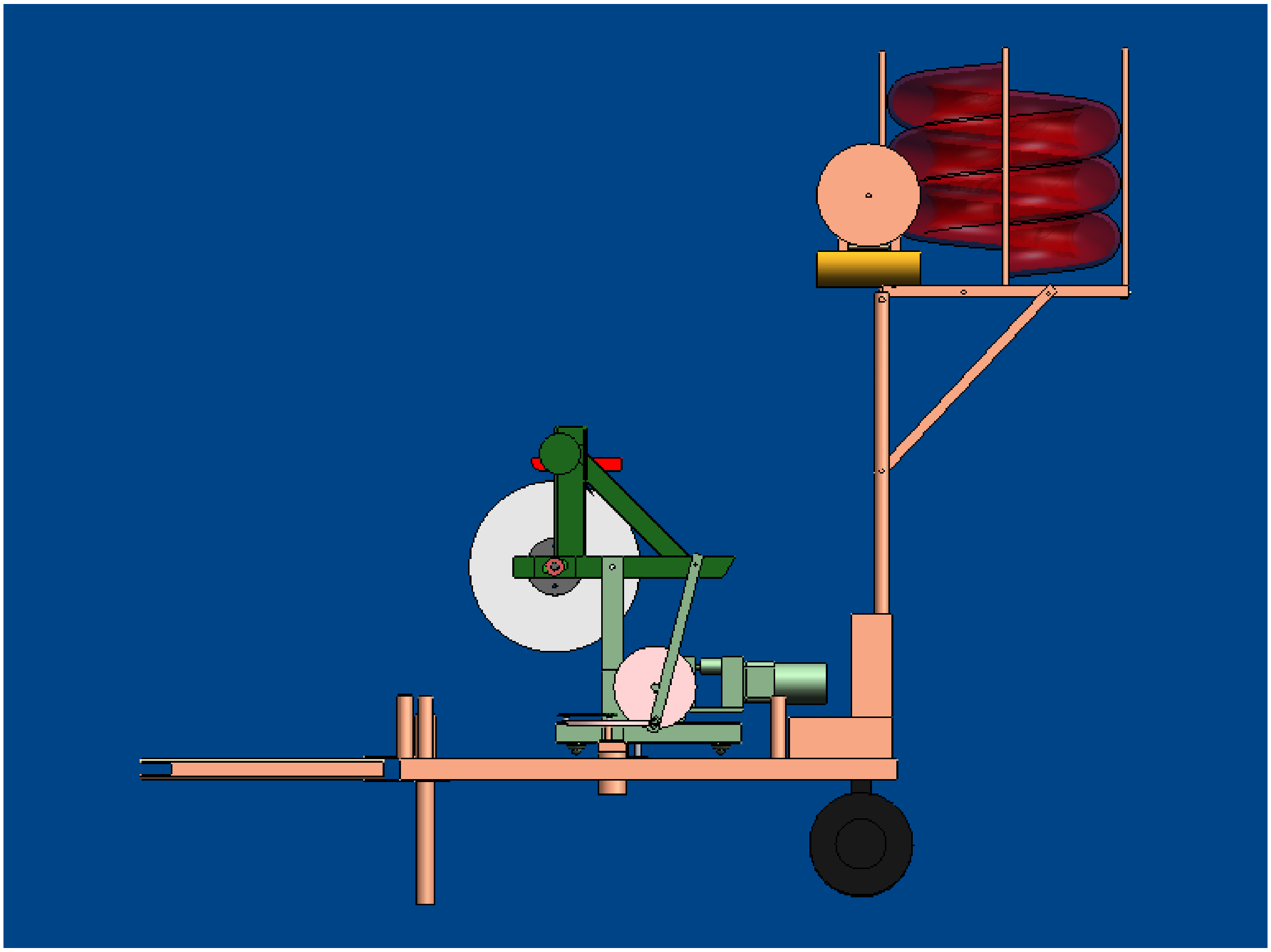
Tim Noel

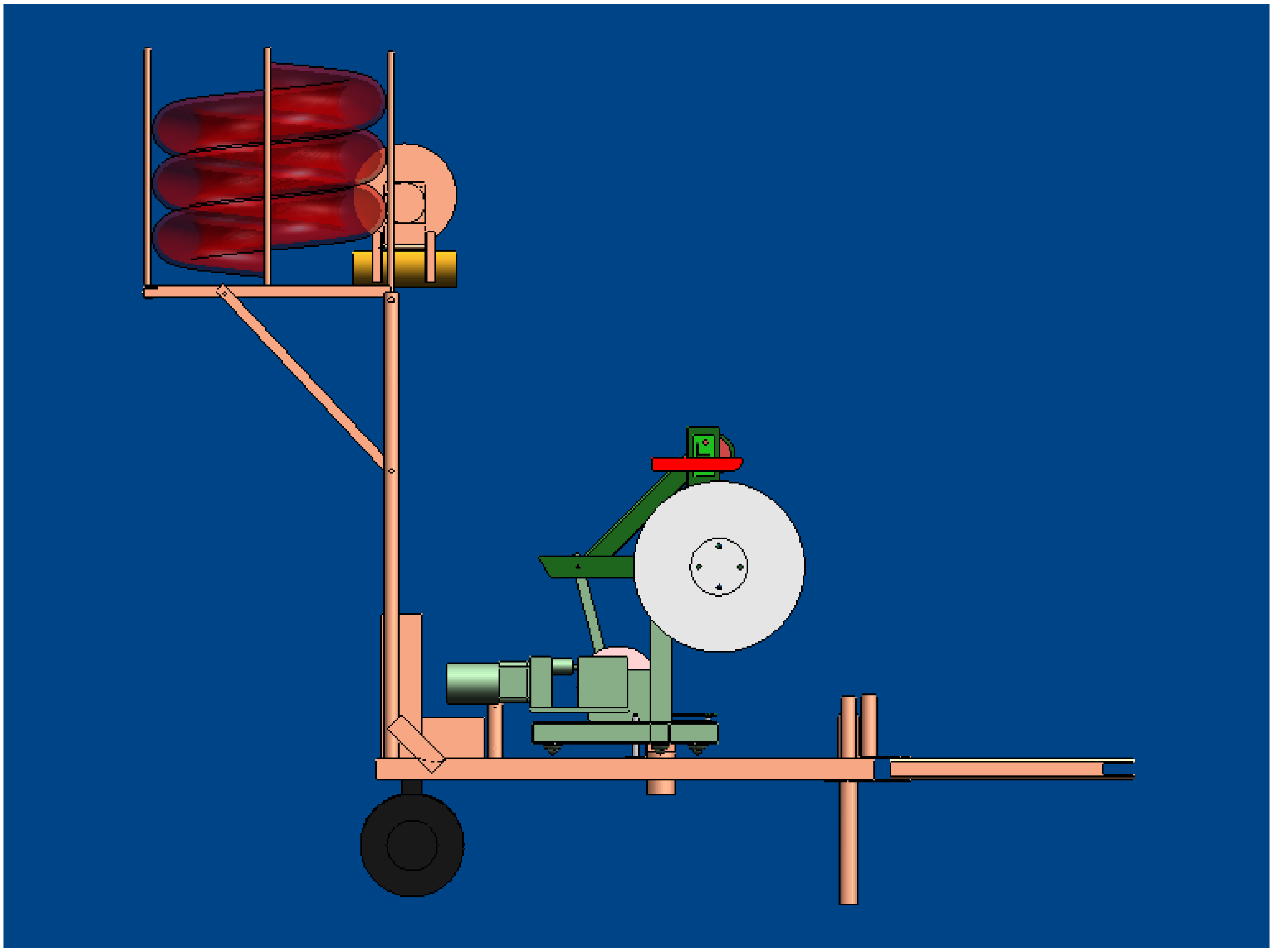
______________________ Date 4/14/04

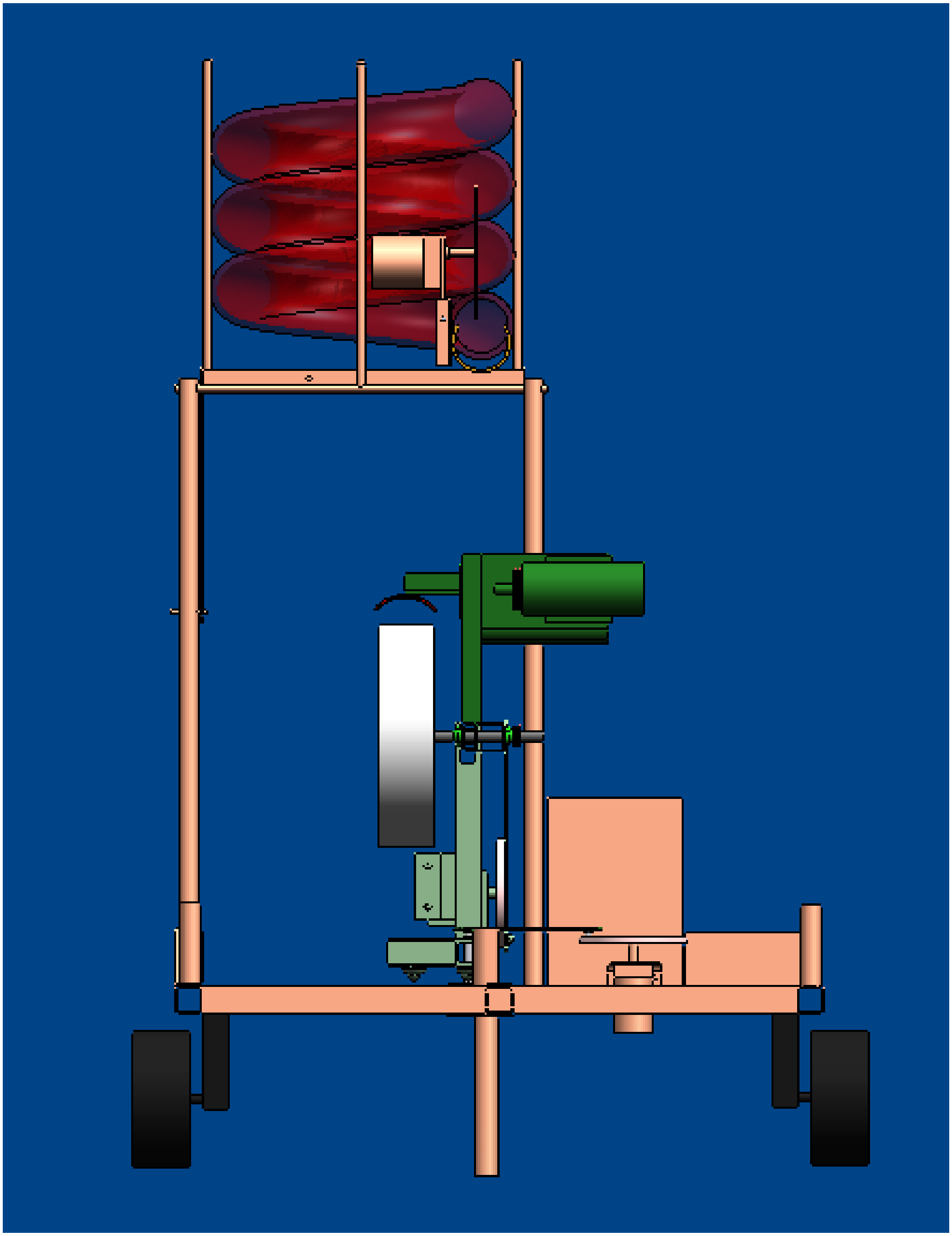
