LABORATORY NOTEBOOK

CORNELL MECHANICAL ENGINEERING MAE 2250

Computer Log In
en-Ma-2250
MAE=Spring 2011

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SCIENTIFIC NOTEBOOK COMPANY

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TITLE MAE 2250's Meteorite Catching Bridge Project

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Group 1: Jennifer Gass, Chian Yeh Goh, Lemay Perez, Rebecca Ventimiglia

2/7/11

Problem Statement: A NASA base on an asteroid has built a magnetic field generator in order to force meteorites to impact 1 mile away from the base. However, this has resulted in NASA's base to be surrounded by a gorge. As a result bridges spanning the 20 ft. wide gorge need to be built. A prototype for these bridges is to be built and tested. It should span the gorge, survive meteoritic strikes, and capture the meteorites (due to their value). Given specifications are that the meteorites strike with 6-8 Joules of kinetic energy and will damage if an acceleration of 60 G's or greater occurs. The materials available on the asteroid are timber and Elmer's glue.

2/10/11

Organize Dates and Timeline

- Deliverables Due Dates
  - Week 4 – Morphological Charts – 2/18/11
  - Week 5 – Preliminary Design Review – 2/25/11
  - Week 6 – Final Design Review/Presentations/Testing – 3/4/11
  - Week 7 – Turn in product development file – 3/11/11

2/11/11

Organize Group's First Meeting via Email

- Sent out an e-mail to 3 other group members requesting a meeting time and the best form of communication
  - Group decided to meet at 3pm on Sunday, February 13th in Duffield Artium.
  - Group agreed that e-mail and texting were best ways to communicate.
  - In addition to Sunday, group was available for meeting on Tuesdays and Thursdays

- Contact Information for Group members
  - Jennifer Gass – (jlg363) Phone: (845) 238-7584
  - Chian Yeh Goh – (cg357) (607) 379-4582
  - Lemay Perez – (lp269) (786) 338-3754

2/13/11

Group Meeting at 3pm in Duffield Atrium to Enter Phase 1 of Design Process!

- Tasks for the meeting: identify & prioritize customer needs, create numerical specifications/way to measure each task, produce needs matrix.
- Group agreed to think of ideas for morphological chart for next meeting on Thursday, 2/17/11 at 4:30pm in Duffield Atrium

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From Page No. 1

→ Task: Identifying Customer Needs from Customer Statements
Below are numbered customer statements with the group's interpretation.

① "The structure will be built entirely of fibrous materials provided by the instructors and Elmer's glue."
- The materials used to construct the bridge are not man-made materials. They are natural and have the characteristics of fibrous materials.

② "The structure must be lightweight"
- The structure minimizes material and maximizes strength so that it will not collapse due to its own weight.

③ "The structure must be simple to manufacture"
- All steps for assembly are easy to follow and it is clear how the structure comes together.

④ "The structure must be able to catch a baseball"
- The structure dissipates 6-8 Joules of kinetic energy when struck from above.

⑤ "The structure must provide a margin of safety"
- The structure reliably absorbs forces and energy which are a factor of the maximum

⑥ "The structure must be innovative"
- Proof of a detailed thought and decision making process leading up to the final design exist.

⑦ "The structure must be able to be used after catching the meteorite"
- The structure can withstand at least 3" of deflection (see "back of envelope calculations") without critical damage.

⑧ "The prototype must span 21" ± 1/4" and sit stably between two flat surfaces."
- The prototype structure is scaled to span 21" ± 1/4" and sit stably/statically without extra support between two flat edges.

⑨ "The meteoroid must not damage on impact"
- The final physical condition of the meteorite is the same as the initial; it can be reused.

⑩ "Baseballs almost always hit the center of the bridge."
- The structure is designed for impact close to the center of the structure.

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	2/17/11	Recorded By Rebecca Ventimiglia	2/17/11

From Page No. 2

(11) "Some" specialty shipments of materials ~~made~~ may be made, but requests must be 1 week in advance."
- The one week shipment period for special materials is accounted for when considering the structure's design and testing.

