Linear Vibration Feeder

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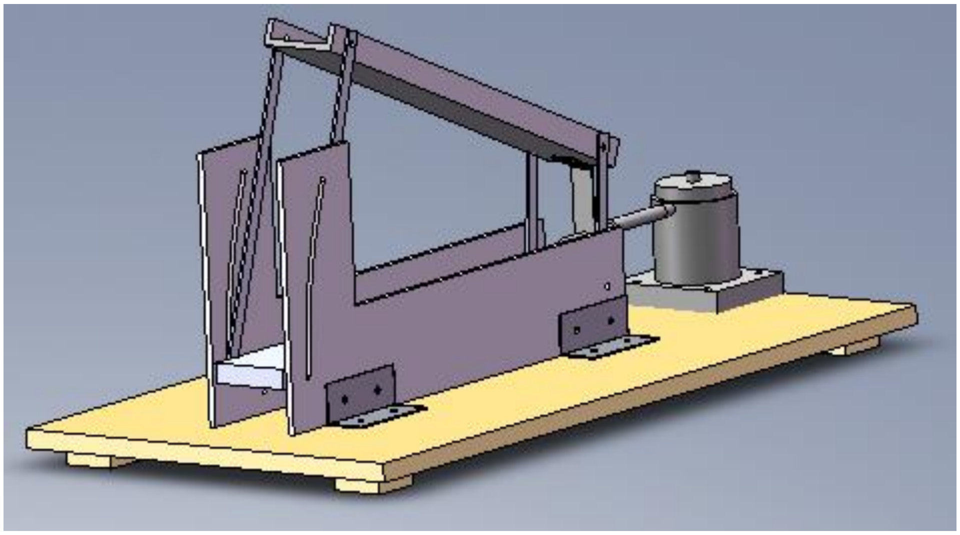
4/24/08



Abstract:

By altering the angle of a vibration plate and the angle of vibration relative to the plate, different resulting force can be achieved. A working prototype model is built that demonstrates the vibration theory though there are limitations due to design.

Table of Contents

Introduction

This project was specifically designed for professors of Worcester Polytechnic to have a working model to show students (and others), one of the theories of vibration. When professors explain a new concept or theory, students might not be able to fully comprehend how it works or how it might be applied to real life. This is true especially for those who are visual learners. This project would give students a visual representation of the vibration theory (that will be discussed in the next section) so that can aid students in better understand the material.

Therefore, the ultimate goal of this project is to build a working model that demonstrates how the vibration theory can be applied in real life. A sub-goal would be have the model should be easy to carry, assemble, use, dismantle, and store.

Background

Vibratory feeders are not something new to the industrial world. They have been used in many industries such as pharmaceutical, mining, and even food. There are 2 main types of feeders, linear and bowl shaped, operating with the same theory. Many of the industrial shakers come will other fixtures suited to the type of job it has to do. Screens are used to separate different size particles or to separate out dirt and other unwanted particles. Other feeders have fixtures that orientate the mediums in a certain direction in preparation for the next step in the process of manufacturing.

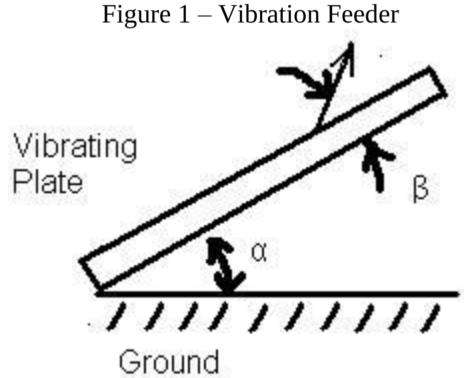
Simplified version of the theory behind the project

An object or particle is placed on a slope. The frictional force(s) prevents the object from rolling/sliding down the slope. When an external force is acted on the slope, it will drop down and back. The object/particle will "fall" onto a higher point on slope. Due to the frictional force(s), the object/particle wouldn't return to the original point on the slope. Repeating this will cause the object/particle to "climb" up the slope.

Detailed version –

A vibration feeder with 1-D motion (Figure 1) with the frame attached to the inclined vibrating plate. Angle α is the angle of the plate relative to the ground. Angle β is the angle of vibration relative to α (or in other words, the surface of the plate).

Figure 1 – Vibration Feeder



Free flight of the particle would make analysis and the system more complicated. Thus free flight of the particle is to be excluded. The way to exclude the particle from free flight with the following equation,

$$(g / A\omega^2) * (\cos \alpha / \sin \beta) > 1$$

g = magnitude of gravity
A = amplitude of the acting force
ω = rotational velocity
α = angle of the plate
β = angle of vibration relative to α

Otherwise, two coefficients are important when the particle is in free flight

$$R = \dot{y}_+ / \dot{y}_-$$

$$\lambda = 1 - \dot{x}_+ / \dot{x}_-$$

R = restitution coefficient ratio of normal velocities
λ = coefficient of instantaneous friction

The subscripts "+" and "-" refers to values of velocities after and before impact respectively upon return of the particle onto the plate.

Conditions for positive (thus directed upwards) apparent mean longitudinal velocity of the particle *V* if,

$$\tan \alpha \leq f^2 \tan \beta$$
$$\alpha < \rho = \tan^{-1} f$$

α = angle of the plate
β = angle of vibration relative to α
f = coefficient of friction

$V = A\omega F (A\omega^2 / g , \alpha , \beta , f , R , \lambda)$ where F is a certain non-dimensional function. Basic conclusions can be drawn up based on analysis for solutions of equations of motion.

1. For fixed acceleration amplitude $A\omega^2$ mean longitudinal velocity V is proportional to $A\omega$ and thus to $1 / \omega$. There assigning A as high as possible would minimize the admissible frequency.
2. Increasing $A\omega^2$ increases V however this growth becomes small at high $A\omega^2$ and β.
3. Growth of V with A at fixed ω has a higher rate than a linear one.
4. Function $V(\beta)$ has a clear peak for fixed values of all other parameters (being zero or negative at $\beta = 0$ and $\beta = \pi / 2$)
5. Increasing inclination angle α of the plate would decrease V.
6. V decreases with increasing R and λ.

Methodology

Overall Design Concepts

The whole system can be divided into four major parts or subsystems. The first part is the beam that the material will be transported on (hence forth designated as Load Ramp). The second is the Support system for the beam (hence forth designated as Load Ramp Support(s)). The Load Ramp Supports have two jobs. The first is to Support the Load Ramp and prevent any side forces or movements that might occur. Its second job is to allow the user whoever he/she might be to change the Load Ramp angle. The next is the shaker and possibly a system to change its angle of acting. The shaker that is procured can pivot on its own allowing various angles of acting force thus there were no need for its own subsystem. The last major subsystem is the base assembly that the rest of the system rest on.

The first objective for the designing stage is to determine the natural frequency of the loading beam. This is to ensure that when the system is turned on, the vibration would not shake at the natural frequency of the Load Ramp. If that situation *does* occur then the energy from the vibration not only would just excite the beam and not the medium, but it could potentially destroy the ramp and the rest of the system. The original plan was to use steel, aluminum, wood, or plastic. The Load Ramp would have side Supports to make sure that the materials would not fall off the side and possibly damage the system.

The medium(s) that will be transported on the Load Ramp will be flat with a large surface area compared to its thickness (such as coins). This is to prevent a rolling effect that a spherical-like object will have when the system is turned on.

Design Process

For the Load Ramp and the Load Ramp Support, wood and plastic as a potential material is eliminated because of the stiffness. Aluminum is chosen as the final material because of the cost of materials.

The original design for the Load Ramp Support was to have legs as support. It was scrapped because it only had a set number of configurations allowing only a limited number of angles that the Load Ramp can be set. The first version of the new Load Ramp Support is shown in (Figure 2) and (Figure 3) shows it being attached to the Load Ramp.

Figure 2 – Load Ramp Support 1.0

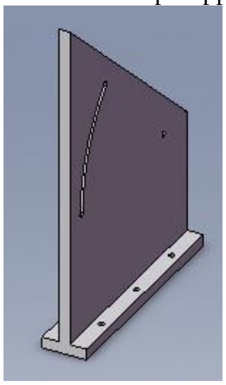
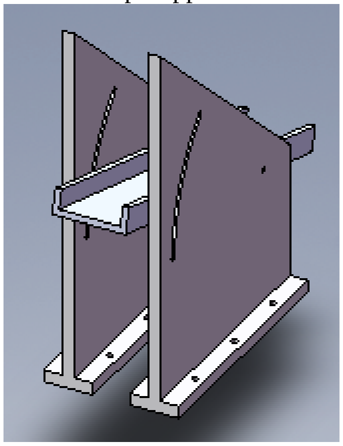
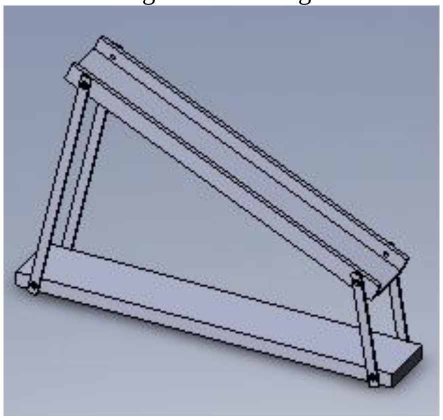


Figure 3 – Load Ramp Support 1.0 and Load Ramp



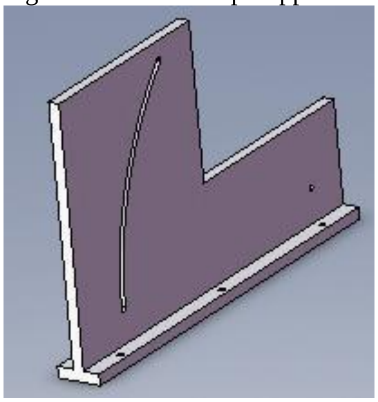
Based on further analysis of the system, it is determined that the Load Ramp would be too stiff to actually vibrate. Thus a linkage system was used (commercial linear vibration feeders similar to this also use linkages). The lengths of the linkages, Load Ramp, and Load Ramp Support were determined based on the resulting movements of the Load Ramp. To determine the final linkage system, four-bars is used (Figure 4). For full analysis of the four-bar linkage, refer to Analysis section.

Figure 4 – Linkage



Version 2 of the Load Ramp (Figure 5) accommodates the linkage system and easily allows for Load Ramp to change angles but from a manufacturing point of view, the T base creates some problem.

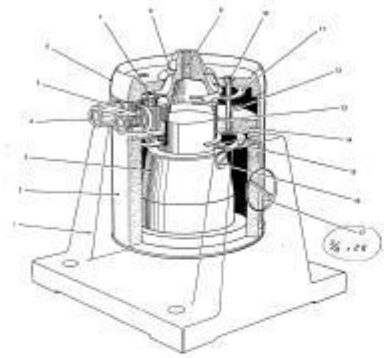
Figure 5 – Load Ramp Support 2.0



For the final version (Appendix B Load Ramp Support), angle brackets are used to attach the supports to the base. The final version of the Load Ramp Support was determined based on a manufacturing point of view to lower cost of material and ease of machining.

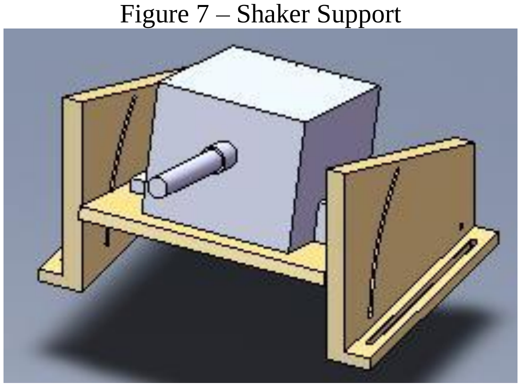
The shaker that was obtained turned out to be able to pivot on its own. Figure 6 below depicts a schematic of the shaker.

Figure 6 – Shaker



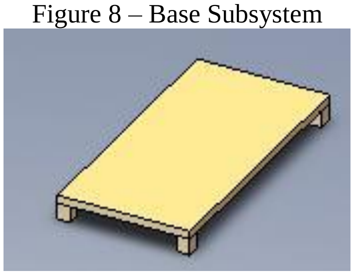
This eliminated the need for its own support subsystem which the preliminary design (Figure 7) had.

Figure 7 – Shaker Support



The base subsystem specs were based on the final design to ensure that the base is large enough and strong enough to ensure that everything fits and wouldn't collapse. Also, to make sure that it wouldn't be too large to create unnecessary weight. Figure 8 below shows the Base Subsystem.

Figure 8 – Base Subsystem



Software

Solidworks is a CAD (computer-aided design) computer program that many engineers use in the design process. The program creates a 3-D environment where the user can design and draw either simple parts or complicated assemblies. Solidworks can also allow the user to “see” how the objects will look and whether the parts will come together in the way they are supposed to.

FOURBAR is a computer program created by Prof. Norton from Worcester Polytechnic to analyze a four bar linkage. By altering the lengths of the links and the angle of freedom, it is possible for the program to “draw out” the resultant actions. Thus, the user can easily design a linkage with the desired resulting actions without lengthy calculations or having to build a prototype.

GibbsCam is a CAM (computer-aided manufacturing) computer program created to aid engineers in CNC (computer numerical control) functions. GibbsCam allows engineers to program machines to machine their parts.

Mathcad is computer software used for calculating engineering, math, and scientific problems. It also has engineering units to help ensure that the calculations are done correctly.

LabVIEW (possibly) (short for **Lab**oratory **V**irtual **I**nstrumentation **E**ngineering **W**orkbench) is a computer program created by National Instruments. The user is able to create a program to acquire, analyze, and output data from measuring instruments.

Final Design

See Appendix B for the final version of the linear vibration feeder designed using Solidworks.

The final version of the Load Ramp was similar to the one in Figure 4 except that it has a hole at one end for the Link Bracket which connects the Load Ramp with the stinger from the shaker (Figure 9).

The Load Ramp Filler from Figure was changed to look like the Load Ramp because there were extra stock to use and the consideration of stock costs.

The Solidworks model showed that the Load Ramp Support is one piece (Figure 10). However, the Load Ramp Support was machined from two pieces because the cost of obtaining a large square stock is much higher than a long beam. It is held together by one of the brackets.