MET Adviser – Muthar Al-Ubaidi

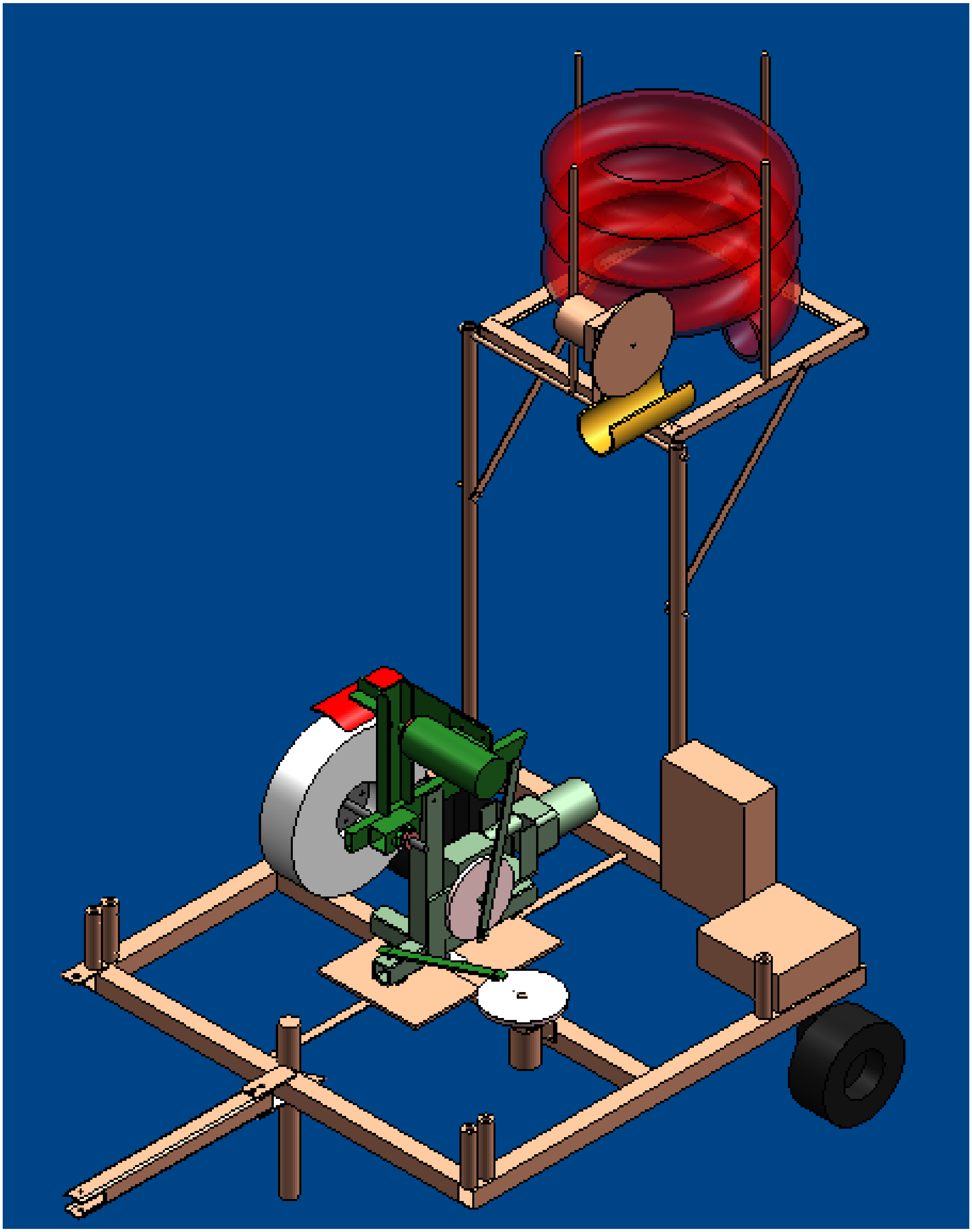
Muthar R Al-Ubaidi ______________________ Date 4/14/04