(12) "The meteorite cannot 'shatter' on impact."
The energy of the meteoroid is dissipated slowly so that it maintains it's original form.

— Task: Prioritize Customer Statements/Needs

	Priority	Customer Statement #
Highest	1	1, 8
↓	2	4, 7, 10
	3	5, 9, 12
	4	2, 3
Lowest	5	6, 11

— Task: Assign Metrics to Various Specifications/Parameters

Customer Needs	Metric	Priority	Units of Measurement
1, 2	Cost of Structure	4	Dollars ($)
8	Structure Length	1	Inches (in.)
2	Mass	4	Ounces (oz.)
3	Ease of Assembly	4	Subjective
10	Impact Location	2	Inches (in.)
9, 12	Rate of Energy Dissipation	3	Pounds Force feet per second ($\frac{lbf \cdot ft}{s}$)
4	Energy Absorbed	2	Pounds force-feet (lbf·ft)
7	Maximum Deflection of Impact Point	2	Inches (in)
5	Safety Factor	3	Dimensionless ($\frac{\text{Actual Failure Pt.}}{\text{Designed Failure Pt.}}$)
6, 11	Planning & Organization	5	Percentage of Deadlines Met

— Task: Create a Needs vs. Metric Matrix to Focus Design Process Priorities
The matrix created by the group is found attached to the next page.

— Meeting Adjourned at 5 pm & matrix is distributed to group via e-mail.

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Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	2/17/11	Rebecca Ventimiglia	2/17/11

TITLE NAE 2250: Bridge Design Project

From Page No. 3 Attached is the Needs-Metric Matrix created at the group meeting on 2/13/11

Needs \ Metric	Cost of Structure	Mass	Ease of Assembly	Energy Absorbed	Safety Factor	Maximum Deflectional Impact Point	Structure Length	Impact Location	Time Management/ Planning	Rate of Energy Dissipation
Structure is only made of natural and fiberous materials	x									
Structure minimizes material and Maximizes strength	x	x								
All steps for assembly are easy to follow			x							
Structure must be able to dissipate 6-8 Joules of kinetic energy when struck from above				x						
Structure absorbs forces and energy which is a factor of the maximum					x					
Proof of a detailed process leading up to the final design exists									x	
Structure can withstand at least 3" deflection without critical damage						x				
The prototype must be scaled to span 21" ± 1/4" and sit stably without extra support							x			
The final physical condition of the meteroid is the same as the initial/ can be reused										x
The bridge is designed for impact close to the center								x		
The one week shipment period for special materials is accounted for when considering the structure's design and testing									x	
The energy of the meteroid is dissipated slowly so that it maintains it's original form										x