Prototype Construction Materials

Stock

Linkage arms – Multipurpose Aluminum (Alloy 6061), 1/8 inch Thick X ½ inch Width X 6 feet Length

Load Ramp and Load Ramp Filler – Alloy 6061 Aluminum Channel, 1/8 inch Thick, 3 inches Base X 1 inch Leg, 8 feet Length

Angle brackets – High-Strength Aluminum (Alloy 2024), 90 Degree Angle, 1/16 inch Thick, 1-1/2" X 1-1/2" Leg, 3 feet Length

Load Ramp Support – Multipurpose Aluminum (Alloy 6061), ¼ inch Thick X 4 inches Width X 6 feet Length

Link between Load Ramp and Stinger – 6061 Al, 0.31 inch Thick X 0.91 inch Thick X 5 inches Length

Screws and Nuts

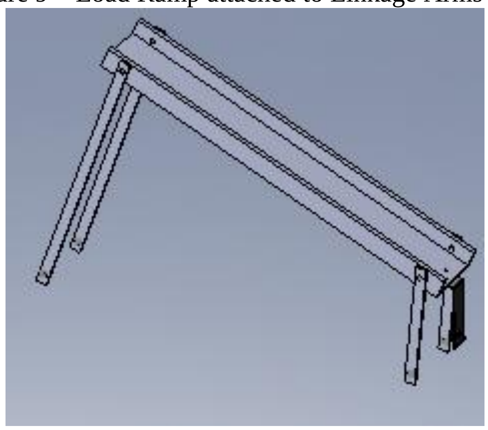
- Steel Shim, w/o Internal Notch, .005" Thick, ¼ inch Inner Diameter, 3/8 inch Outer Diameter
- 18-8 SS Precision Phillips Shoulder Screw, ¼ inch Shoulder Diameter, 3/8 inch Shoulder Length, 10-32 Thread
- 18-8 SS Precision Phillips Shoulder Screw, ¼ inch Shoulder Diameter, 1/2 inch Shoulder Length, 10-32 Thread
- Zinc-Plated Steel Machine Screw Nut 6-32 Screw Size, 5/16 inch Width, 7/64 inch Height
- Acetal Hex Nut, 10-32 Screw Size, 3/8 inch Width, 1/8 inch Height
- Zinc-plated Steel Flat Head Philips Machine Screw, 6-32 Thread, 1 inch Length
- Wood Screw 6-32 Thread, 1 inch Length

How to build / assemble

Linkage –

1. Place a shim between the Load Ramp and Linkage arms
2. Thread a shoulder screw through the hole from the Load Ramp side
3. Secure screw with hex nut and tighten
4. Secure link between Load Ramp and Stinger (Figure 9)

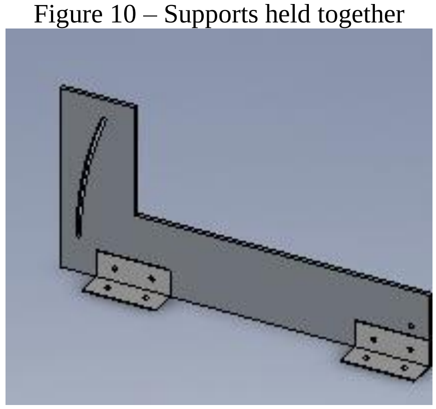
Figure 9 – Load Ramp attached to Linkage Arms



Linkage Support –

1. Line up the Support plates
2. Secure them together using an angle bracket with a machine screw and hex nut
3. using more screws and hex nut to secure another Angle Bracket to the Support (Figure 10)

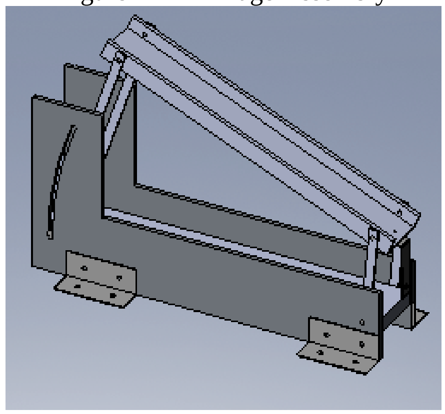
Figure 10 – Supports held together



Linkage Assembly –

1. Thread the (longer shoulder length) shoulder screw through Filler, Linkage Arms, and Support)
2. Secure with a hex nuts (Figure 11)

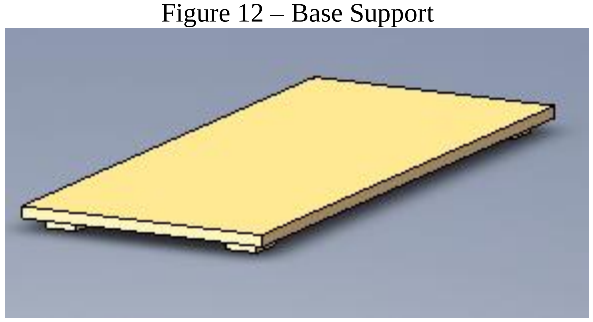
Figure 11 – Linkage Assembly



Final Assembly –

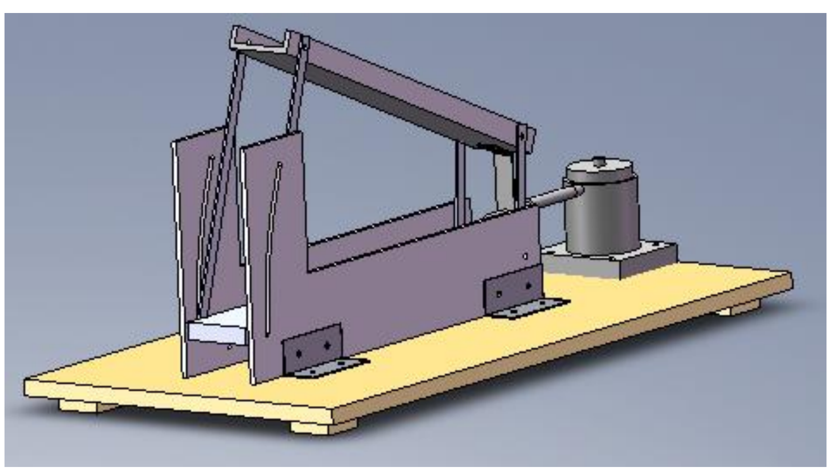
5. Screw the Legs to the Base using wood screws (Figure 12) The Legs are 1 inch inward in each direction to give more surface area for hand grips and to decrease the chance of splinters to the wooden legs.

Figure 12 – Base Support



6. Line up the Angle Brackets to pre-drill holes on the bases secure using the wood screws having already line up the Leg Block (the Leg Block is to ensure that the wood screws doesn't stick out)
7. Secure link between Load Ramp and Stinger
8. Attach Stinger to Link
9. Secure Shaker to Base (Figure 13)

Figure 13 – Finished Assembly

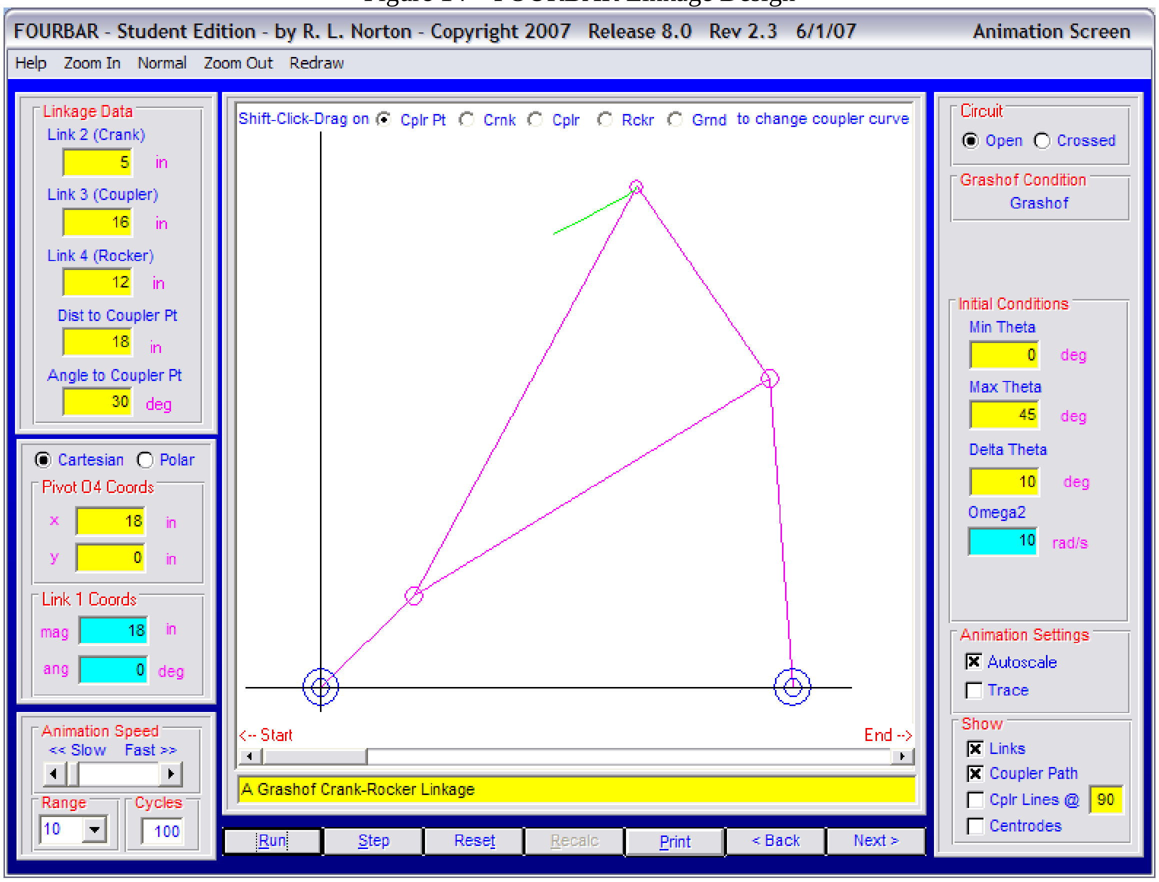


Analysis

Linkage Analysis –

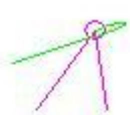
To design the linkage system, first the software FOURBAR (Figure 14) is used. This software helps analyze the motions based on inputs in the yellow box in figure below.

Figure 14 – FOURBAR Linkage Design



First, the type of resulting motion that the linkage will have is required. The linear vibration feeder should have a linear motion with a little loop at the end like the one from Figure 15 (in green).

Figure 15 – Desired Linkage motion



Using Figure 3-21 in *Design Machinery* by Prof. Norton as reference, the approximate length of the desired linkages was achieved. Based on the raw numbers, some manipulations and iterations were used to determine the final numbers. Thus linkage system is designed. The lengths of the links, Load Ramp, and Load Ramp Filler are based on this design. Crank (5 inches) is equal to the short linkage arm, coupler (16 inches) is the Load Ramp, rocker (12 inches) is the long linkage arm, and distance to coupler point (18 inches) is the Load Ramp Filler. The distances between the holes in these parts were based on these lengths.

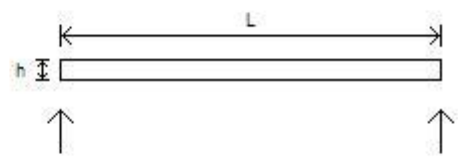
Load Ramp Analysis –

In determining the natural frequency of the load Ream (to avoid), the *Shock and Vibration Handbook* by Harris and Crede is used. Figure 16 shows the type of beam that the Load Ramp is similar to. The equation for the natural frequency is

$$\omega = A * \sqrt{[(E * I) / (\mu * L^4)]}$$

ω = rotational velocity with units [rad / sec] which can be converted to Hz by 2π
A = coefficient of the beam (depends on the parameters)
E = modulus of elasticity of material with units [lbf/in^2]
I = area moment of inertia with units [in^4]
μ = mass density of material with units [($lbf * sec^2$) / in^2]

Figure 16 – Hinged-Hinged (simple) Load Ramp



A is given in the *Shock and Vibration Handbook* as 9.87 for a Hinged-Hinged (simple) Load Ramp. Hinged-Hinged means that the beam is supported on both ends. Simple means that the beam only has one wave traveling through it at one time.

E is modulus of elasticity of materials that could be found in various engineering textbooks or handbooks. The modulus of elasticity for aluminum is $1.04 * 10^7$ lbf / in^2.

I is the area moment of inertia. For simplification, the Load Ramp is considered only as a square beam without the sides. The equation for area moment of inertia for a square beam is,

$$I = (b * h^3) / 12$$

I = area moment of inertia with units [in^4]
b = base of the beam with units [in]
h = height of the beam with units [in]

In this case b is equal to 3 inches (width of the beam) and h is equal to 1/8 inch (thickness of the beam. Thus, *I* comes out to $4.883 * 10^{-4}$ in^4.

μ is the mass density of the material with units of ($lbf * s^2$) / in^2. The equation to solve of μ is,

$$\mu = (A * \gamma) / g$$

μ = mass density of material with units [(lbf * sec^2) / in^2]
A = cross sectional area of the beam with units [in^2]
γ = weight density of the material given in engineering textbooks with units [lbf / in^3]
g = gravity constant with units [in / s^2]

The cross sectional area is then 3 in * 1/8 inch = 0.375 in^2. γ is given as 0.10 lbf / in^3 in the *Machine Design* textbook by Prof. Norton. Gravity on Earth is 386.089 in / sec^2. Thus, μ comes out to 9.713 * 10^{-5} lbf * s^2 / in^2.

L is the length of the beam which is 2 feet in this case based off the linkage design analyzed early in the report.

Calculations were done using Mathcad. See Appendix A for the Mathcad file. Based on analysis of the simple beam, the natural frequency of the beam when it is 2 feet long is 30.975 Hz. Thus frequency at about 31 Hertz should be avoided.

Results and Discussion

Results from accelerometer? Results within expectations? Results outside expectations

Conclusion

The demo works within the specifications of the theory. Thus this system demonstrates that the theory is valid. The particle moves up the Load Ramp with varying combinations of angle α and β. In the current configuration and surface, the greatest resulting acceleration is X with α being X° and β being X°.

Comments

This had been an interesting project to work on. This project applies several classes' worth of material into real life. Also, there was a need to seek outside help and learn about things that aren't taught in class. This project "forced" me to think more like a mechanical engineer working in a company rather than a student working on another class project.

I would like to thank Professor Cobb and Professor Dimentberg for letting onto this project and their patience into completion of this project. I would also like to thank the personal at the manufacturing lab for their time and aid into helping make the demo. Without their help, this project would not have reached completion.

As engineers, "mistakes" are made no matter how careful the planning stages are. After the assembly is finished, there were several problems that could have been avoided. The geometry of the linkage system was not fully addressed. As such, the Load Ramp would be at angle of 24° when the Load Ramp Filler is at 0° and the short linkage arms are vertical. Also the hex nuts would hit the Supports in wide motions limited the range that the system could operate at.

Recommendations

One of the variables in the theory is the coefficient of friction. Too much friction and the medium(s) being carried wouldn't move much, while too little friction would cause the medium(s) to simply/roll slide down. By changing the coefficient of friction (via changing the surface either by materials or finishes), it is possible to achieve the optimal result. Tests should be done to find this optimal result based on the surface material or finishes possibly in combination with varying angles and thrust amplitude.

Design of solid models using Solidworks (and other CAD software) should also take the manufacturing stage into consideration. Making the model extrude in either direction might be easy but when it is imported to CAM software(s) like GibbsCAM, it could create extra steps to maneuver the model to the right orientation for machining. When designing a part or assembly, try to find tools and parts that could be used. If the tool or part is not available, then it might be required to alter the model slightly to accommodate for this. Otherwise, there will be trouble when the manufacturing parts.

When modeling a piece, whole numbers or simple fractional numbers are easy to use. However, in reality, the work stock and design have tolerances that could determine whether something is held the way it is suppose to or if there is interference. Machined holes are not 100% to specification due to defects and burrs in the stock. Design and tolerances should take machining into account. Warping of pieces during machining could happen especially for long flexible thin strips like the longer linkage arm.

Fine-tuning the linkage system design would provide a more optimal resulting acceleration of the system. Also, the frictions and clearance between the parts could be altered to increase the velocity of the particle(s) / medium(s) being transported.

The steel shims or spacers should be longer to increase the distances between the different pieces thus to decrease possible interference when the system is in motion. Also this would prevent the hex nuts from hitting the Support in wide motions.