Appendix – F – Drawings & 3D Models









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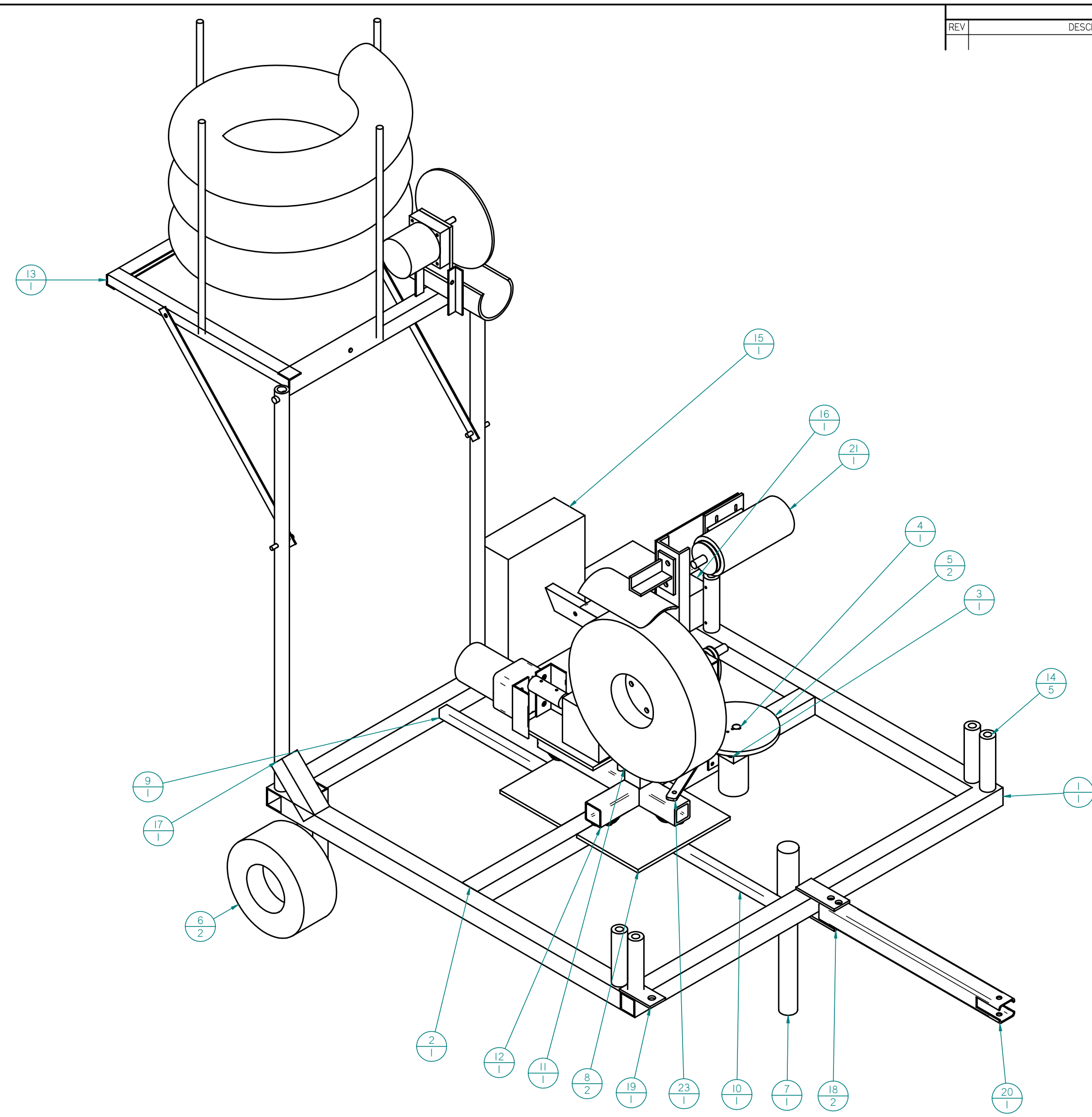
1	PT - 014	Frame	steel	1	Tim Noel
2	F-001	Tube Frame Support	steel	1	Tim Noel
3	H-001	Horizontal Motor Mount	steel	1	Tim Noel
4	H-002	Horizontial Motor	brass	1	Tim Noel
5	H-003	Motion Cam Disk	steel	2	Tim Noel
6	PT - 015	Ground Wheel Support	steel	2	Tim Noel
7	PT - 022	Trailer Jack	steel	1	Tim Noel
8	PT - 021	Hopper Support Plate	steel	2	Eric Huhn
9	H-018	Horizontial Support Angle Back	steel	1	Tim Noel
10	H-005	Horizontial Support Angle Front	steel	1	Tim Noel
11	H-006	Horziontial Pivot Pin	steel	1	Tim Noel
12	H-000	Horziontial Assembly		1	Tim Noel
13	HA-000	Hopper Assy		1	Eric huhn
14	H-014	Guard Support	steel	5	Tim Noel
15	H-017	Electrical Box 1	aluminum	1	Tim Noel
16	H-016	Elecrtical Box 2	aluminum	1	Tim Noel
17	BF-009	Hopper Support Angle	steel	1	Eric Huhn
18	F-011	Hitch Support	steel	2	Tim Noel
19	F-010	Hitch Holder	steel	1	Tim Noel
20	F-012	Hitch	steel	1	Tim Noel
21	V-000	Vertical Assembly		1	Tim Noel
22*	VL-001	Vertical Link Assembly		1	Tim Noel
23	HL-001	Horizontial Link Assembly		1	Tim Noel

REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED



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DRAWN	Tim Noel	05/29/04
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ENG APPR		
MGR APPR		

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SOLID EDGE
EDS-PLM SOLUTIONS

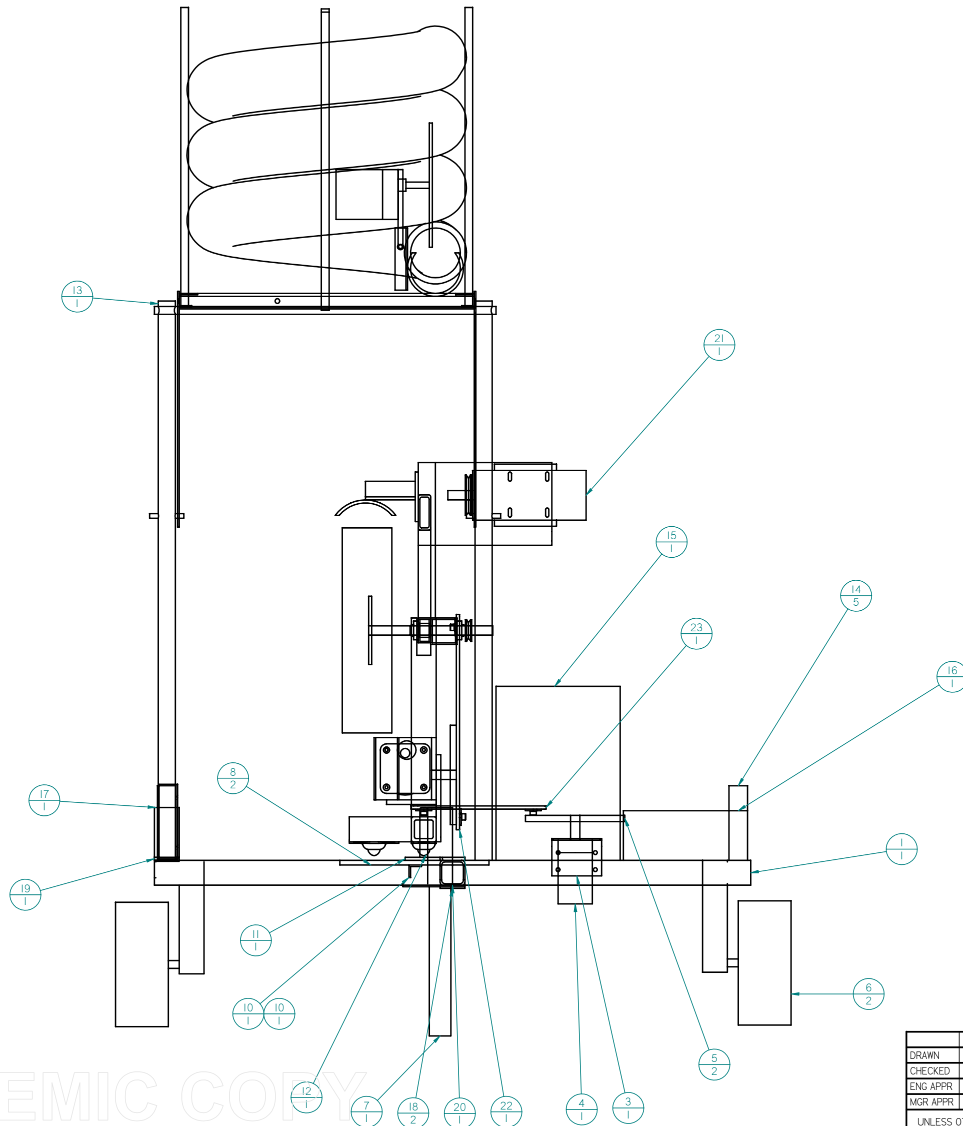
TITLE: The 11th Man

SIZE: D DWG NO: MFA-000 REV: A

FILE NAME: Main-frame-assy.dft

SCALE: WEIGHT: SHEET 1 OF 3

Item Number	Document Number	Title	Material	Quantity	Author
1	PT - 014	Frame	steel	1	Tim Noel
2	F-001	Tube Frame Support	steel	1	Tim Noel
3	H-001	Horizontal Motor Mount	steel	1	Tim Noel
4	H-002	Horizontial Motor	brass	1	Tim Noel
5	H-003	Motion Cam Disk	steel	2	Tim Noel
6	PT - 015	Ground Wheel Support	steel	2	Tim Noel
7	PT - 022	Trailer Jack	steel	1	Tim Noel
8	PT - 021	Hopper Support Plate	steel	2	Eric Huhn
9	H-018	Horizontial Support Angle Back	steel	1	Tim Noel
10	H-005	Horizontial Support Angle Front	steel	1	Tim Noel
11	H-006	Horziontial Pivot Pin	steel	1	Tim Noel
12	H-000	Horziontial Assembly		1	Tim Noel
13	HA-000	Hopper Assy		1	Eric huhn
14	H-014	Guard Support	steel	5	Tim Noel
15	H-017	Electrical Box 1	aluminum	1	Tim Noel
16	H-016	Elecrtical Box 2	aluminum	1	Tim Noel
17	BF-009	Hopper Support Angle	steel	1	Eric Huhn
18	F-011	Hitch Support	steel	2	Tim Noel
19	F-010	Hitch Holder	steel	1	Tim Noel
20	F-012	Hitch	steel	1	Tim Noel
21	V-000	Vertical Assembly		1	Tim Noel
22	VL-001	Vertical Link Assembly		1	Tim Noel
23	HL-001	Horziontial Link Assembly		1	Tim Noel