Group 1: Needs-Metric Matrix

To Page No. 5

Witnessed & Understood by me, Rebecca Ventimiglia Date 2/17/11

Invented by

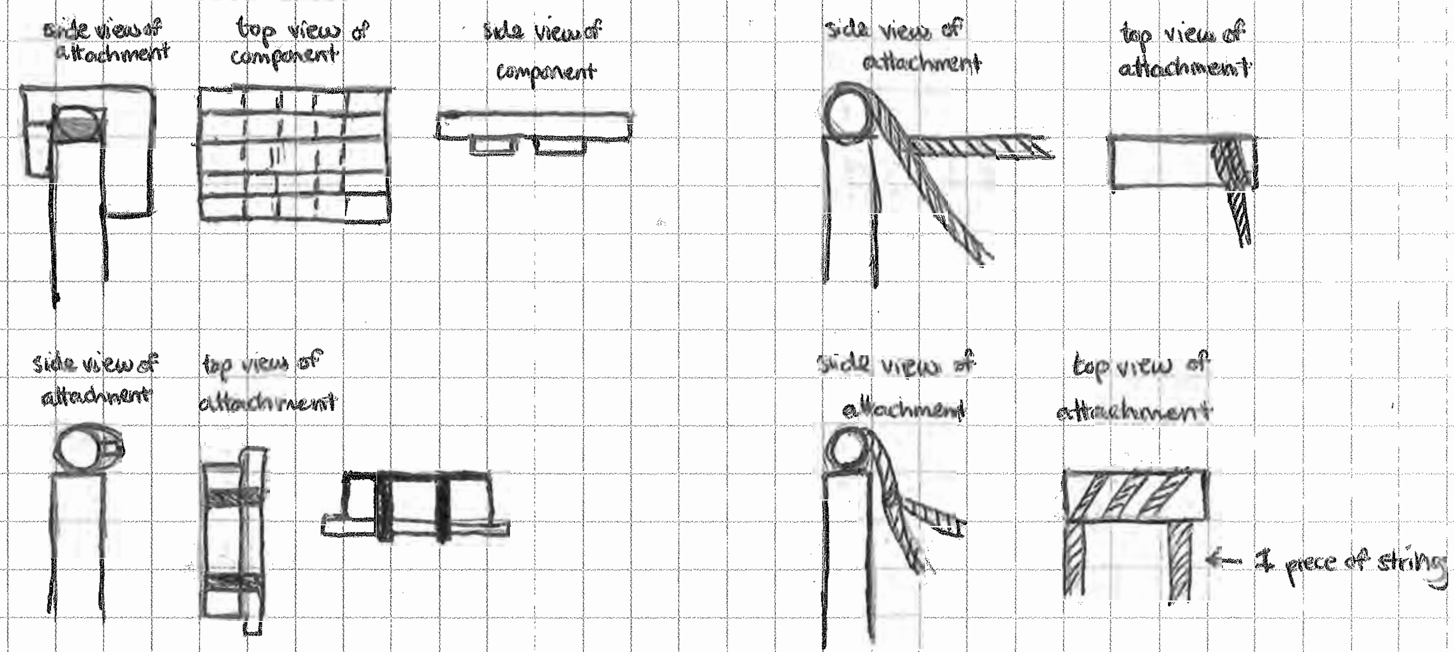
Recorded By Rebecca Ventimiglia Date 11/17/11