Things like bolts and screws should always be checked and updated with the design to ensure that the size is correct. Also, extra stock is important in case something goes wrong with the piece. Always double check everything and re-probe CNC tools prior to every usage.

Bibliography

Harris, Cyril M. and Crede, Charles E. *Shock and Vibration Handbook* Fourth Edition. New York: McGraw-Hill 1996.

Norton, Robert L. *Machine Design: An Integrated Approach* Third Edition. Upper Saddle River, NJ: Pearson Prentice Hall 2006.

Norton, Robert L. *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines* Fourth Edition. New York: McGraw-Hill 2008.

Blekhman, I.I., Dzhanelidse, G.Iu. "Vibrational Displacement" (M. Dimentberg, Trans.). Moscow, Nauka, 1964

Appendix A – Natural Frequency of Load Ramp

$A_{canti} := 9.87$ Coefficient for Hinged-Hinged (simple) (Harris, *Shock and Vibration Handbook*. 1996. Page 1.13)

$g = 386.089 \cdot \frac{in}{s^2}$ Gravity Constant on Earth

$g = 32.174 \cdot \frac{ft}{s^2}$ Gravity Constant on Earth

Material Data of Aluminum

$\gamma_{aluminum} := 0.10 \frac{lbf}{in^3}$ Weight Density of aluminum (Norton, *Machine Design*. 2006. Table C-1 p.944)

$\rho_{aluminum} := \frac{\gamma_{aluminum}}{g}$ Mass Density of aluminum

$\rho_{aluminum} = 2.59 \times 10^{-4} \cdot \frac{lbf \cdot s^2}{in^4}$

Geometry Assumptions

$b_{beam} := 3in$ (Width of the beam)

$h_{beam} := \frac{1}{8} in$ (Thickness of the beam)

$A_{beam} := b_{beam} \cdot h_{beam}$ Cross Sectional Area of Beam

$A_{beam} = 0.375 \cdot in^2$

$I_{beam} := \frac{b_{beam} \cdot h_{beam}^{\ 3}}{12}$ Area Moment of Inertia for rectangular prism (Norton, *Machine Design*. 2006. Appendix B p.942)

$I_{beam} = 4.883 \times 10^{-4} \cdot in^4$

$L_{beam} := 12in, 13in .. 48in$ Various Length of Beam (1foot to 4 feet with 1 inch increments)

For Aluminum:

$E_{aluminum} := 1.04 \cdot 10^{7} \cdot \frac{lbf}{in^{2}}$ Young's Modulus for aluminum (Norton, *Machine Design*. 2006. Figure 2-17 p.52)

$E_{aluminum} = 1.04 \times 10^{7} \cdot \frac{lbf}{in^{2}}$

$\mu_{aluminum} := \frac{A_{beam} \cdot \gamma_{aluminum}}{g}$ Mass Density of Aluminum per Unit Length of Beam

$\mu_{aluminum} = 9.713 \times 10^{-5} \cdot \frac{lbf \cdot s^{2}}{in^{2}}$

$\omega_{naluminum}(L_{beam}) := A_{canti} \cdot \sqrt{\frac{E_{aluminum} \cdot I_{beam}}{\mu_{aluminum} \cdot L_{beam}^{4}}}$

$\omega_{naluminum}(L_{beam})$ $\cdot Hz$

495.603
422.289
364.117
317.186
278.777
246.944
220.268
197.692
178.417
161.83
147.452
134.909
123.901
114.187
105.572
...

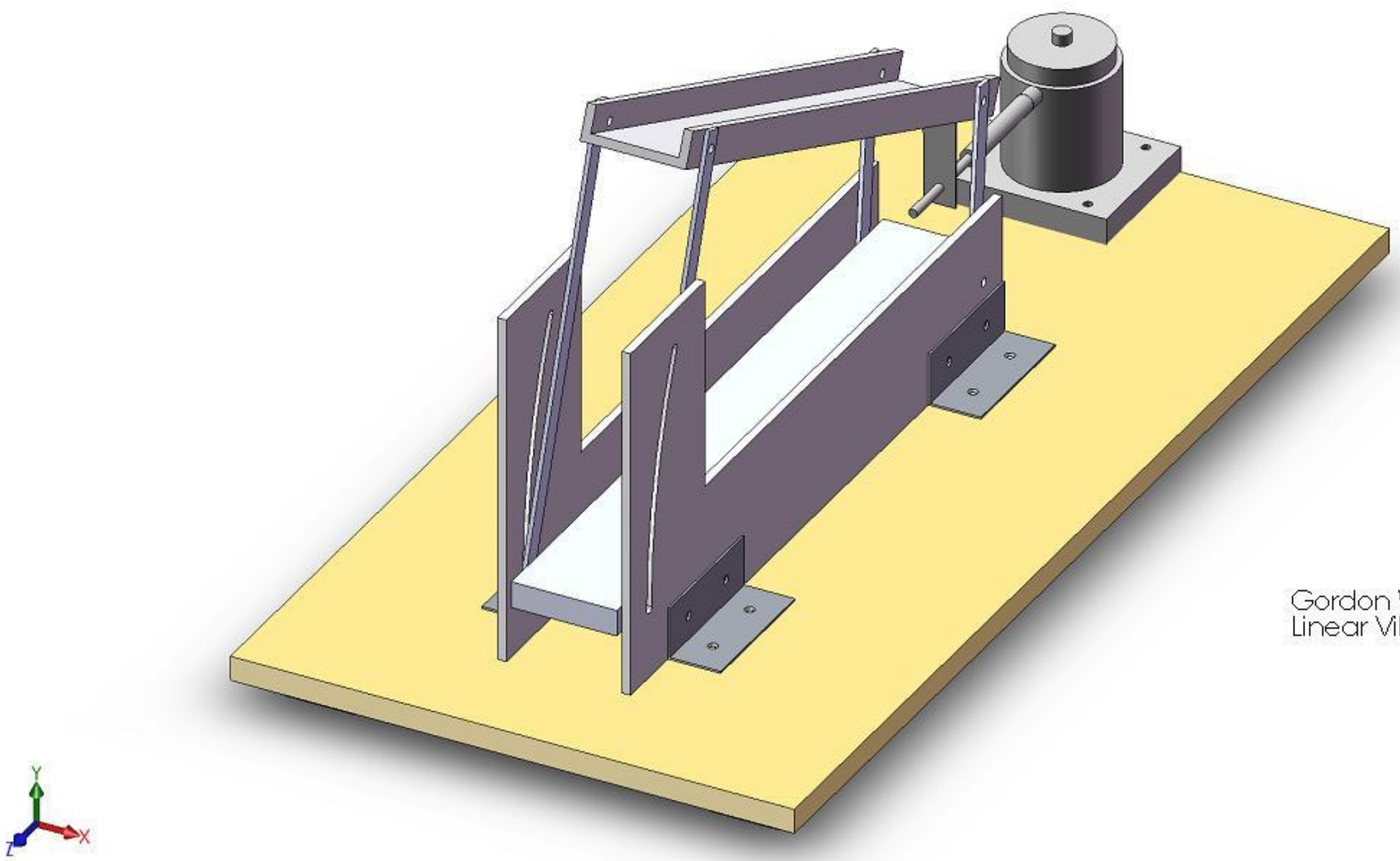
$\omega_{naluminum}(48in) = 30.975Hz$

Appendix B – Solidwork Drawings and Models

The following pages are a compilation of final versions of Solidwork drawings, and models (of individual parts and assembly).

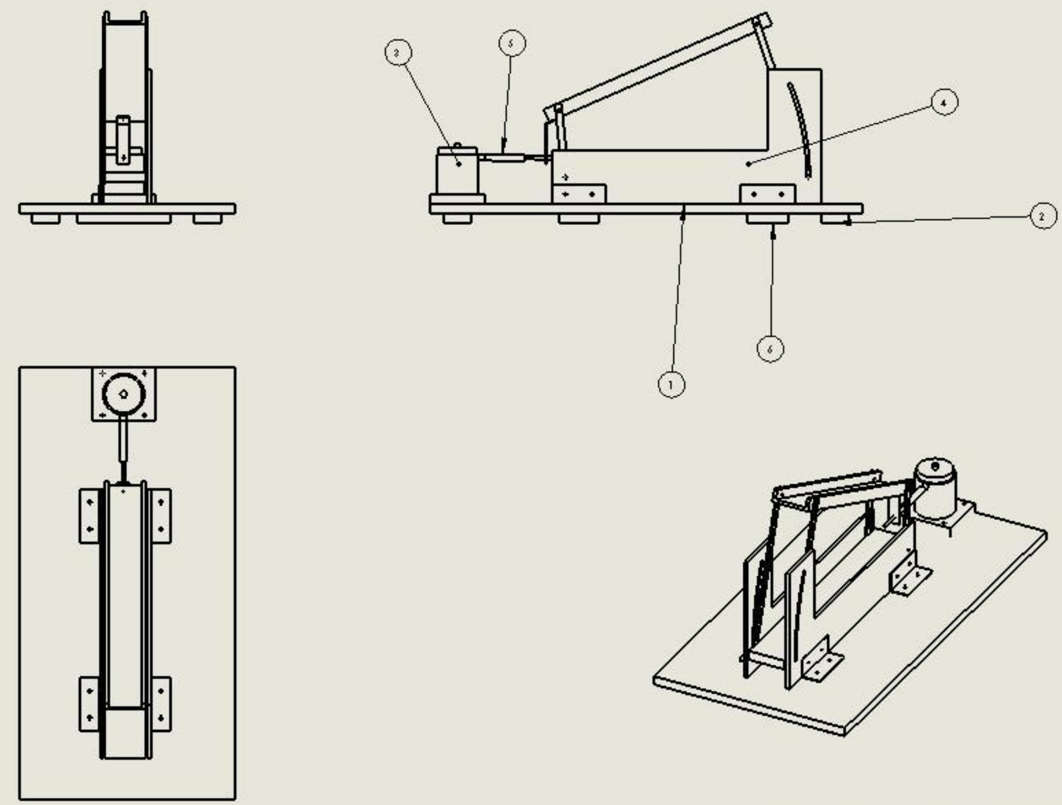
The stinger and the shaker are not shown because the objects haven't been physically seen. The model drawing of the shaker is taken from the manual that the shaker comes with.

Linear Vibration Feeder



Gordon Wong
Linear Vibration Feeder

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Base - 101	Base	1
2	Leg - 101	Leg	4
3	892071	Shaker	1
4	LA - 101	Linkage Assembly	1
5	Stinger	Stinger	1
6	LB - 101	Leg Block	2