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SOLID EDGE
EDS-PLM SOLUTIONS

TITLE The 11th Man

SIZE D | DWG NO MFA-000 | REV A

FILE NAME: Main-frame-assy.dft

SCALE: | WEIGHT: | SHEET 2 OF 3

Item Number	Document Number	Title	Material	Quantity	Author
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2	F-001	Tube Frame Support	steel	1	Tim Noel
3	H-001	Horizontal Motor Mount	steel	1	Tim Noel
4	H-002	Horizontial Motor	brass	1	Tim Noel
5	H-003	Motion Cam Disk	steel	2	Tim Noel
6	PT - 015	Ground Wheel Support	steel	2	Tim Noel
7	PT - 022	Trailer Jack	steel	1	Tim Noel
8	PT - 021	Hopper Support Plate	steel	2	Eric Huhn
9	H-018	Horizontial Support Angle Back	steel	1	Tim Noel
10	H-005	Horizontial Support Angle Front	steel	1	Tim Noel
11	H-006	Horziontial Pivot Pin	steel	1	Tim Noel
12	H-000	Horziontial Assembly		1	Tim Noel
13	HA-000	Hopper Assy		1	Eric huhn
14	H-014	Guard Support	steel	5	Tim Noel
15	H-017	Electrical Box 1	aluminum	1	Tim Noel
16	H-016	Elecrtical Box 2	aluminum	1	Tim Noel
17	BF-009	Hopper Support Angle	steel	1	Eric Huhn
18	F-011	Hitch Support	steel	2	Tim Noel
19	F-010	Hitch Holder	steel	1	Tim Noel
20	F-012	Hitch	steel	1	Tim Noel
21	V-000	Vertical Assembly		1	Tim Noel
22	VL-001	Vertical Link Assembly		1	Tim Noel
23	HL-001	Horizontial Link Assembly		1	Tim Noel

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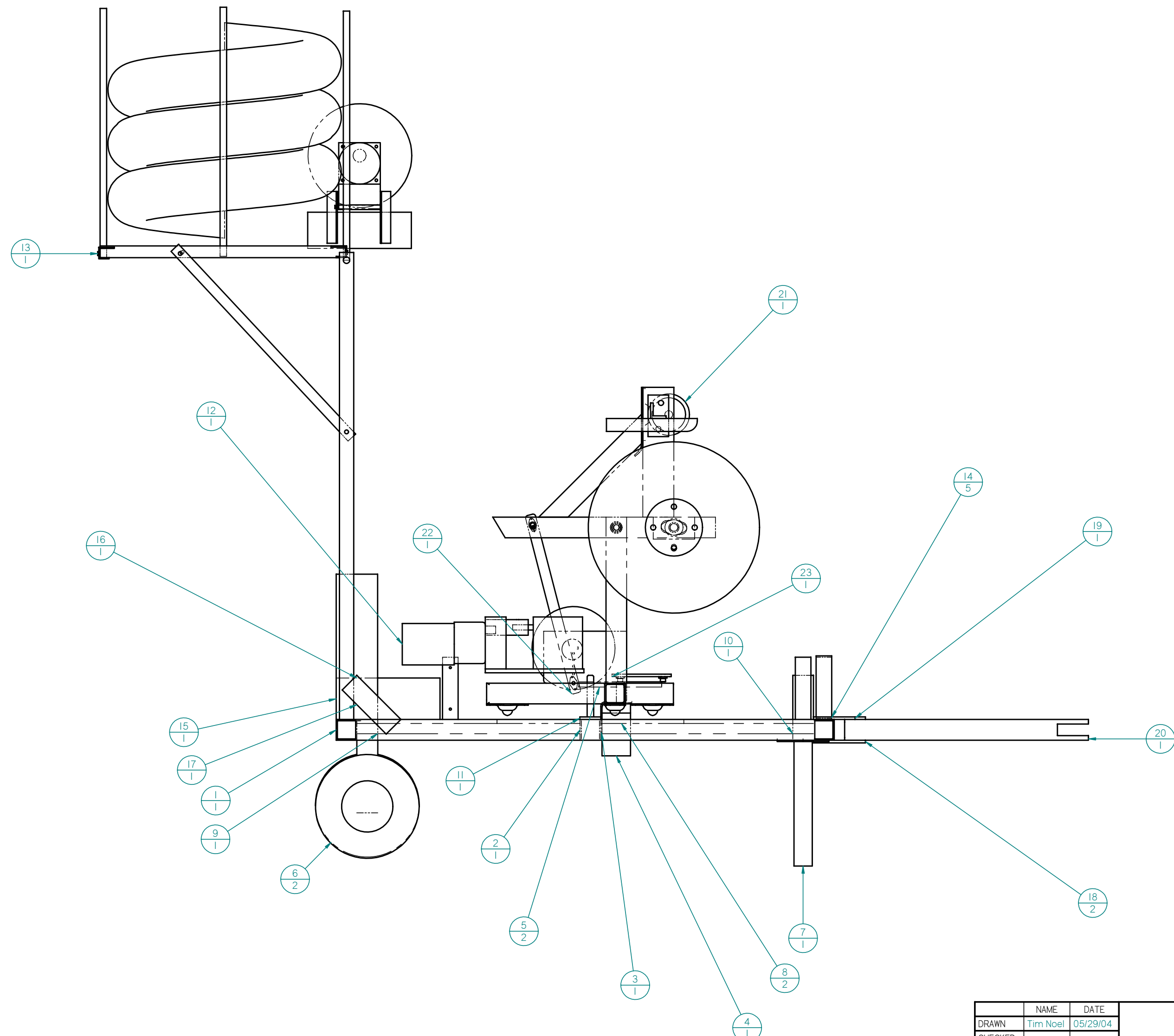

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SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
The 11th Man

SIZE D DWG NO MFA-000 REV A

FILE NAME: Main-frame-assy.dft

SCALE: WEIGHT: SHEET 3 OF 3

Item Number	Document Number	Title	Material	Quantity	Author
1	V-008	Up_Right Support	steel	1	Tim Noel
2*	V-002	Vertical Support Leg	steel	1	Tim Noel
3	V-004	Vertical Support Bearing	steel	1	Tim Noel
4	V-001	Shaft Support	steel	1	Tim Noel
5*	V-003	Shaft Bearing	Bearing	2	Tim Noel
6	V-007	Wheel Shaft	steel	1	Tim Noel
7	V-008	Wheel Hub	steel	1	Tim Noel
8	V-010	Flat Plate Ball Mount	steel	1	Eric Huhn
9	V-005	Angle Support	steel	1	Tim Noel
10	V-009	Ball Thrower Friction Plate	steel	1	Tim Noel
11	V-011	Pitching Wheel	aluminum	1	Eric Huhn
12	V-012	Motor Mount Plate	steel	1	Eric Huhn
13	V-020	Pitching Motor	brass	1	Tim Noel
14*	V-021	Motor Pulley	aluminum	1	Tim Noel
15	V-021	Shaft Pulley	aluminum	1	Tim Noel
16	Z-022	Thrower Support	steel	1	Tim Noel