TITLE MAE 2250: Meteorite Catching Bridge

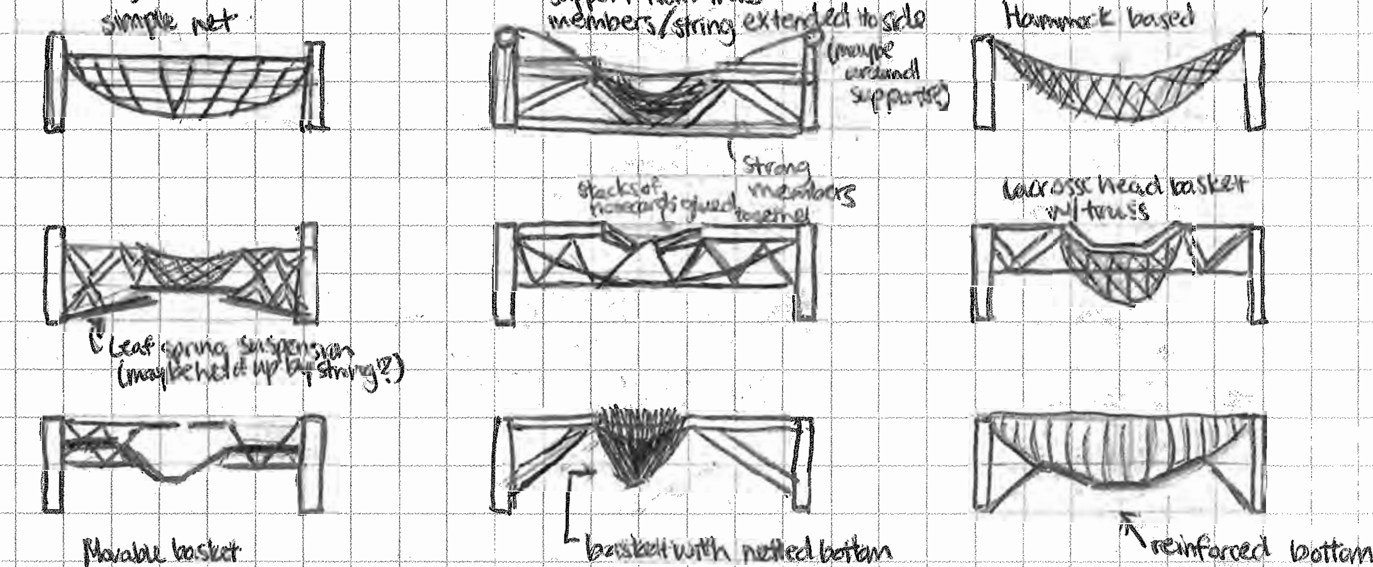
From Page No. 4

2/17/11 - Sketches / Various Ideas / Preliminary Brainstorming for Morphological Chart

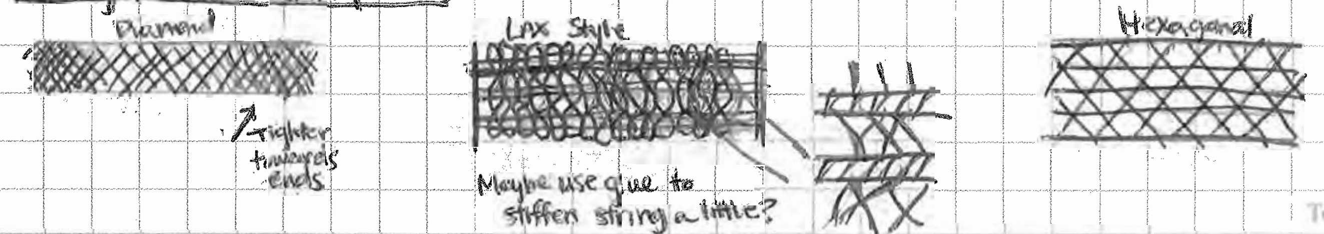
Attachment Variations



Catching Variations



Netting Variations (All Top View)



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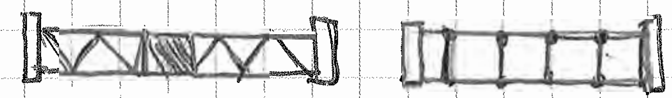
Witnessed & Understood by me, Rebecca Ventimiglia | Date 2/18/11 | Invented by | Recorded By Rebecca Ventimiglia | Date 2/18/11

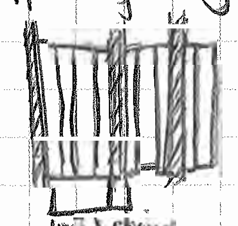
From Page No. 5

Possible Top Views of Bridge



Side Views

Encorperating String



2/17/11

Meeting with Group at 4:30 in Duffield Atrium.
- Group discussed ideas & concepts for morphological chart & put the ideas into a list formats

List of Ideas for Morphological Chart

Fibrous Materials
- Stir Sticks - Small Sticks - glue - small clips - medium clips - napkins
- Notecards - Printer Paper - Cotton String - Card Stock

Attachment
- Attachments
- Wrap string around support - Build latching clip - Bar attached with rubberbands

Latching Mechanism
- Breakpoint with wooden sticks - Cover hole with thick paper - layers of supporting napkins
- Suspended bowl - Funnel-like structure - Paper balls at bottom for dissipation
- Suspension Bridge design - Curved ramped walls of net

Netting
- Weaved paper - Diamond weaving - lacrosse head weaving - basket of paper strips

Joints
- Notched bars - Tieing the bars together w/string - Fold over paper on bars
- Glue the joints together

Top of Bridge
- Truss-like structure on top - Tie the Sides of the Truss together

Using these ideas, a morphological chart complete with sketches was made. The morphological chart can be found in Jen Gass's notebook. (See page 27)

Group agreed to discuss further designs in lab section tomorrow, Friday Feb. 18th, 2011.
Questions to ask TA:
- What are the clips and small sticks on the materials list
- What is meant by sit stably? Can we attach string to supports?
- What the baseball's dimensions

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	2/18/11	Recorded By Rebecca Ventimiglia	2/18/11

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– Additional Information Added to Problem Statement