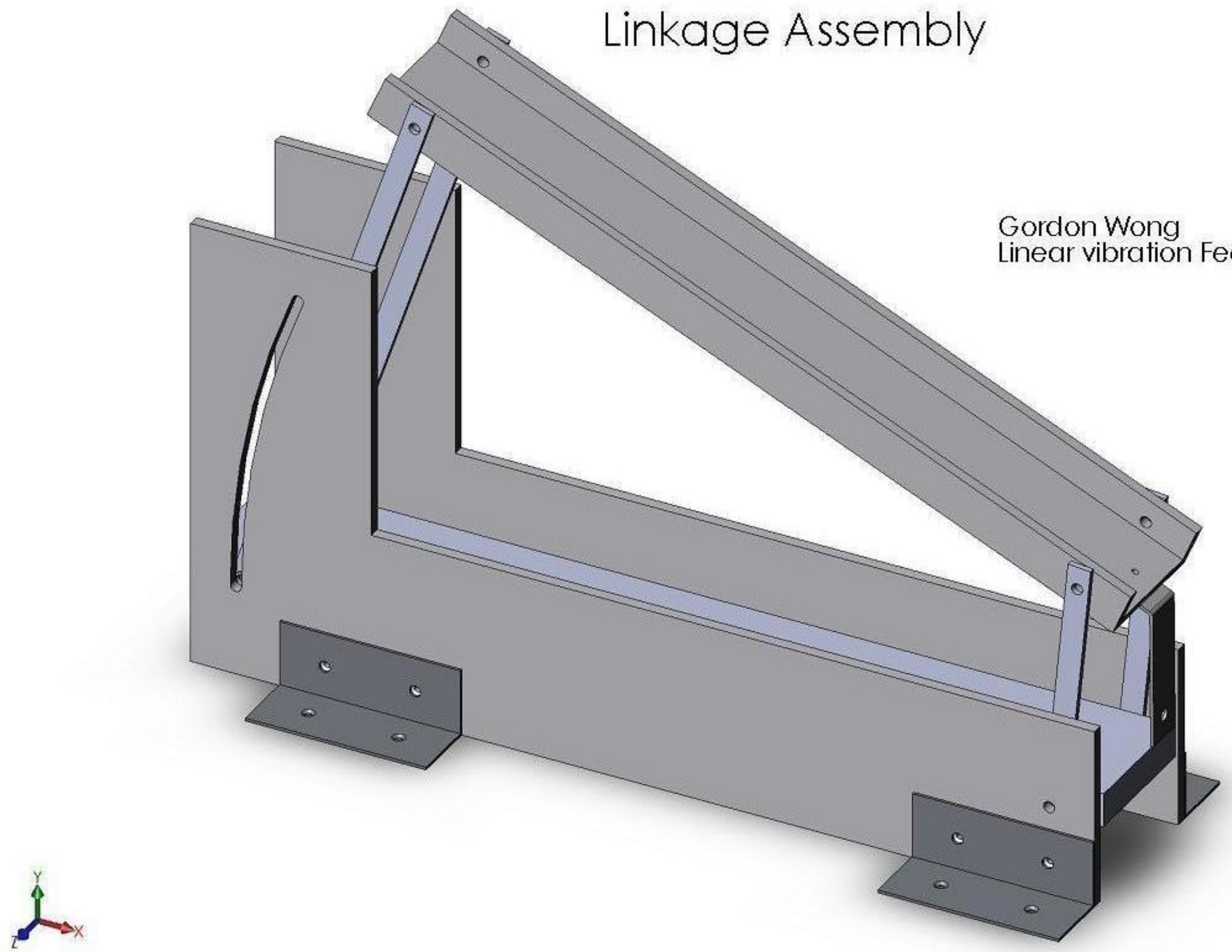


TITLE: Linear Vibration Feeder

SIZE C DWG. NO. LVF - 101 REV

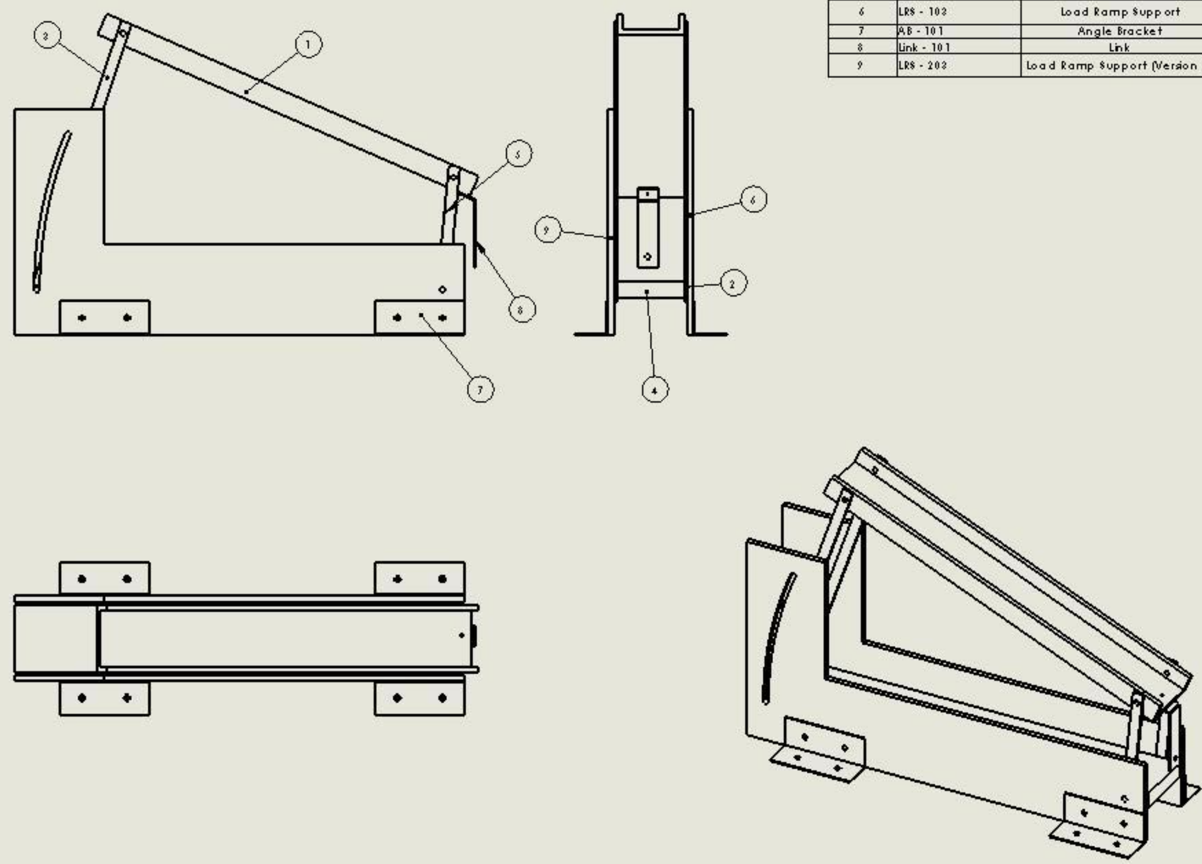
SHEET 1 OF 1

Linkage Assembly



Gordon Wong
Linear vibration Feeder

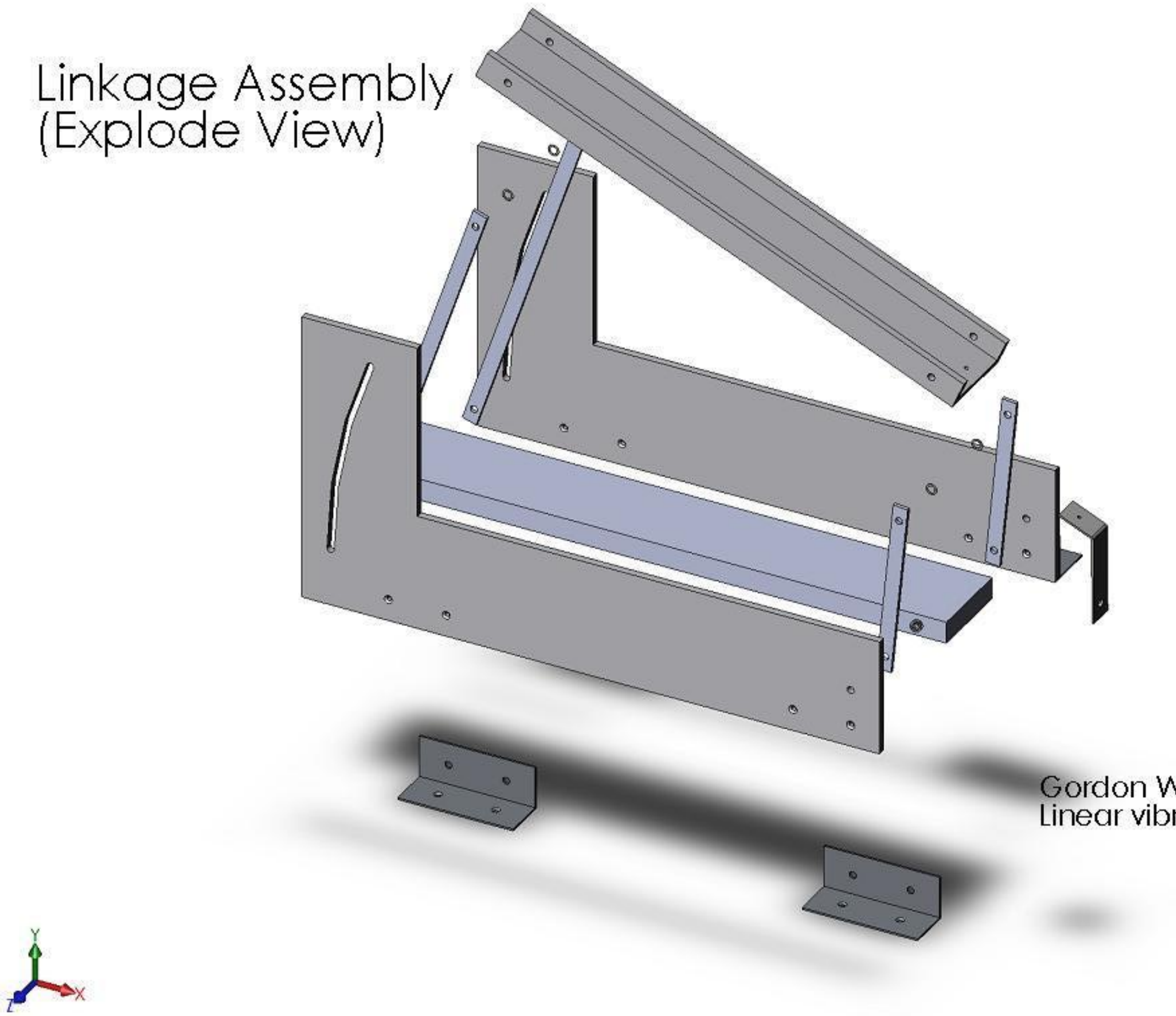
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	LR - 103	Load Ramp	1
2	2088A229	Spacer	12
3	LAL - 101	Linkage Arm (Long)	2
4	LRF - 102	Load Ramp Filler	1
5	LAS - 102	Linkage Arm (Short)	2
6	LRS - 103	Load Ramp Support	1
7	AB - 101	Angle Bracket	4
8	Link - 101	Link	1
9	LRS - 203	Load Ramp Support (Version B)	1



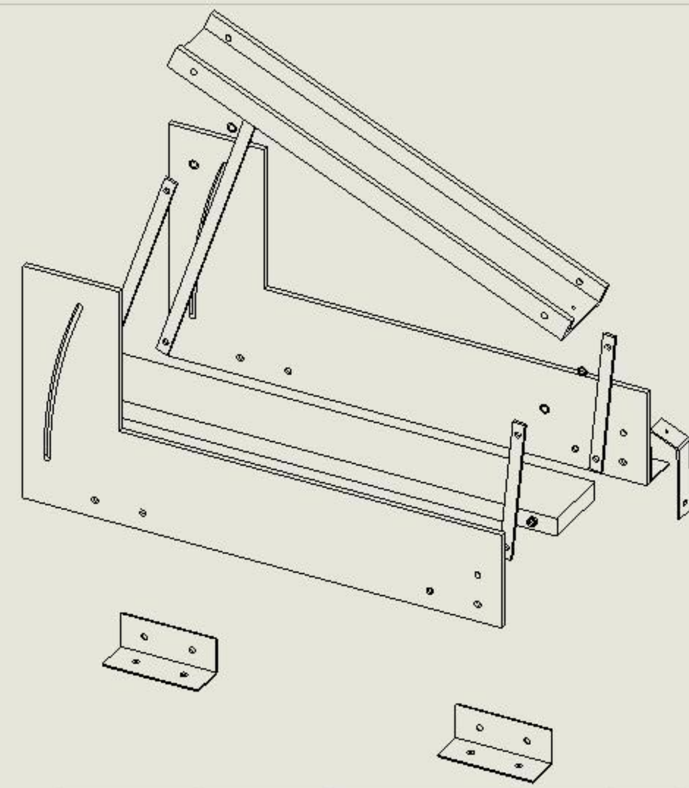
Linkage Assembly

C LA - 101

Linkage Assembly
(Explode View)



Gordon Wong
Linear vibration Feeder



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APPLICATION	

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GW	4/23/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

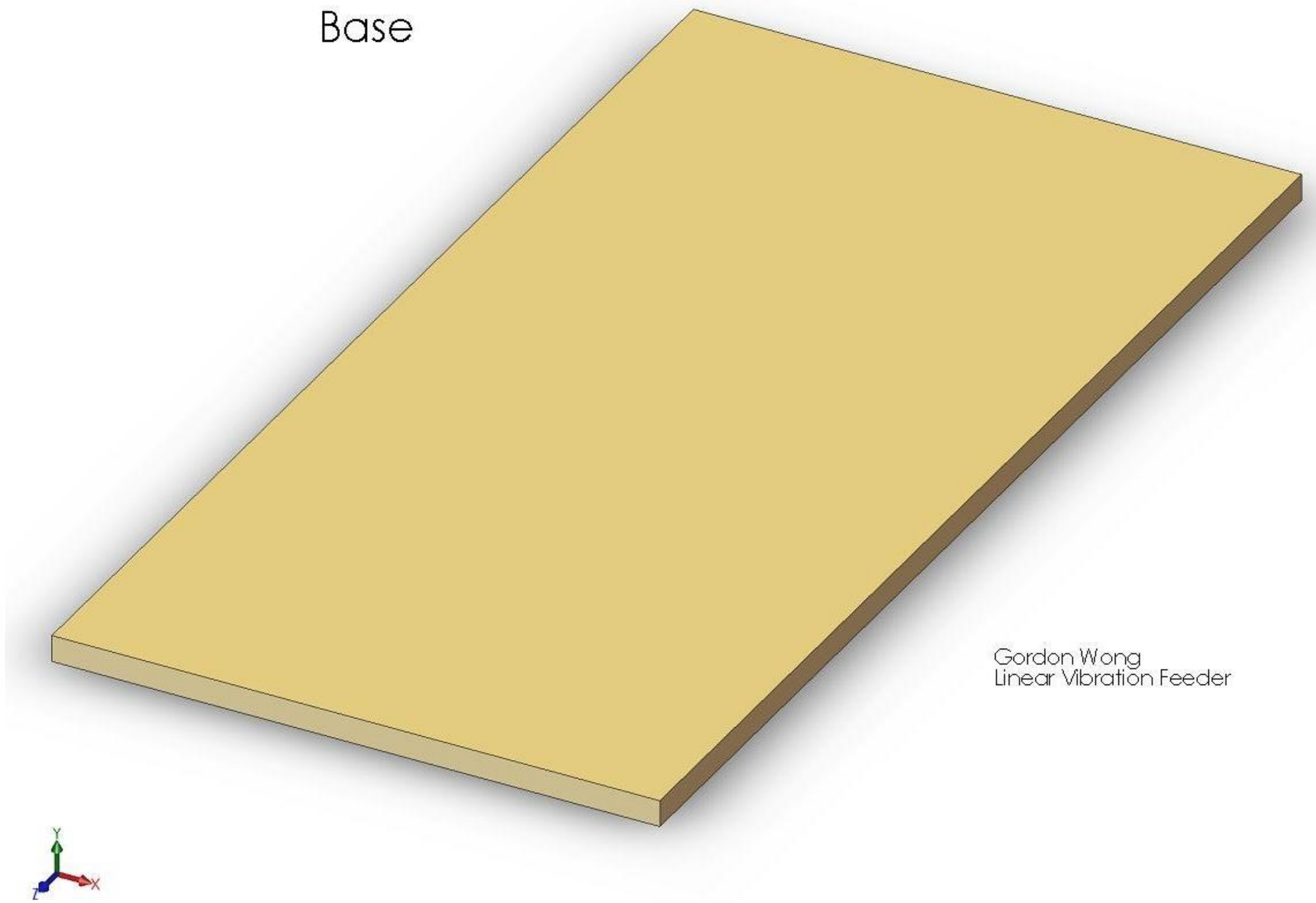
Linkage Assembly
(Explode View)