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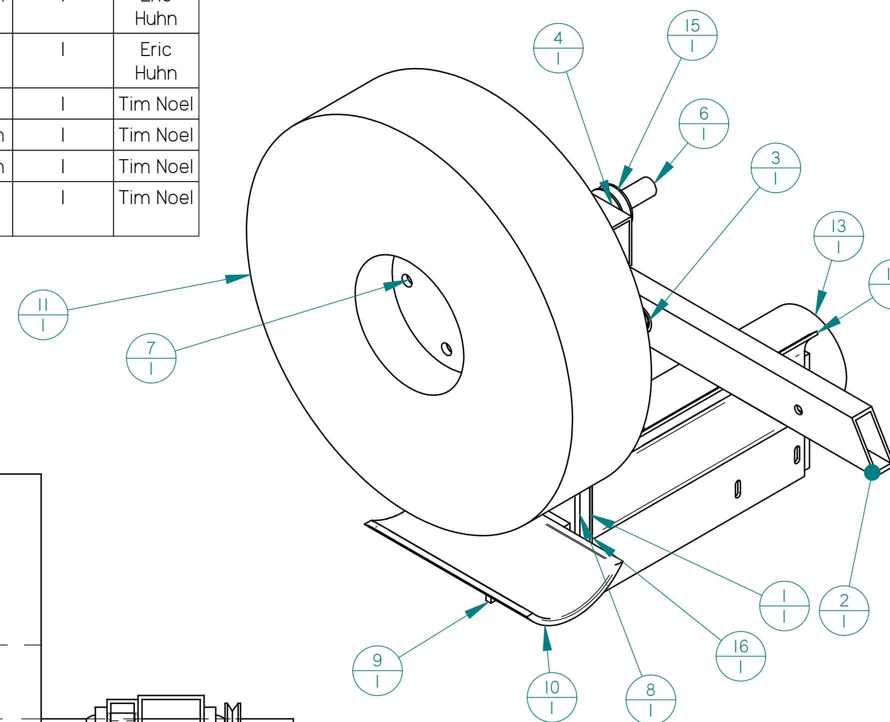

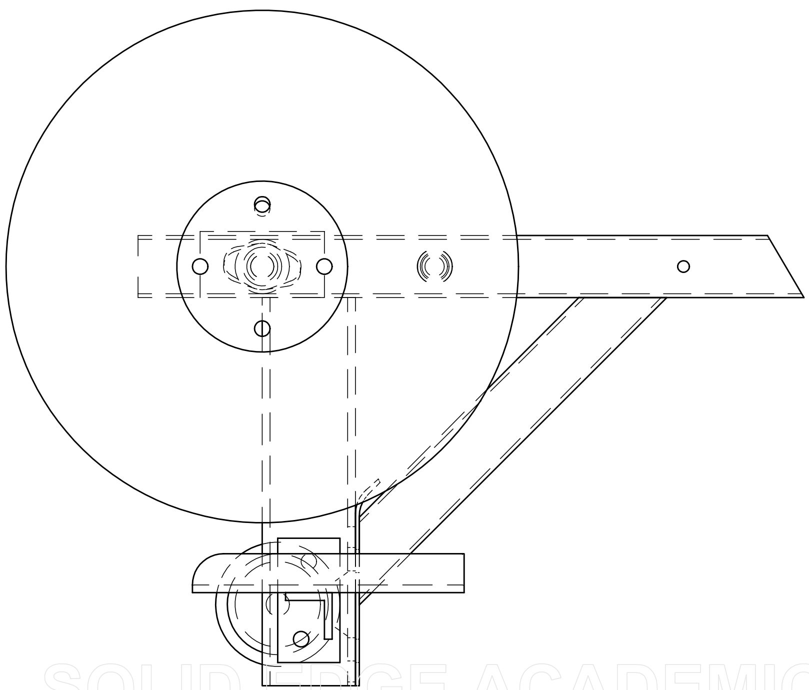

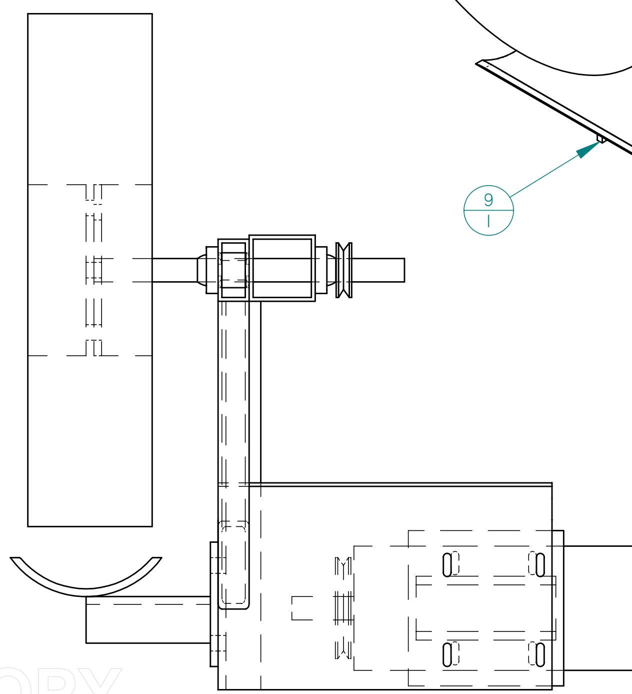

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SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
Vertical Assembly

SIZE D | DWG NO V-000 | REV A

FILE NAME: Vertical Assy - 2.dft

SCALE: | WEIGHT: | SHEET 1 OF 1

Item Number	Document Number	Title	Material	Quantity	Author
1	H-007	Horziontal Support Link Lower	steel	1	Tim Noel
2	PT - 037	Support Bearing for Horzontial	Bearing	3	Tim Noel
3	H-008	Upright Leg	steel	1	Tim Noel
4	H-011	Gear Box Suppot Plate 1	steel	1	Tim Noel
5	H-012	Gear Box Support Plate 2	steel	1	Tim Noel
6	H-010	Gear Box	aluminum	1	Tim Noel
7	H-013	Gear Box Coupler	steel	1	Tim Noel
8	H-014	Vertical Support Motor Angle	steel	2	Tim Noel
9	H-014	Vertical Motor	brass	1	Tim Noel

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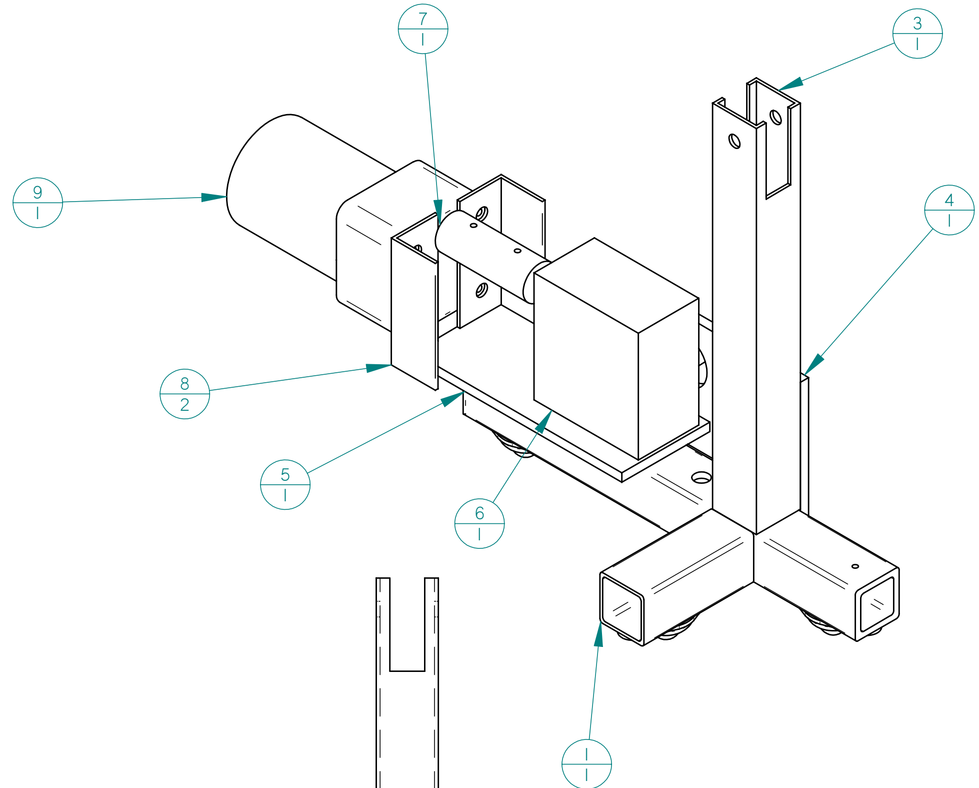