- Teams start with (at no cost) : 100 stir sticks, 2 bottles of glue, 2 box small clips, ½ box med. clips
- Budget (not to be exceeded) : $1.50

Costs of Materials

Items	List Price	Cost
Napkins	4.99/500 ct.	$.01 per
Notecards 3x5	1.79/100 ct.	$.018 per
5x8	3.99/100 ct.	$.04 per
Paper 8.5x11	5.29/500 ct.	$.01 per
Stir Sticks	2.50/500 ct.	$.005 per
Small Sticks	1.00/500 ct.	$.002 per
Cotton String	4.79/400 ct.	$.0012 per/ft

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Witnessed & Understood by me	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	2/18/11	Recorded By: Rebecca Ventimiglia	2/18/11

From Page No. 7

2/18/11 - Lab Section, 2pm, Taylor Design Studio - Team Synthesizers

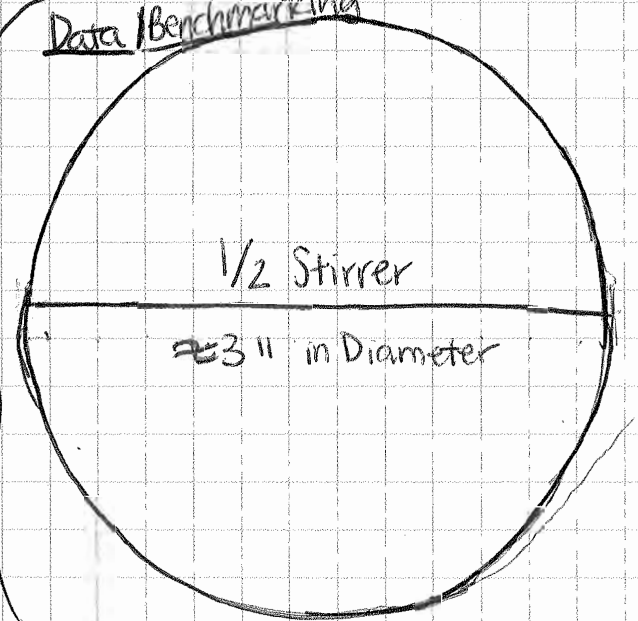
Easel Design/Morphological Chart Review (Below are post-it comments w/ our response)
↳ if we had time to respond

After putting Morphological chart on easel, we analyzed the comments with group members

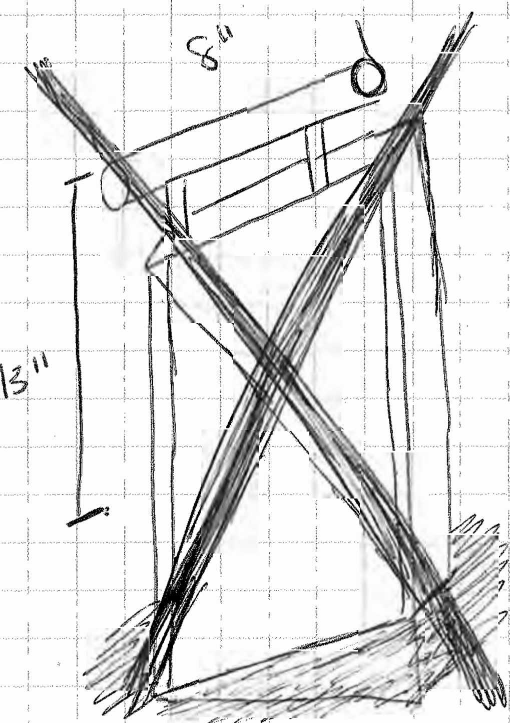
- Tieing Sticks w/ String (Sides)
  - Comment: What if it is in compression?
    - Perhaps mixing string bars w/ stick bars to create suspension
- Suspended Bowl
  - Comments: What if it bounces out? Can you create a suspended net?
    - Maybe a netting would work to better dissipate energy
    - More string for support & suspension
- Paper Balls in Bottom of Net
  - Comment: Would add to weight / cost?
- Netting
  - Complex to manufacture?
- Ramp
  - Where on the bridge would the ball hit?
- Other good ideas? Scissor Jacks