SIZE A DWG. NO. LA - 101 REV

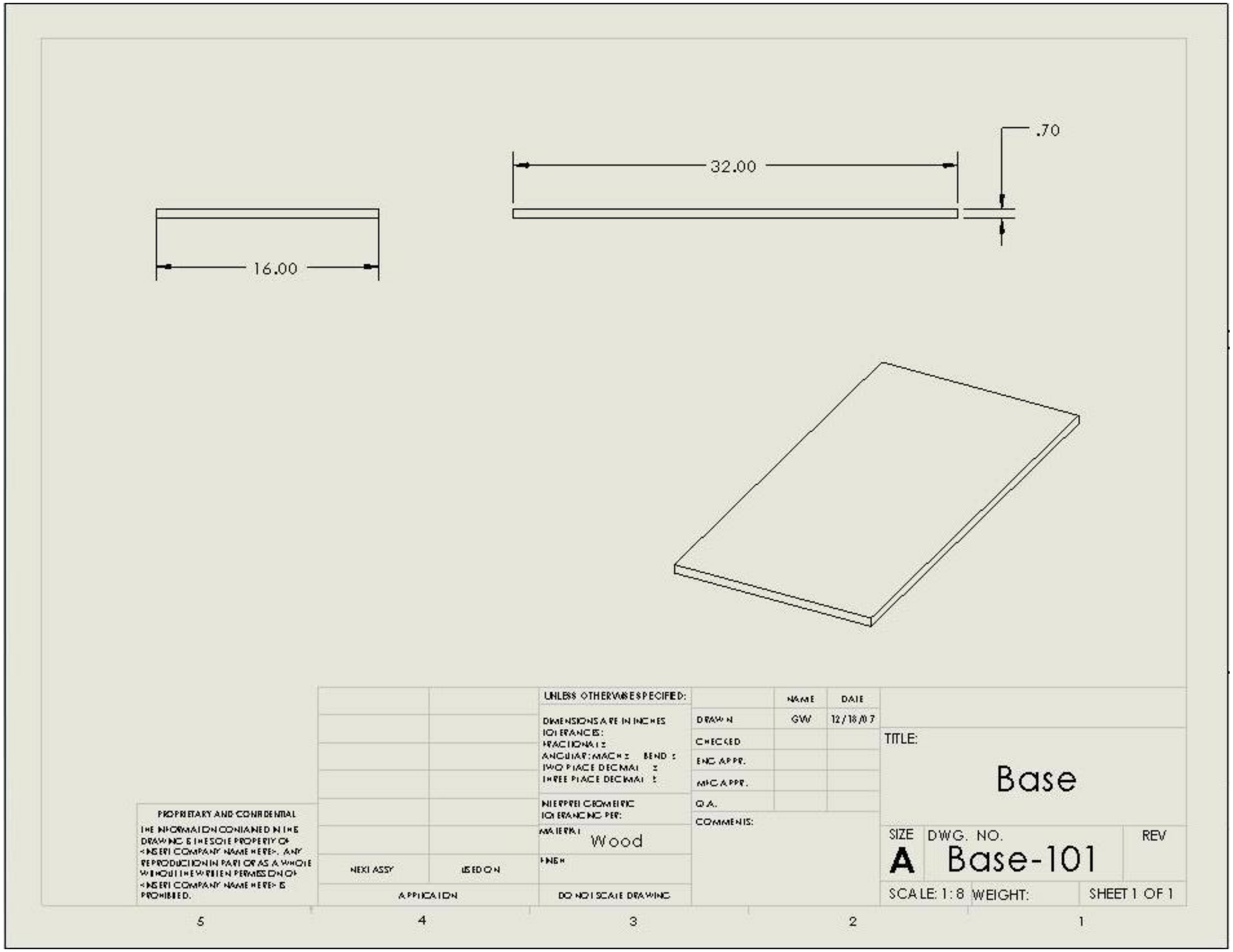
SCALE: 1 : 5 WEIGHT: SHEET 1 OF 1

5 4 3 2 1

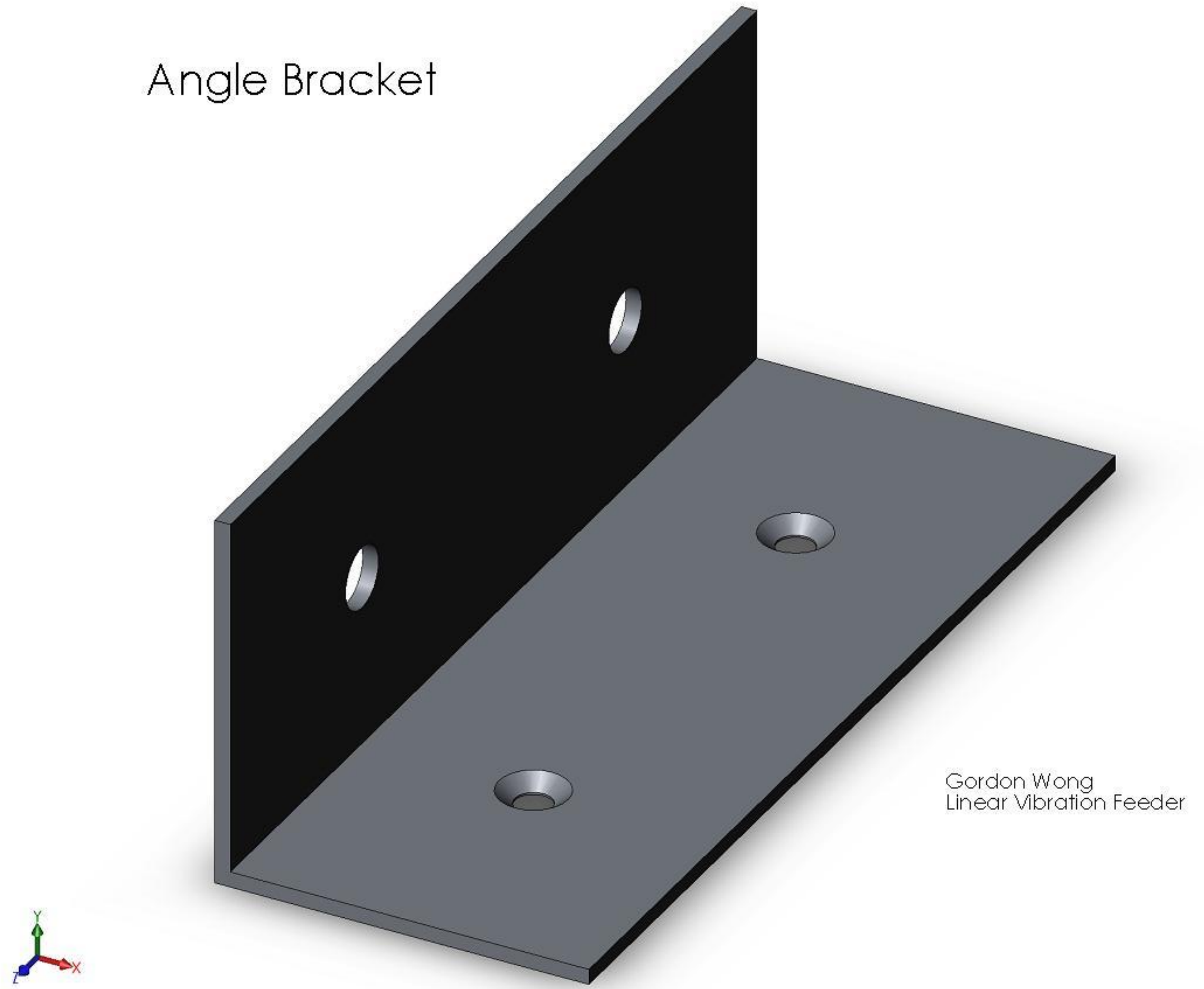
Base



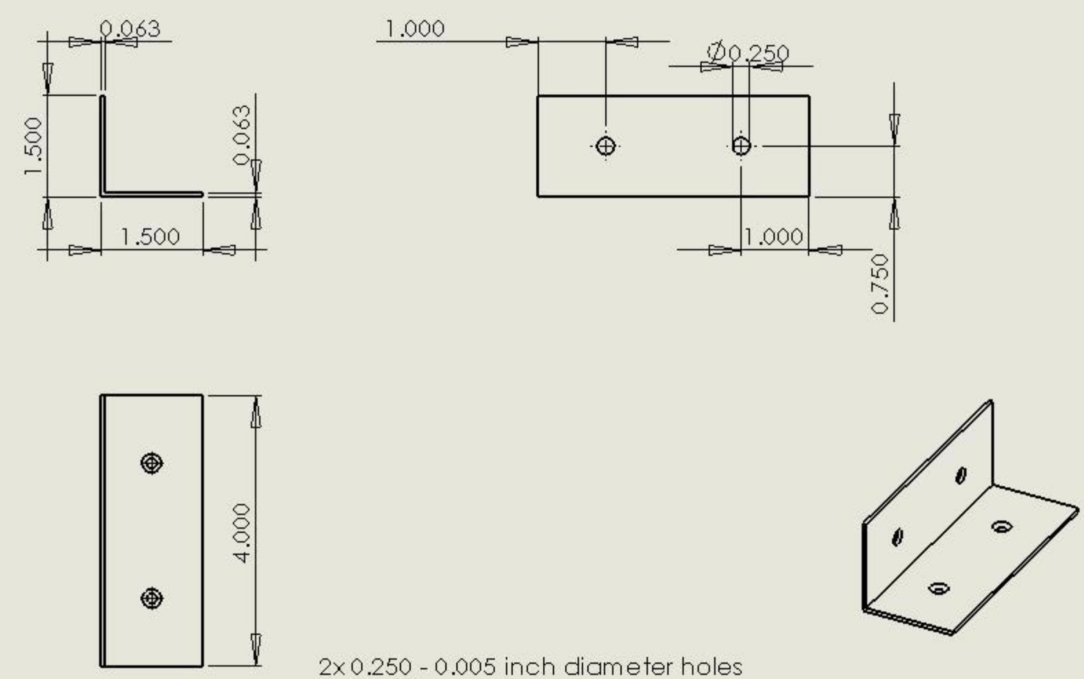
Gordon Wong
Linear Vibration Feeder


.70
32.00
16.00
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
NAME
DATE
DRAWN
GW
12/18/07
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
MATERIAL
Wood
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
TITLE:
Base
SIZE
A
DWG. NO.
Base-101
REV
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1

Angle Bracket



Gordon Wong
Linear Vibration Feeder



2x 0.250 - 0.005 inch diameter holes
2x #6-32 screw holes

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL 2024 Al

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GW	4/17/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

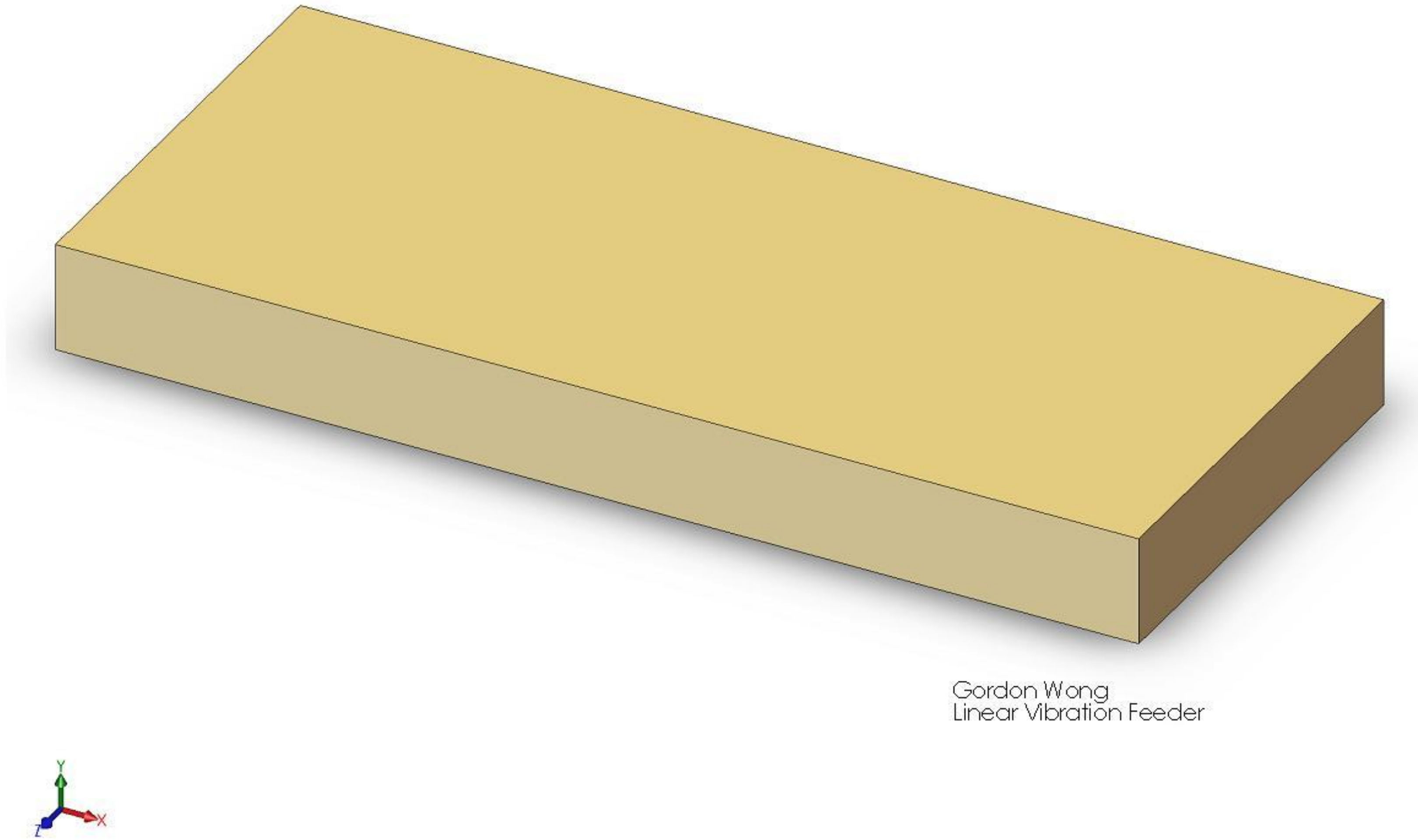
Angle Bracket

SIZE A | DWG. NO. AB - 101 | REV

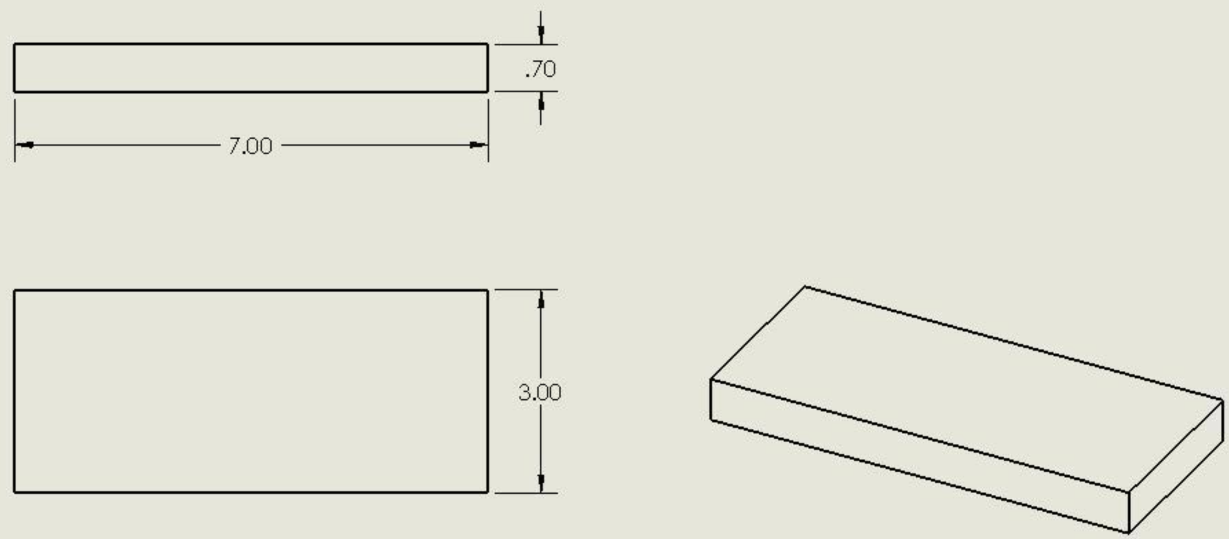
SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1

Leg Block



Gordon Wong
Linear Vibration Feeder



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APPLICATION	

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
Pine

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GW	4/24/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