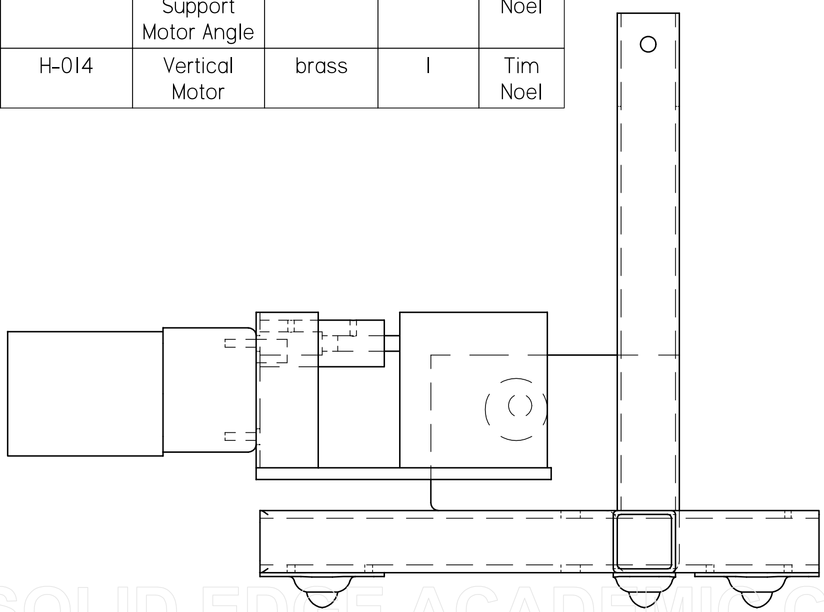

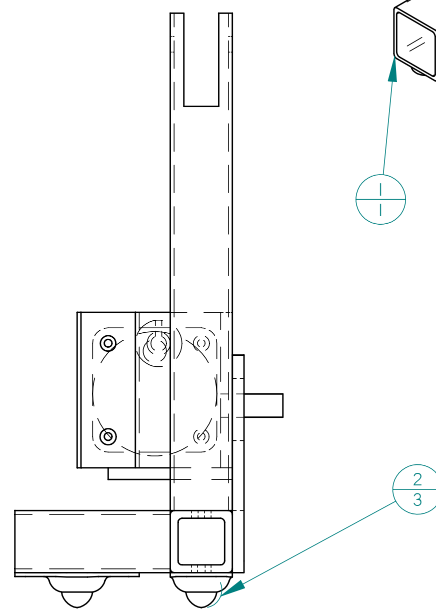

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2 PL ±XXX 3 PL ±XXXX

SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
Horizontial Assembly

SIZE D | DWG NO H-000 | REV A

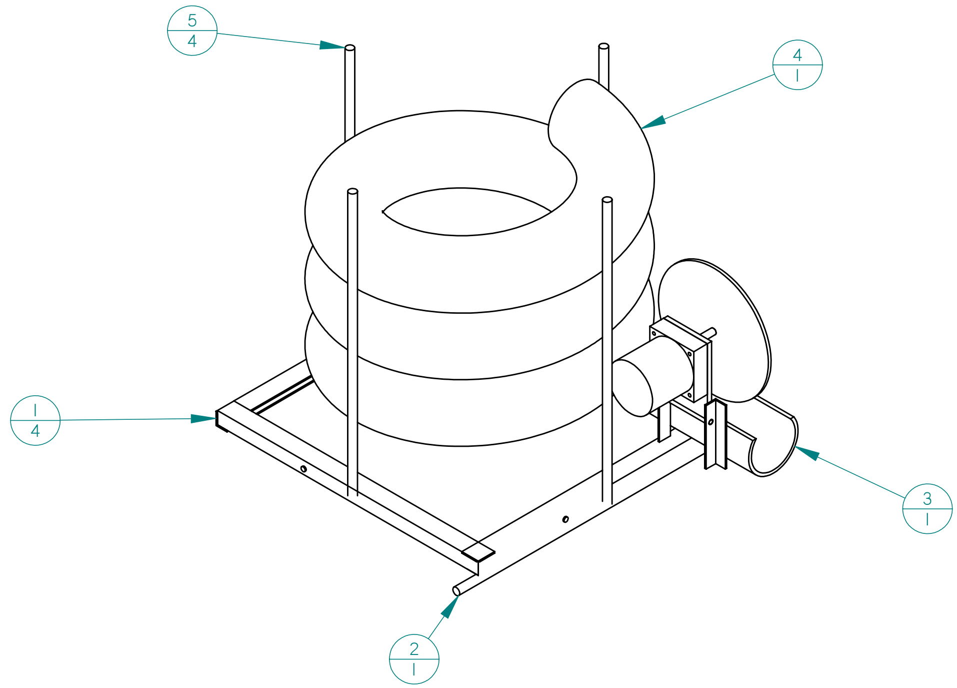
FILE NAME: Horizontial Assy.dft

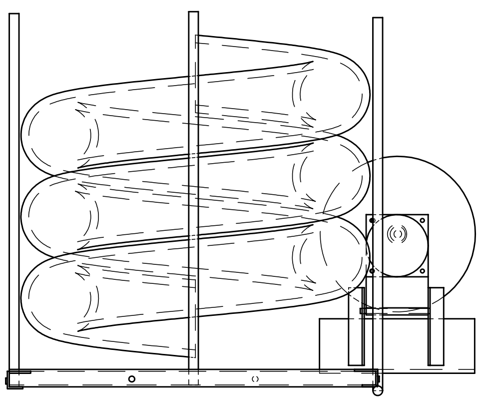
SCALE: | WEIGHT: | SHEET 1 OF 1

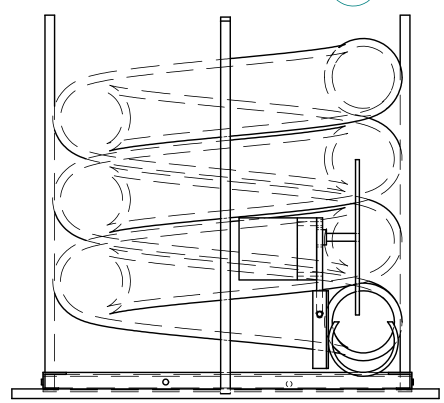
Item Number	Document Number	Title	Material	Quantity	Author
1	BF-006	Hopper Frame Floor	steel	4	Eric Huhn
2	PT - 032	Pivot Rod for Hopper	steel	1	Eric Huhn
3	Assy-001	Ball Feeder Motor Assembly		1	Eric Huhn
4	BF-007	Hopper Hose	Plastic	1	Eric Huhn
5	BF-008	Hopper Frame Post	steel	4	Eric Huhn

REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED







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DRAWN	Eric Huhn	05/29/04
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MGR APPR		

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2 PL ±XXX 3 PL ±XXXX

SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
Hopper Assembly

SIZE D DWG NO HA-000 REV A

FILE NAME: Hopper Assy.dft

SCALE: WEIGHT: SHEET 1 OF 1

Item Number	Document Number	Title	Material	Quantity	Author
1	MA-020	Vertical Link	steel	1	Tim Noel
2	HVA-001	Link Bearing	aluminum	2	Tim Noel

REVISION HISTORY			
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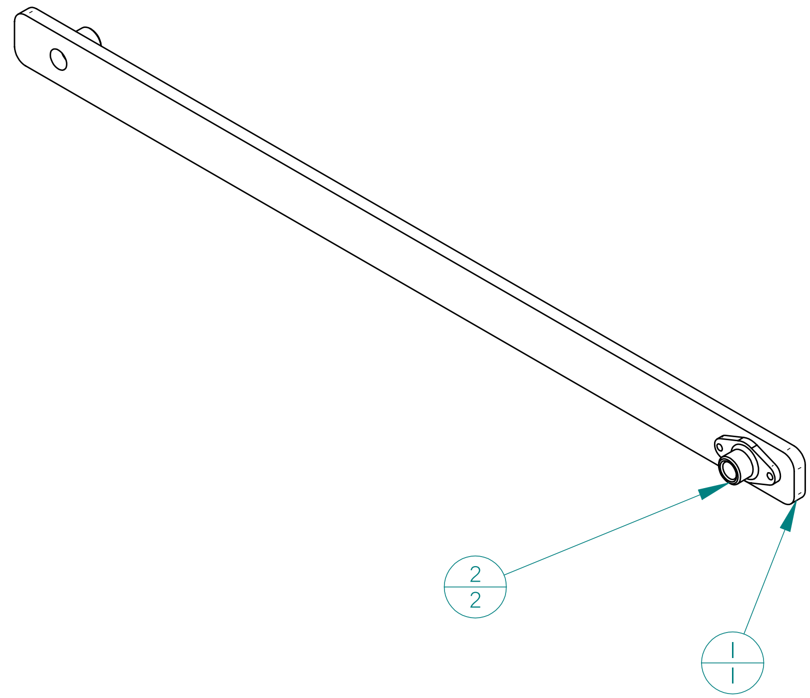

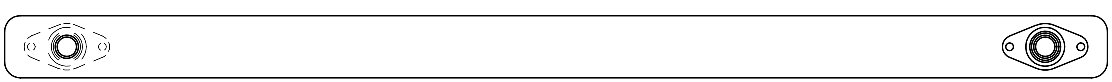

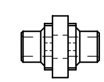

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ENG APPR		
MGR APPR		

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2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
Vertical Link Assembly