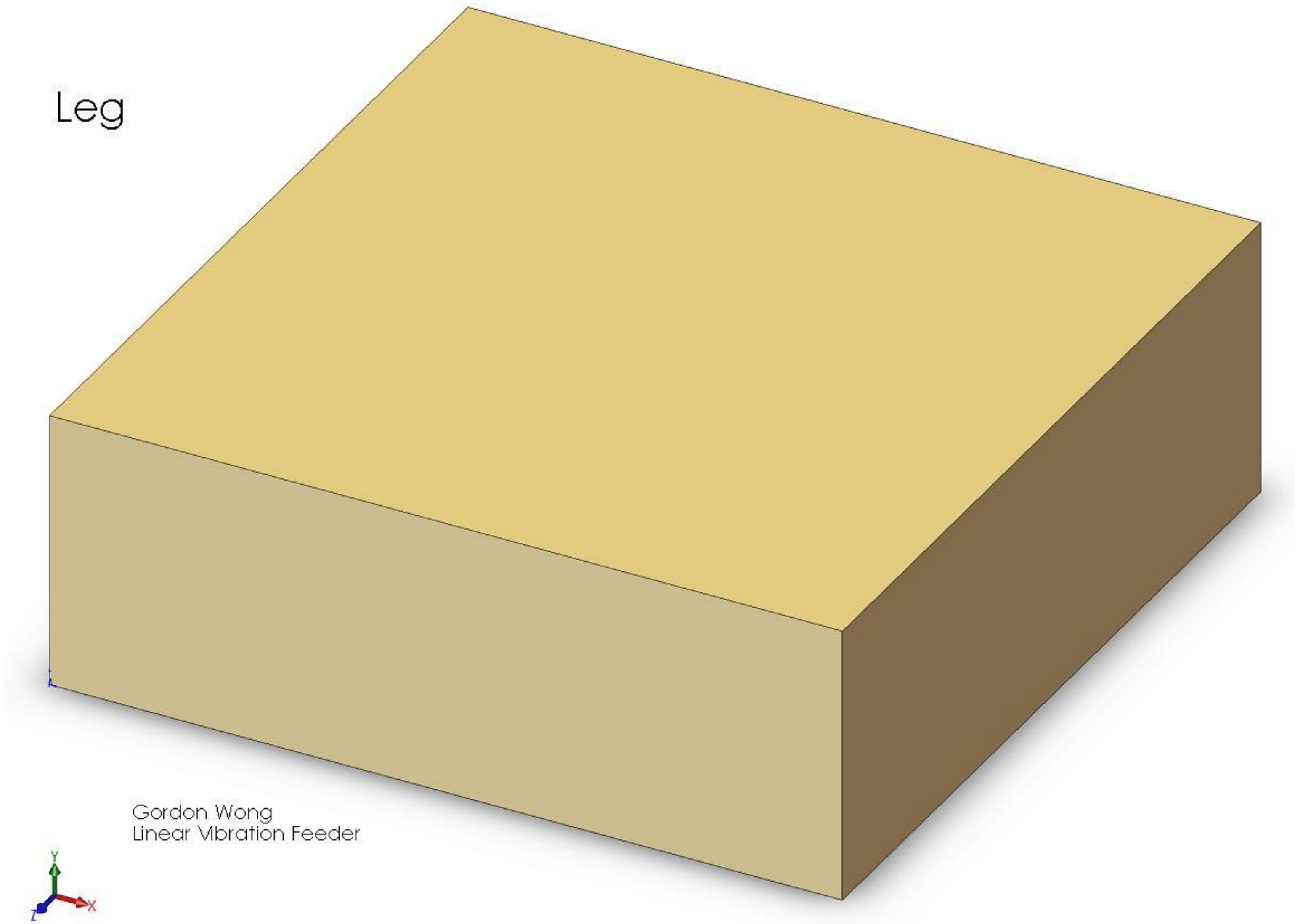
Leg Block

SIZE	DWG. NO.	REV
A	LB - 101	

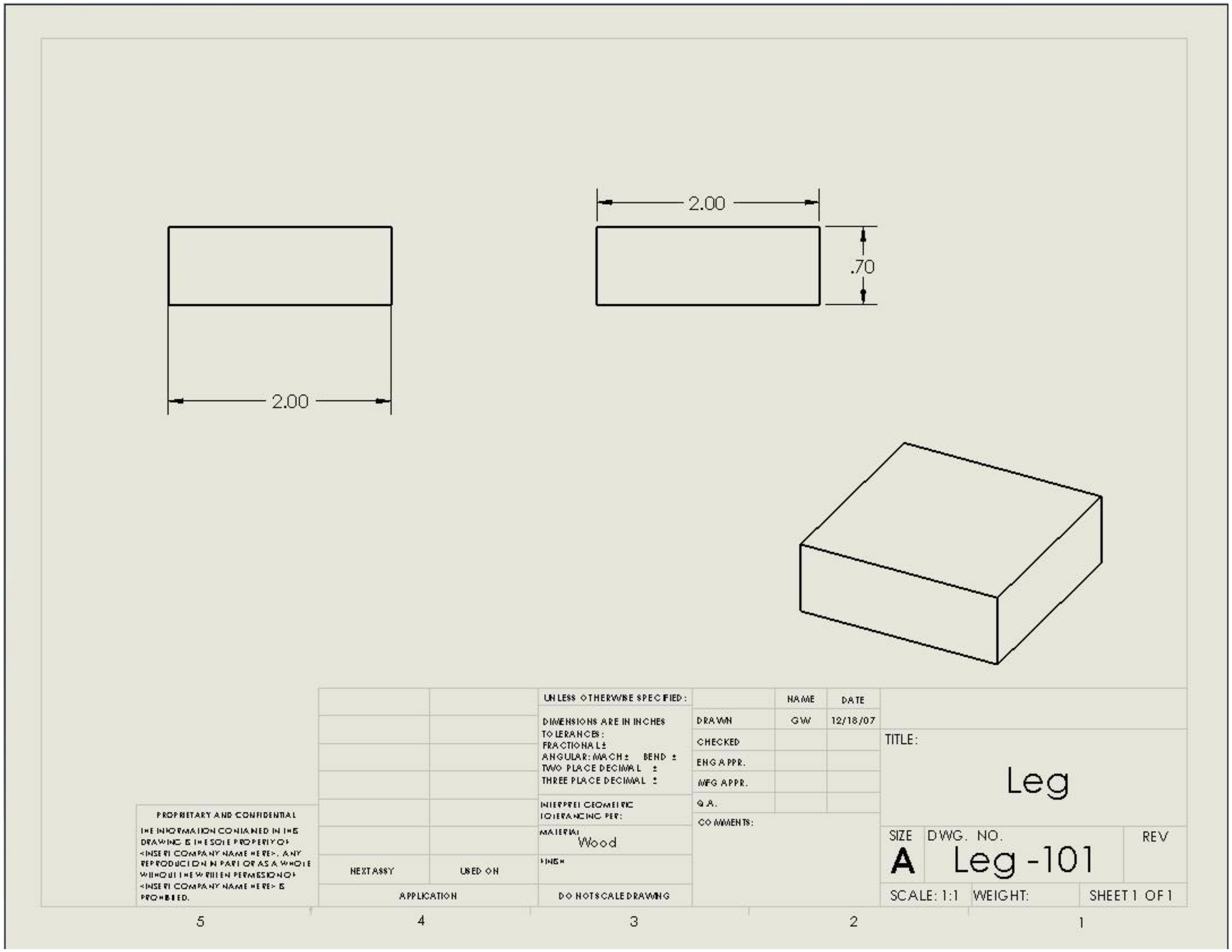
SCALE: 1:2 WEIGHT: SHEET 1 OF 1

5 4 3 2 1

Leg



Gordon Wong
Linear Vibration Feeder


2.00
2.00
.70
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
Wood
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
GW
12/18/07
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
Leg
SIZE
A
DWG. NO.
Leg -101
REV
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
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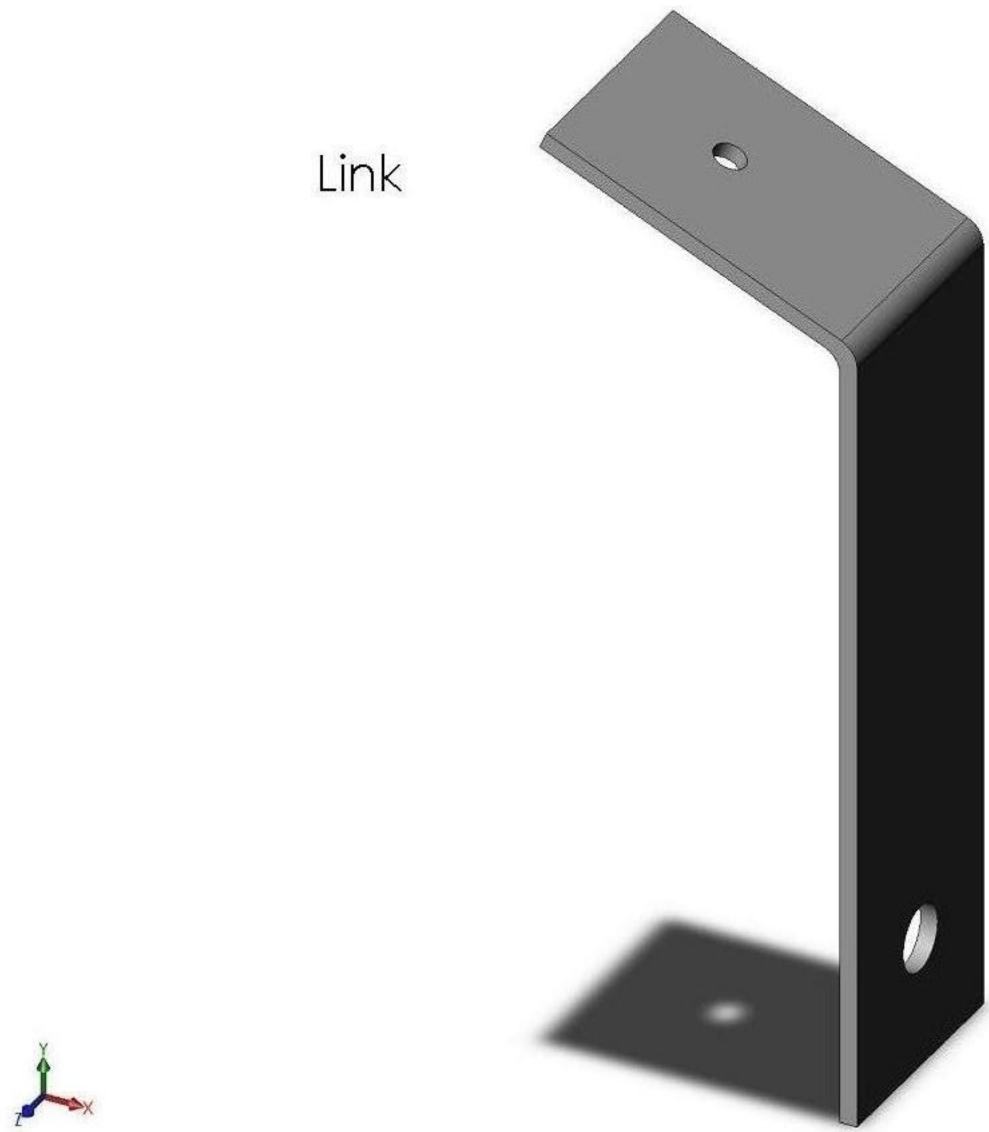
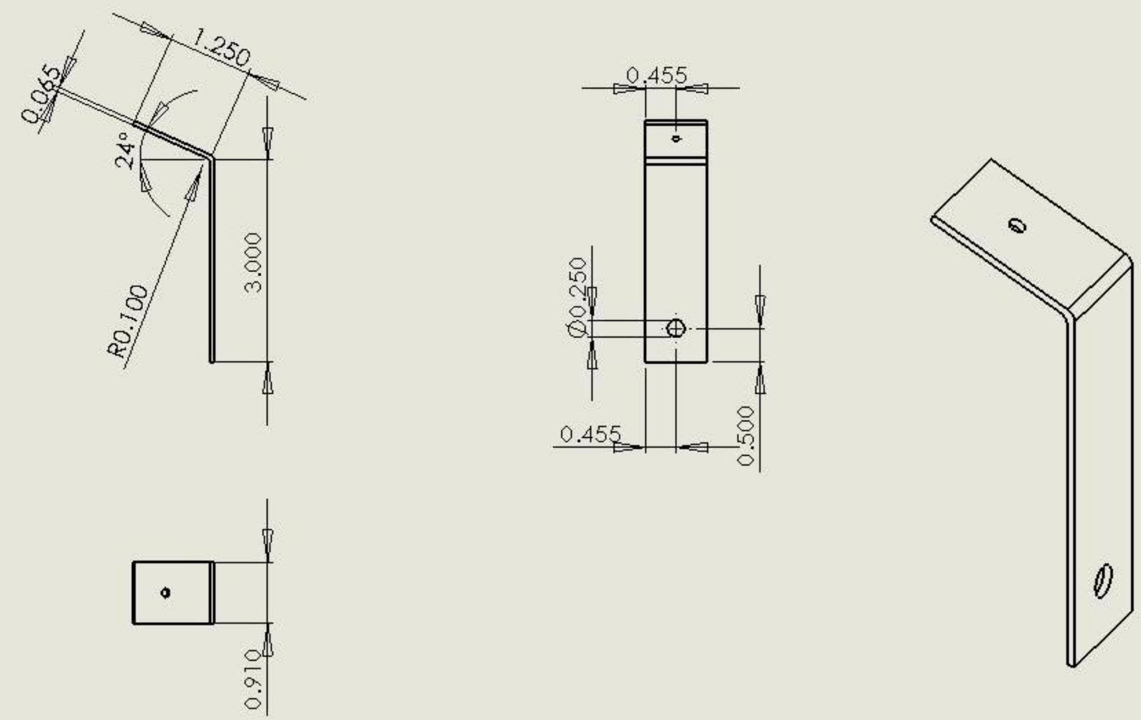
5
4
3
2
1

Link



Gordon Wong
Linear Vibration Feeder



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL 6061 Al
FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GW	4/23/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

NEXT ASSY | USED ON
APPLICATION

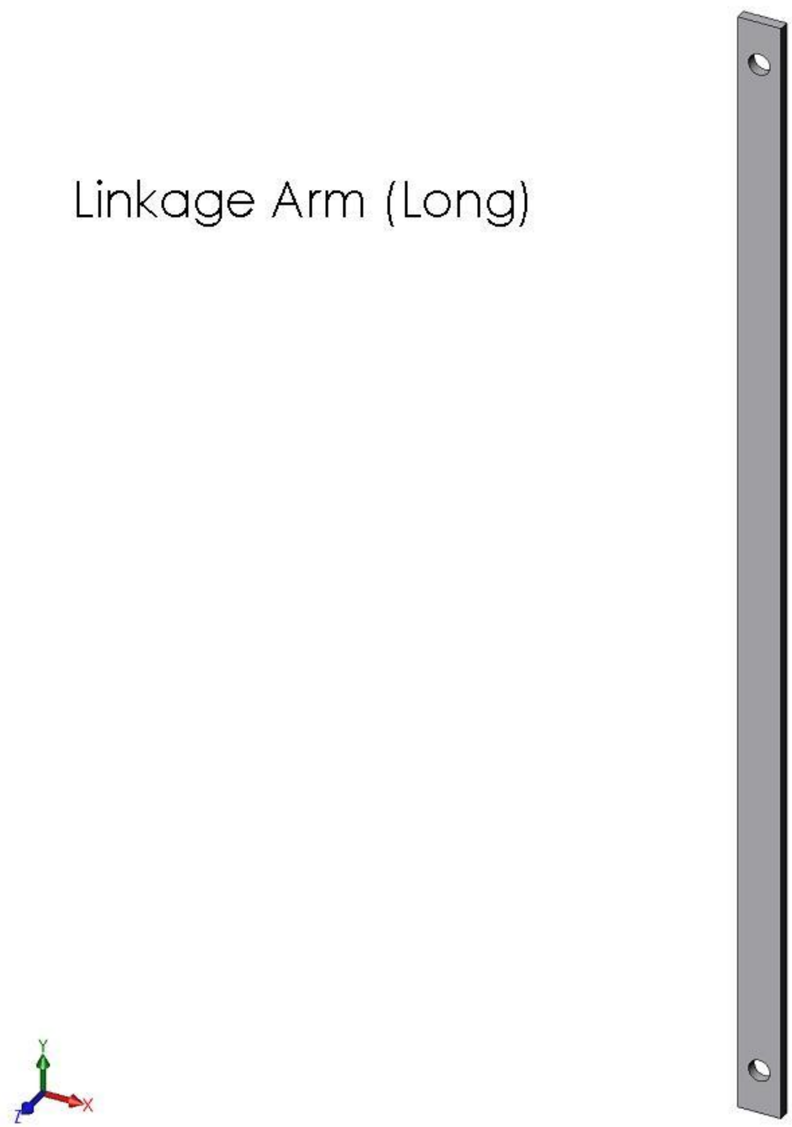
TITLE: Link

SIZE A DWG. NO. Link - 101 REV

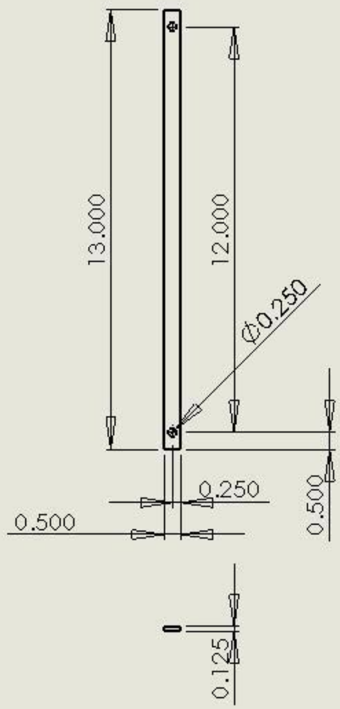
SCALE: 1:1 WEIGHT: SHEET 1 OF 1

5 4 3 2 1

Linkage Arm (Long)



Gordon Wong
Linear Vibration Feeder



2x 0.250 ± 0.005 inch diameter through hole

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APPLICATION	

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL 6061 Al

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GW	3/17/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

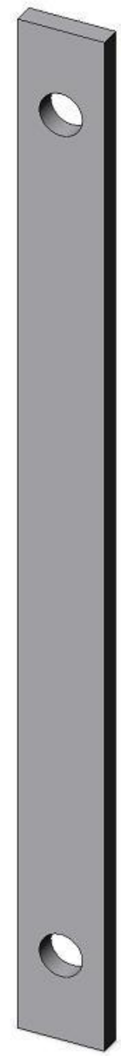
Linkage Arm (Long)

SIZE A DWG. NO. LAL - 101 REV

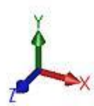
SCALE: 1:4 WEIGHT: SHEET 1 OF 1

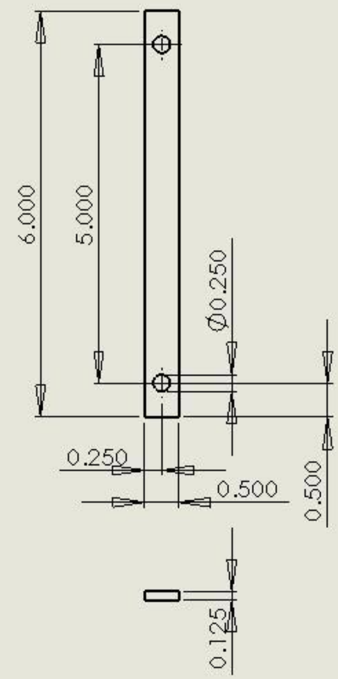
5 4 3 2 1

Linkage Arm
(Short)



Gordon Wong
Linear Vibration Feeder





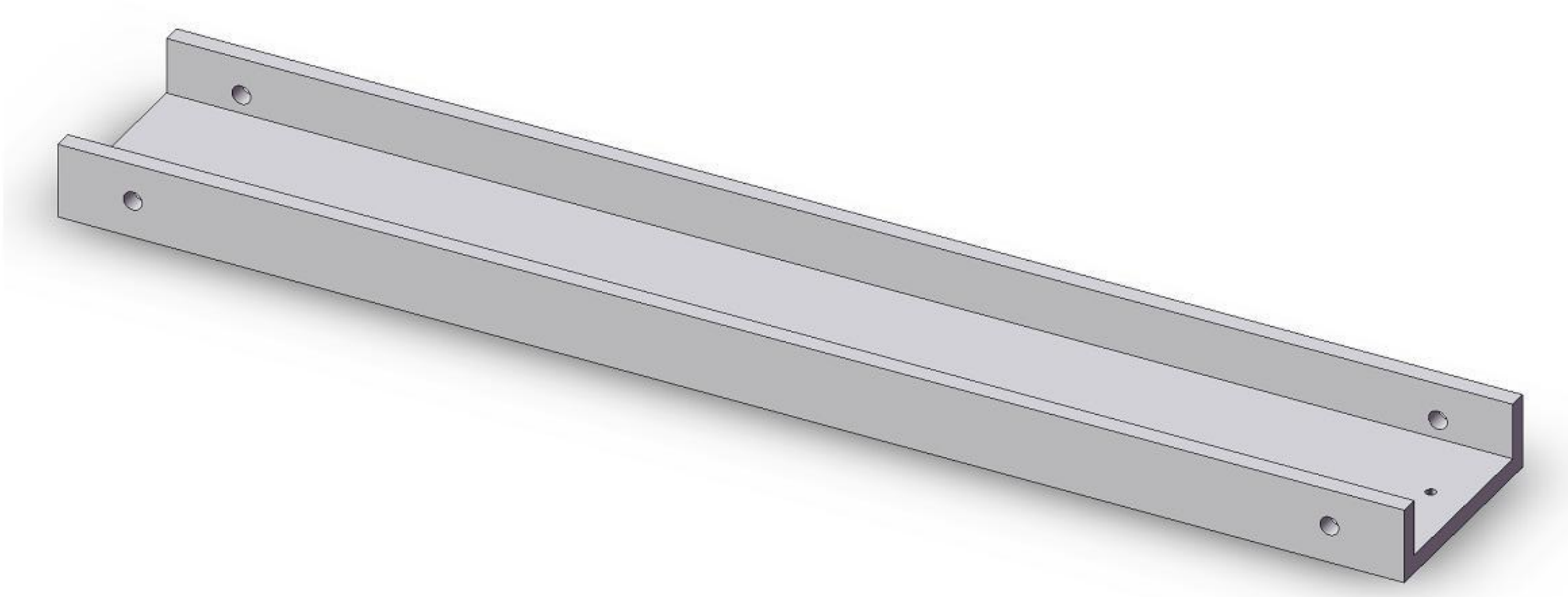
2x 0.250 ± 0.005 inch diameter through hole

UNLESS OTHERWISE SPECIFIED:		NAME	DATE		
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	GW	3/19/08	TITLE:	Linkage Arm (Short)
	CHECKED				
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 6061 Al	COMMENTS:			SIZE A	DWG. NO. LAS - 101 · REV
FINISH					
DO NOT SCALE DRAWING				SCALE: 1:2	WEIGHT: · SHEET 1 OF 1

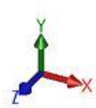
NEXT ASSY	USED ON
APPLICATION	

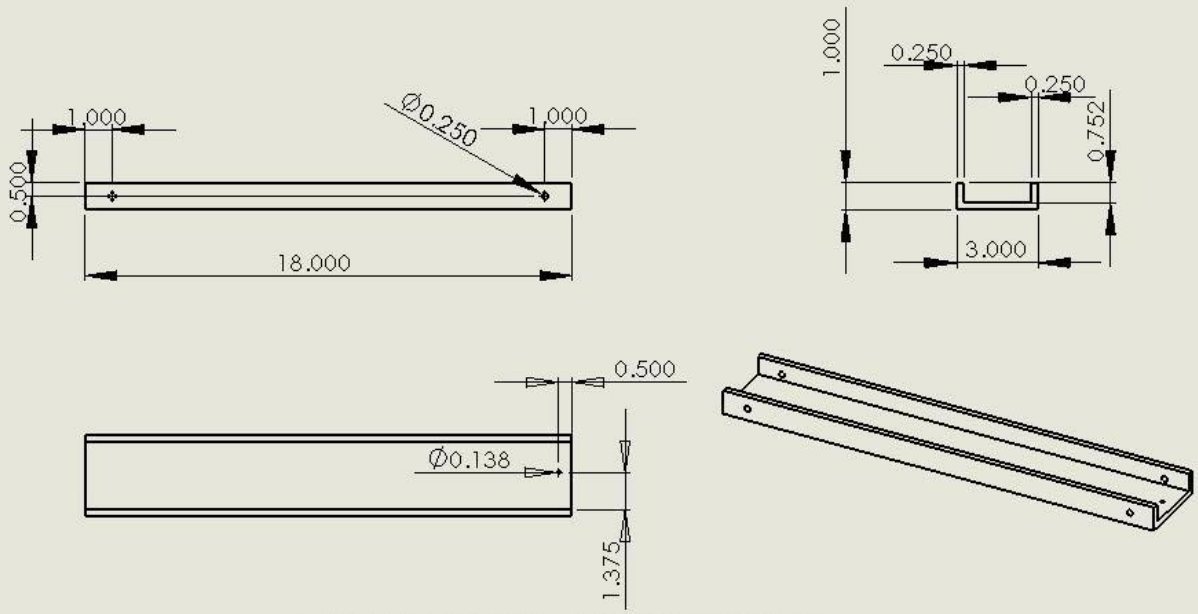
5 4 3 2 1

Load Ramp



Gordon Wong
Linear Vibration Feeder





2X 0.250 ± 0.005 inch diameter through hole
1X 0.138 ± 0.005 inch diameter through hole

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL 6061 Al
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GW	2/22/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:
Load Ramp