SIZE D | DWG NO VLA-000 | REV A

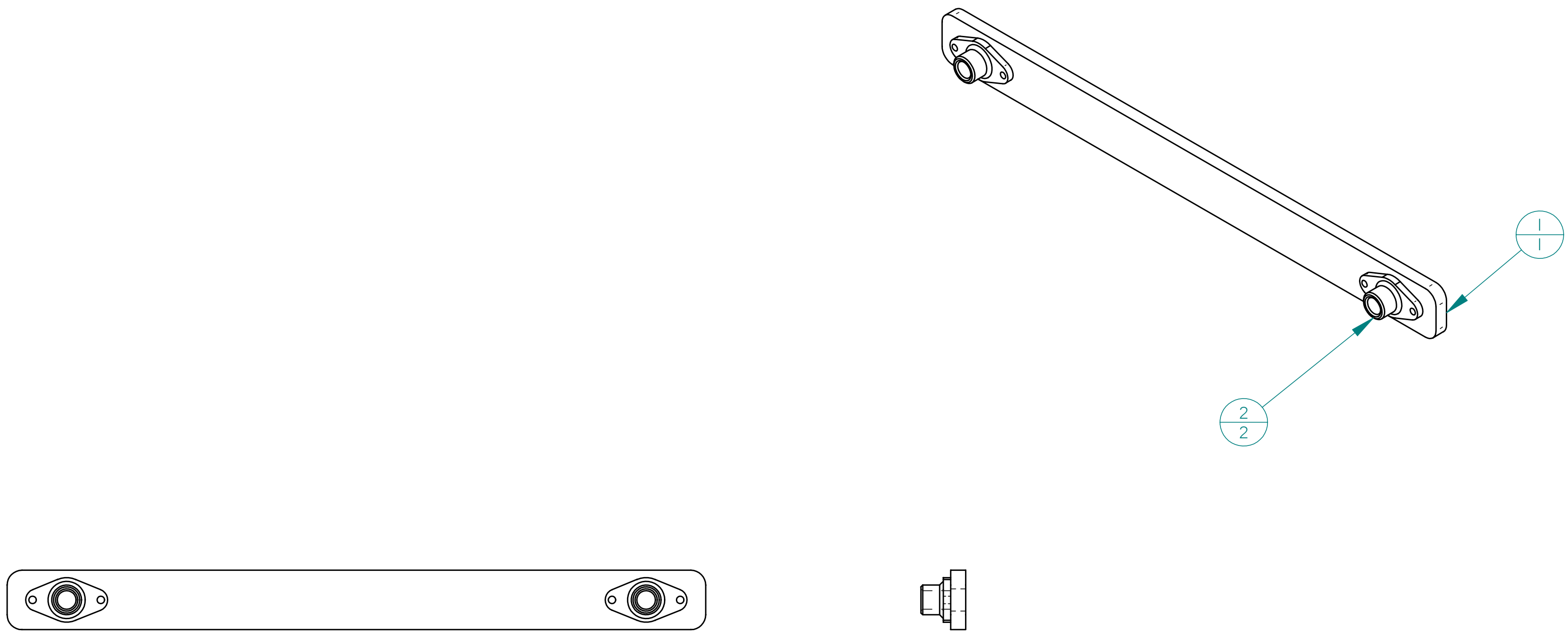
FILE NAME: Vertical Link.dft

SCALE: | WEIGHT: | SHEET 1 OF 1

Item Number	Document Number	Title	Material	Quantity	Author
1	MA-020	Vertical Link	steel	1	Tim Noel
2	HVA-001	Link Bearing	aluminum	2	Tim Noel

REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED



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MGR APPR		

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2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
Vertical Link Assembly

SIZE D | DWG NO VLA-001 | REV A

FILE NAME: Horziontial Link Assy.dft

SCALE: | WEIGHT: | SHEET 1 OF 1

Item Number	Document Number	Title	Material	Quantity	Author
1	PT - 006	Ball Feeder Pipe	steel	1	Eric Huhn
2*	BF-002	Ball Feeder Motor Pivot	steel	1	Eric Huhn
3	BF-003	Ball Feeder Motor Pivot - 2	steel	1	Eric Huhn
4	BF-001	Ball Feederr Motor Support	steel	1	Eric huhn
5	ASSY - 001	Ball Feeder Motor Assy	Motor	1	Eric Huhn
6*	BF-004	Ball Feeder Motor Pivot Pin	steel	1	Eric Huhn
7	BF-005	Ball Feeder Wheel	aluminu m	1	Eric Huhn

REVISION HISTORY

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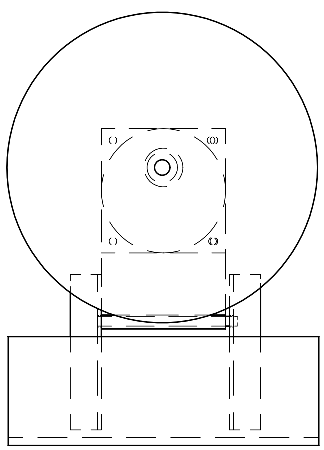

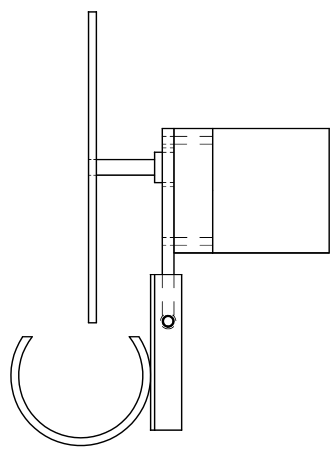

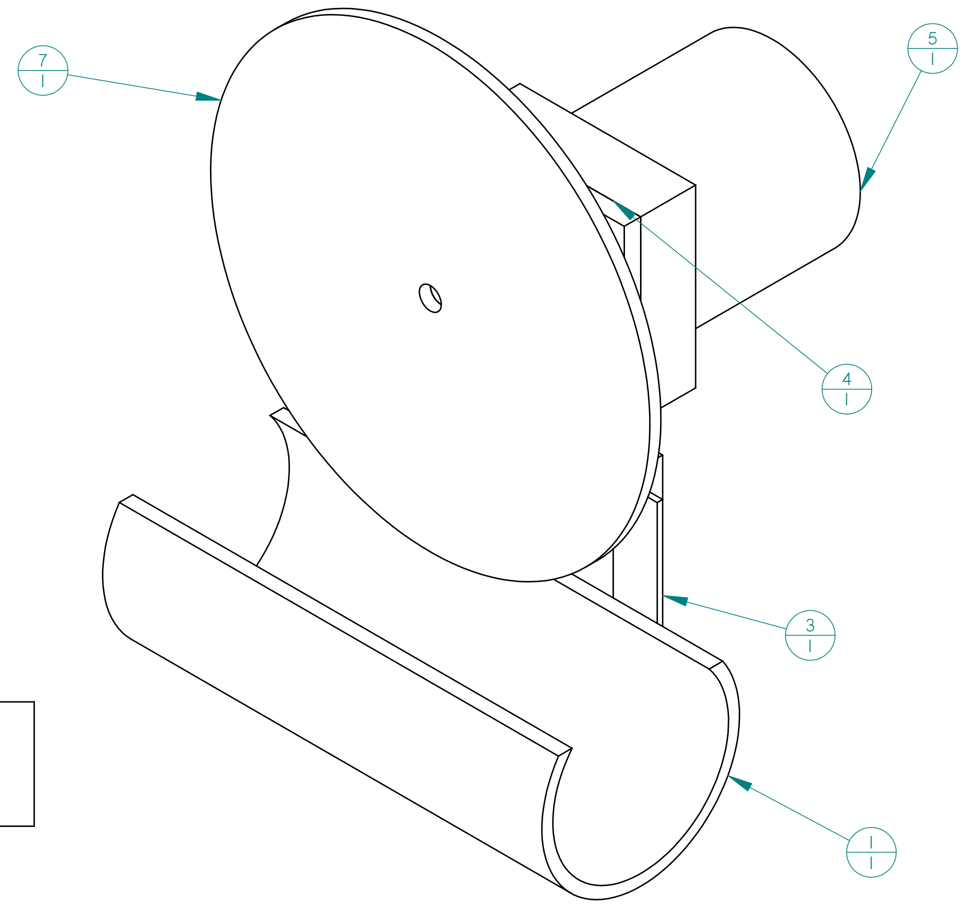

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DRAWN	Eric Huhn	05/29/04
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ENG APPR		
MGR APPR		

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2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
EDS-PLM SOLUTIONS