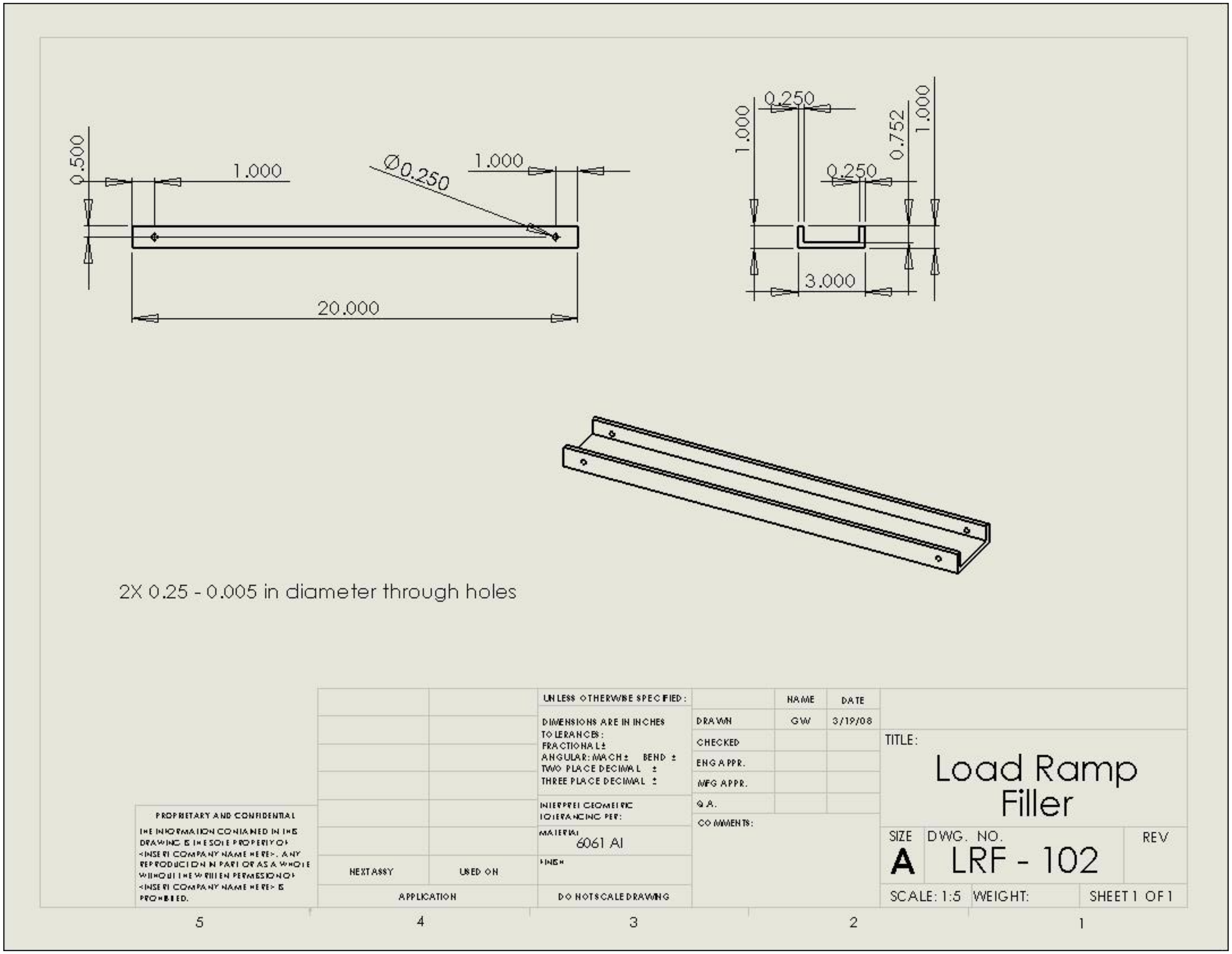
SIZE A DWG. NO. LR-103 REV

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

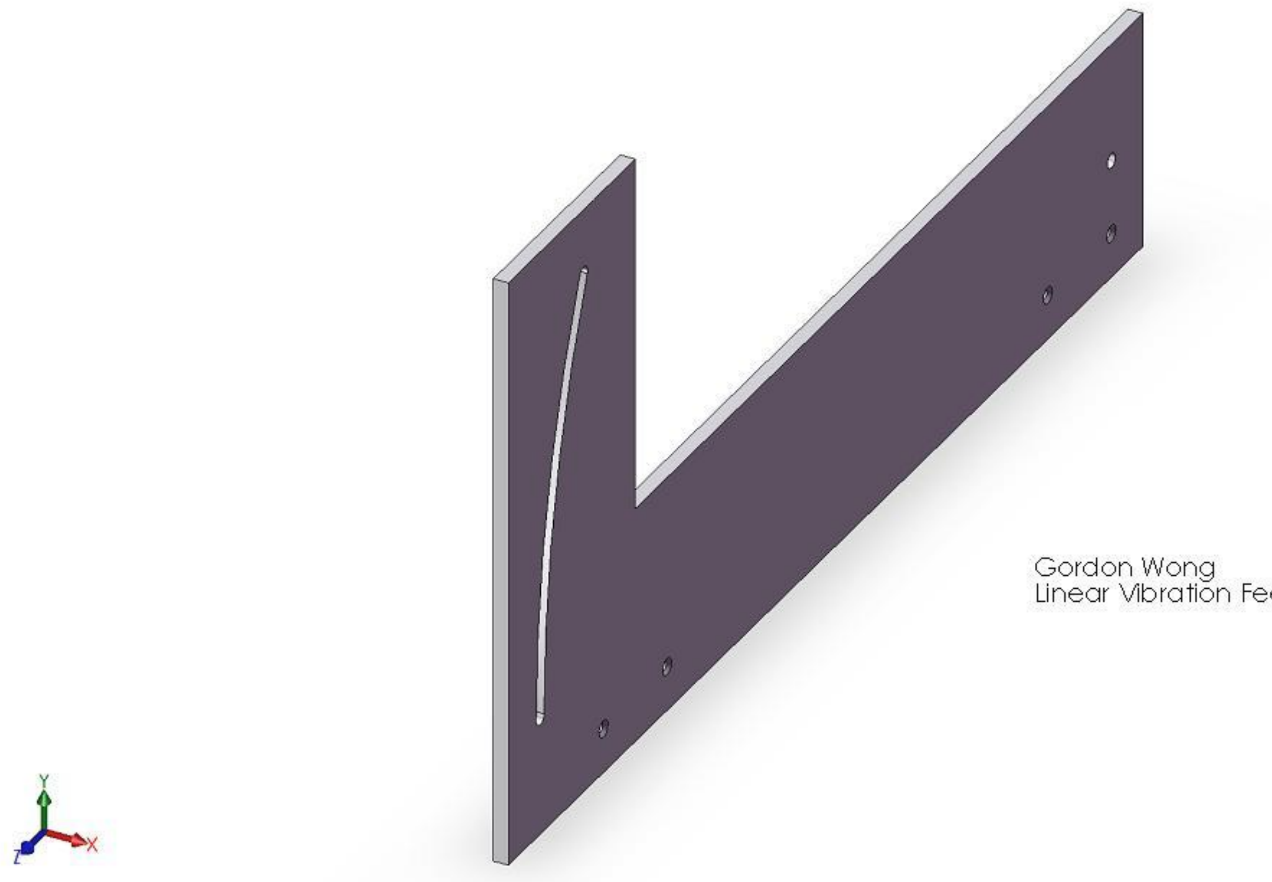
5 4 3 2 1

Load Ramp Filler

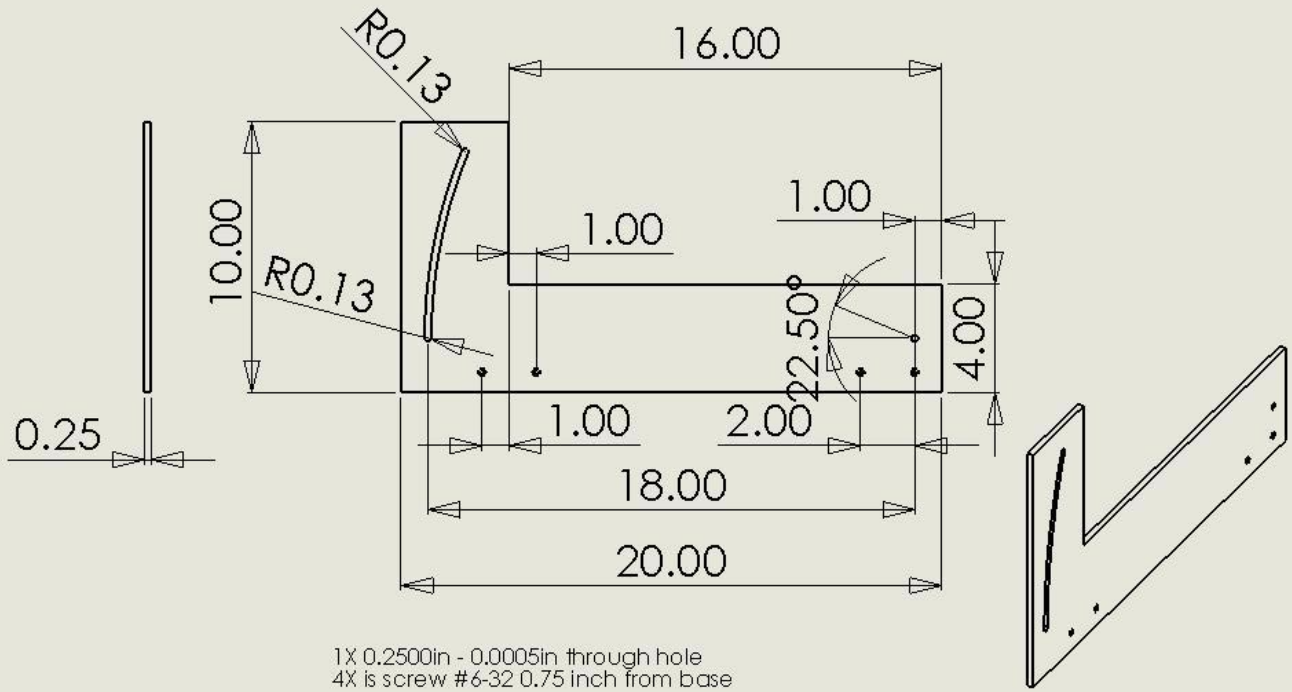
Gordon Wong
Linear Vibration Feeder


0.500
1.000
Ø0.250
1.000
20.000
0.250
1.000
0.752
1.000
0.250
3.000
2X 0.25 - 0.005 in diameter through holes
PROPRIETARY AND CONFIDENTIAL
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
MATERIAL
6061 Al
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
GW
3/19/08
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
Load Ramp Filler
SIZE
A
DWG. NO.
LRF - 102
REV
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1

Load Ramp Support A



Gordon Wong
Linear Vibration Feeder



1X 0.2500in - 0.0005in through hole
4X is screw #6-32 0.75 inch from base

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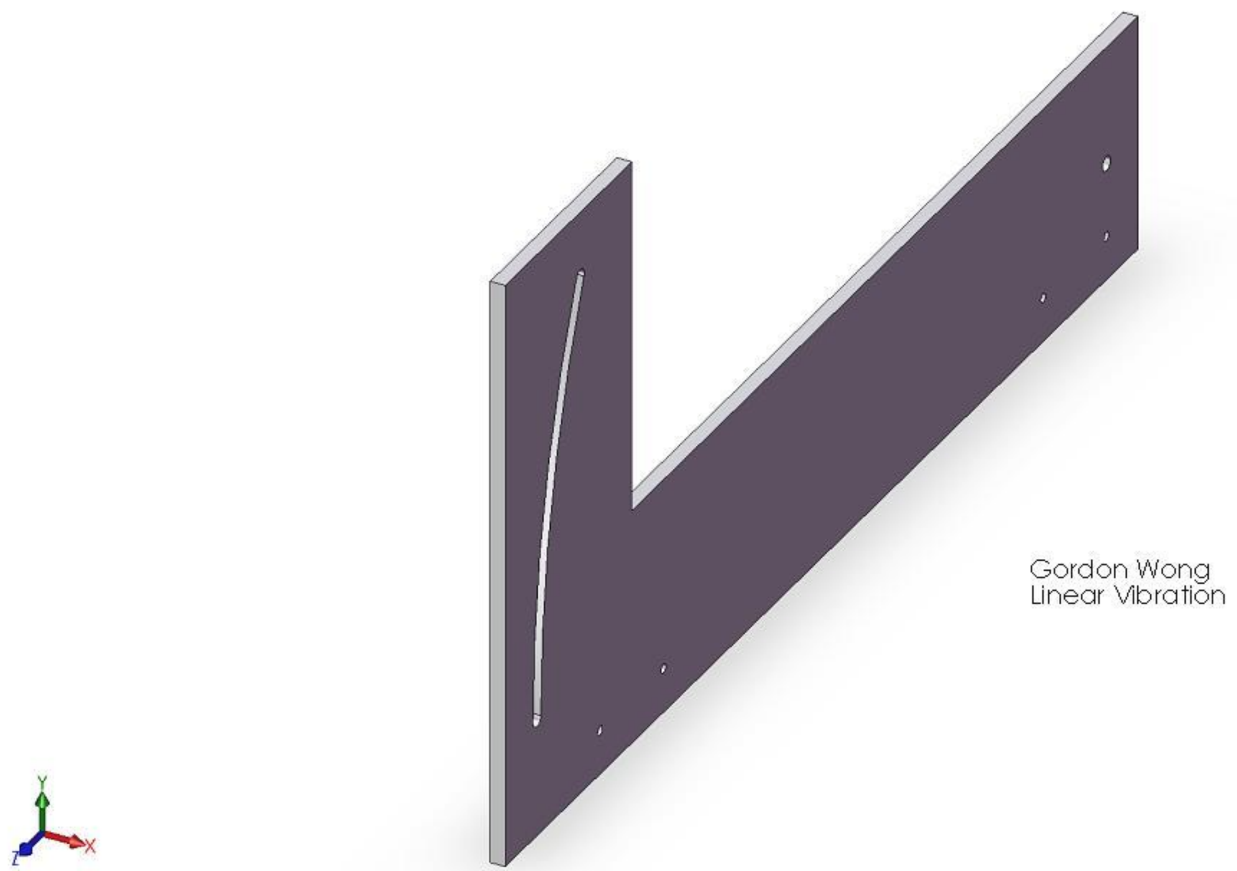
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	GW	3/17/08	TITLE:
	CHECKED			Load Ramp Support
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL 6061 Al	COMMENTS:			SIZE A · DWG. NO. LRS-103 · REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:5 · WEIGHT: · SHEET 1 OF 1

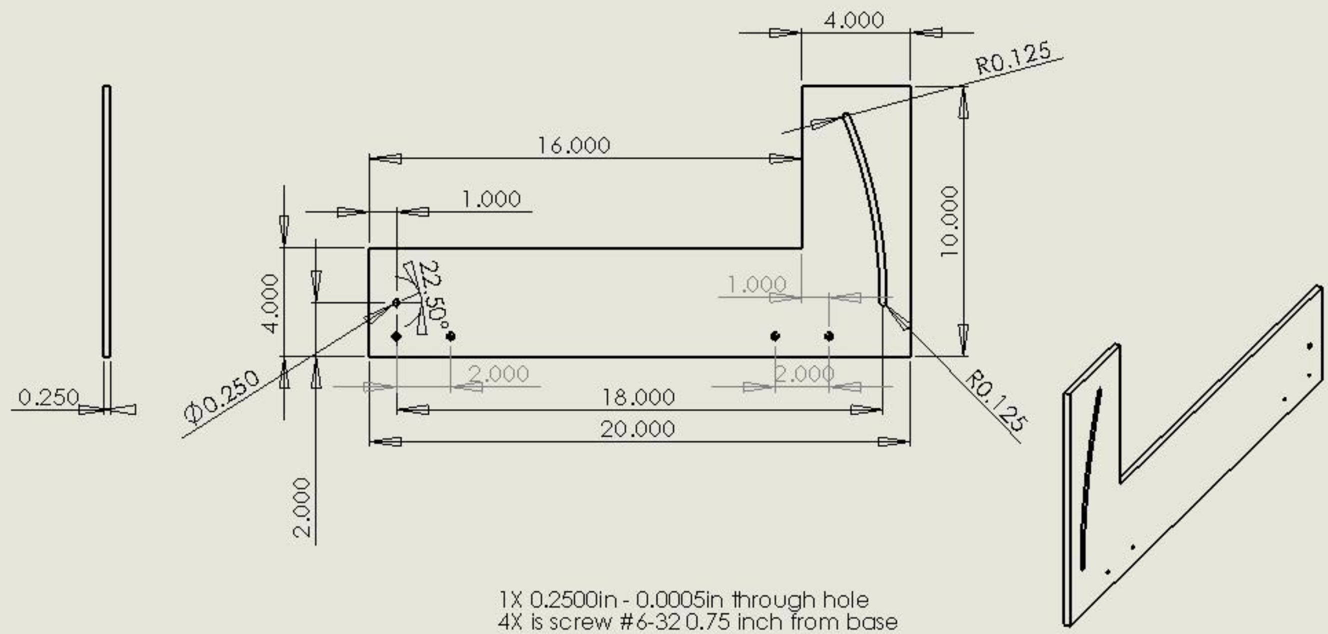
NEXT ASSY	USED ON
APPLICATION	

5 4 3 2 1

Load Ramp Support B



Gordon Wong
Linear Vibration Feeder



1X 0.2500in - 0.0005in through hole
4X is screw #6-32 0.75 inch from base

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TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
6061 Al
FINISH
DO NOT SCALE DRAWING

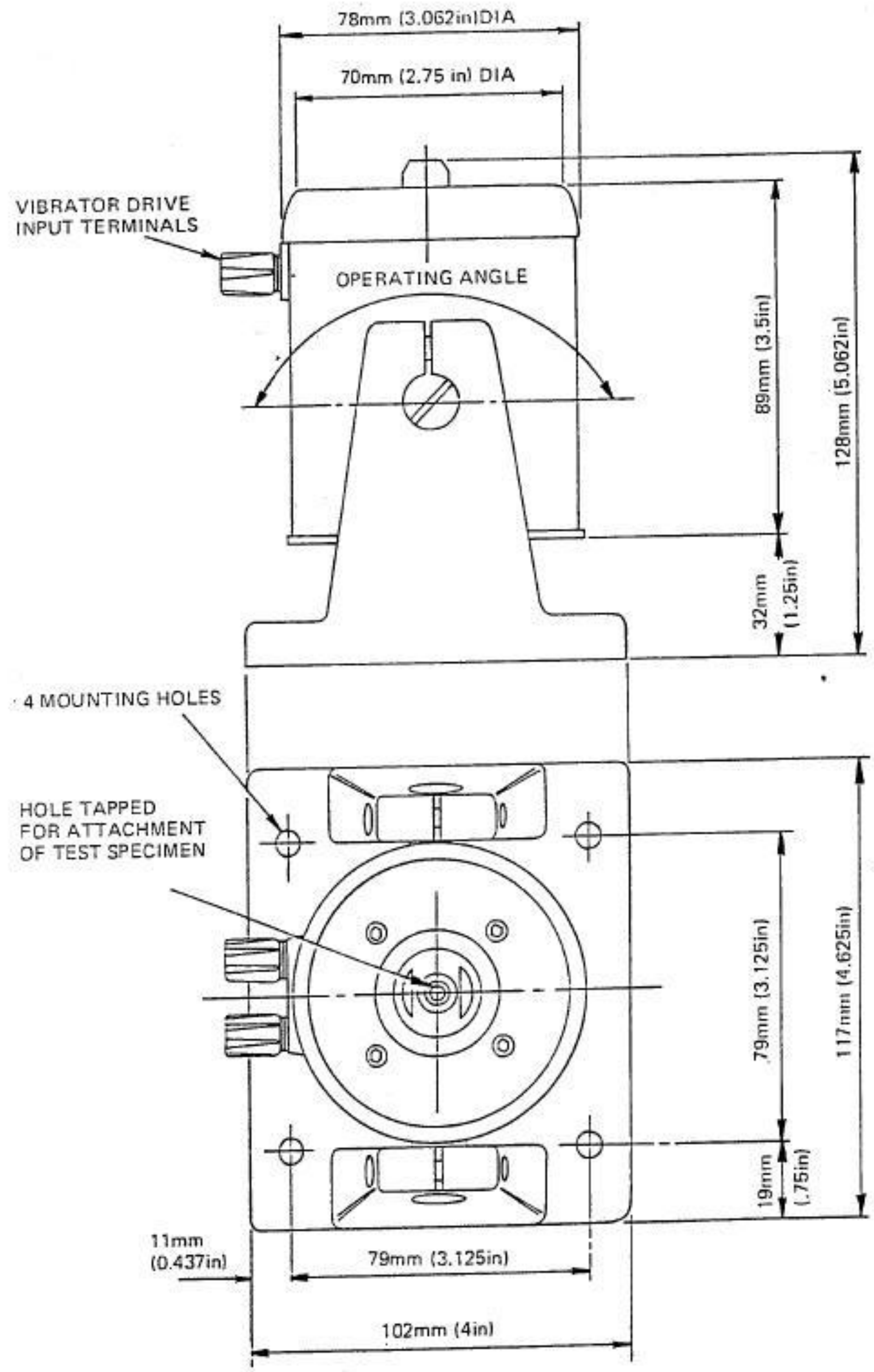
	NAME	DATE
DRAWN	GW	4/23/08
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:
Load Ramp Support B

SIZE	DWG. NO.	REV
A	LRS - 203	

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



Weight: Vibrator 1.8Kg (4.0 lb)
Trunnion 1.4Kg (3.1 lb)