TITLE
Ball Feeder Motor Assembly

SIZE D | DWG NO BF-001 | REV A

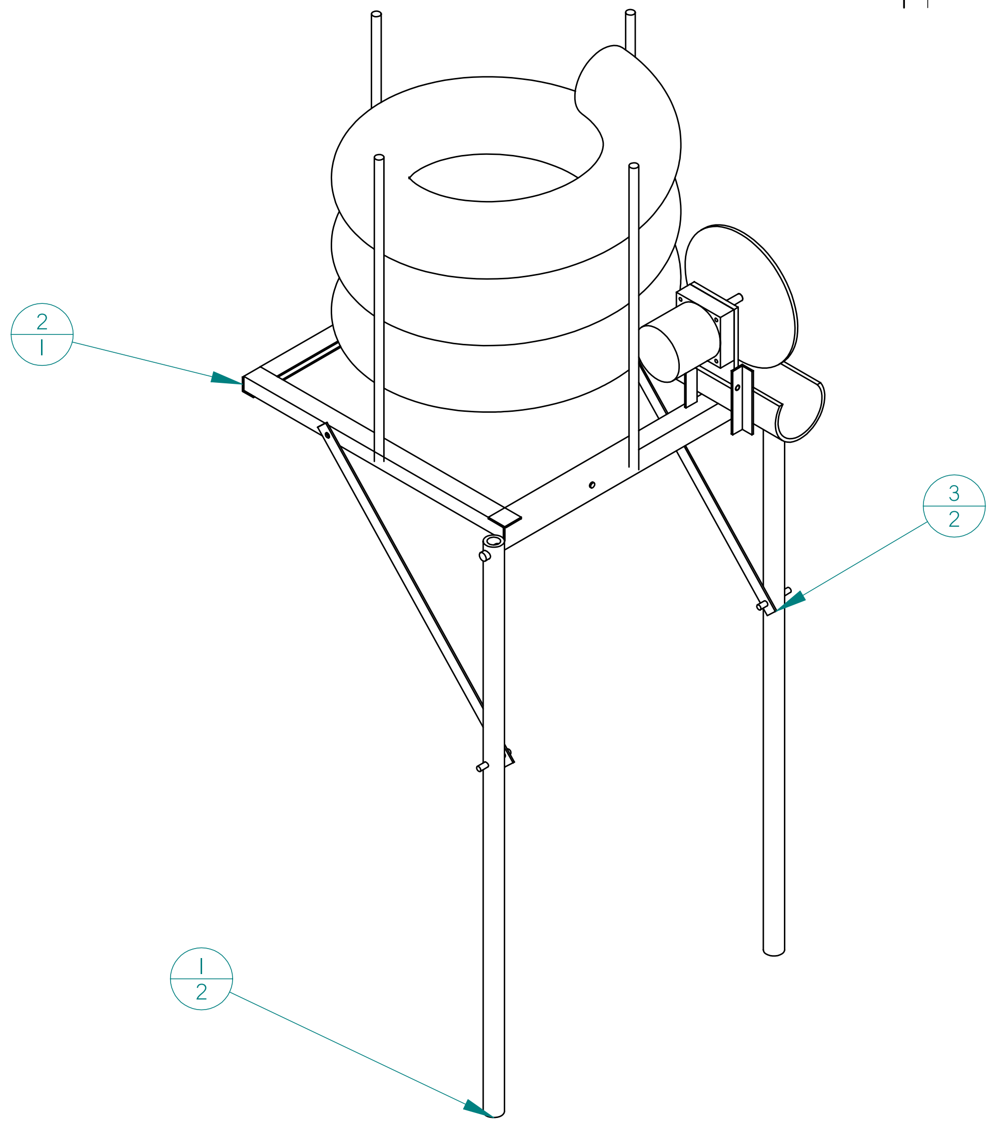
FILE NAME: Ball-Feeder-Motor-Assy.dft

SCALE: | WEIGHT: | SHEET 1 OF 1

Item Number	Document Number	Title	Material	Quantity	Author
1	PT - 020	Hopper Support Bar	steel	1	Eric Huhn
2	BF-006	Hopper Frame Floor	steel	1	Eric Huhn
3	PT - 016	Hopper Support Arm	steel	1	Eric Huhn

REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED



	NAME	DATE
DRAWN	Eric Huhn	05/29/04
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±XX°
2 PL ±XXX 3 PL ±XXXX

SOLID EDGE
EDS-PLM SOLUTIONS

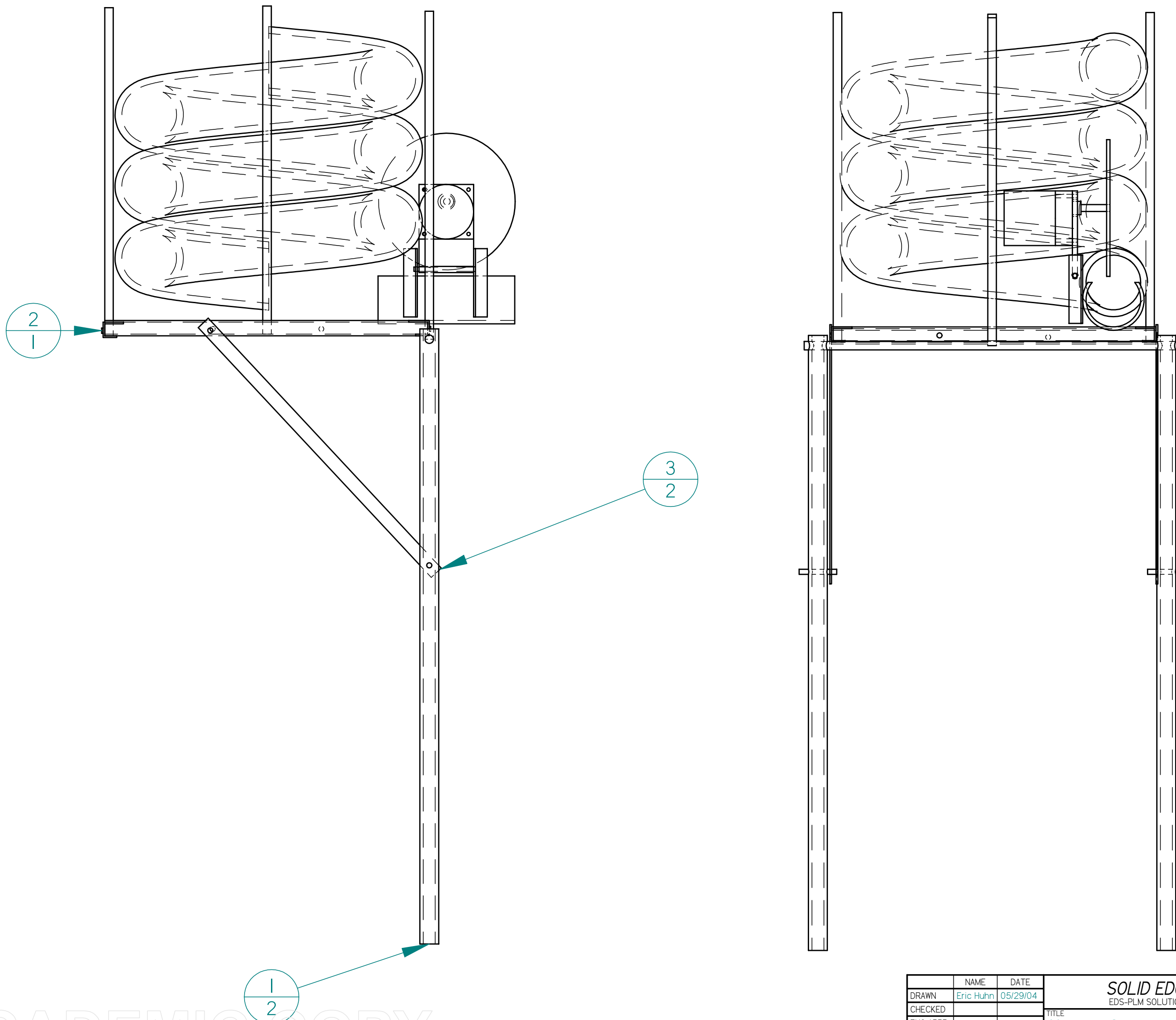
TITLE
Hopper Support Assembly

SIZE D | DWG NO HA-000 | REV A

FILE NAME: Hopper Support Assy.dft

SCALE: | WEIGHT: | SHEET 1 OF 2

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



	NAME	DATE	
DRAWN	Eric Huhn	05/29/04	SOLID EDGE EDS-PLM SOLUTIONS
CHECKED			TITLE Hopper Support Assembly
ENG APPR			
MGR APPR			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES ANGLES ±X.X° 2 PL ±X.XX 3 PL ±X.XXX			SIZE D / DWG NO HA-000 / REV A
			FILE NAME: Hopper Support Assy.dft
			SCALE: / WEIGHT: / SHEET 2 OF 2