We next benchmarked materials that we sought fit: baseball, stirrers, support setup

Data / Benchmarking



Weight = .142 kg = 5.0 oz



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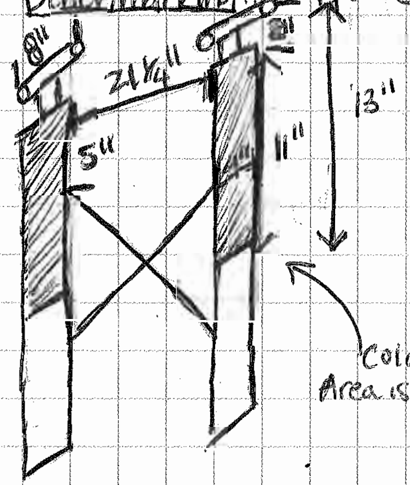
Witnessed & Understood by me, Rebecca Vantimiglia — Date 2/18/11

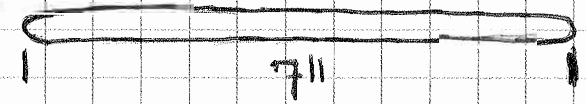
Invented by — Recorded By Rebecca Vantimiglia — Date 2/18/11

From Page No. 8

<u>Benchmarking</u>: Supports



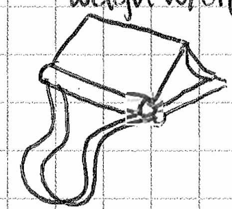
<u>Benchmarking</u>: Stirrers (86 count)



Strength 2x when cut in 1/2

<u>Data on Stirrers</u>
- Breaking when in position shown at 7-8 N
- At 20 N when 1/2 length
- .05 lbs = 27 sticks
- Curvable/plastic to a certain degree
- When on side - 20 N of strength
- A lot of twisting 1.75" from midpoint
- One stick: .15 G

- <u>Benchmarking</u>: Med. Clips (so that when we weigh w/clips, we can determine actual weight)



m = .015 lbs

- Things for Next Time:
  - <u>Preliminary Design Review</u> (Presentations + Questions)
    - Needs + Specs ✓
    - Morphological Chart ✓
    - Decision Matrix
    - 3 Complete Concepts

<u>Testing</u>: Test strength of paper next time

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	2/18/11	Recorded By Rebecca Ventimiglia	2/18/11

From Page No. 9

2/20/11

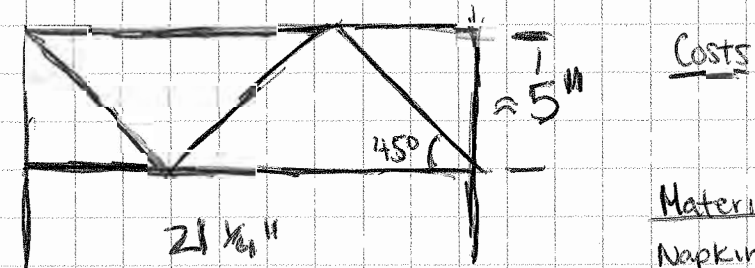
- Group meeting in Duffield, at 3:30 pm
  Objectives for Meeting: Complete Decision Matrix & Come Up w/ 3 Unique Concepts

- Decision for Safety Factor

We decided to make the Safety factor 5 because the standard safety factor for civil engineering is typically 5-10. Since this bridge is a structure typically associated w/civil engineering, we picked a safety factor within the range of the civil engineering standard. We chose towards the lower end since we do not know much about our materials, except for that one popsicle stick/stirrer can take a load of 7-8N, and there are 6-8 J of energy that need to be dissipated. Therefore, since one popsicle stick can take 24.5-28 Nm(J), we have confidence we can design to this safety factor.

"Back of Envelope" Calculations

.05 lbs = .029 oz. ← weight of one popsicle stick } Weight of materials
. = .024 oz ← weight of a big dip }
7 inches ← means ≈ 4 stirrer lengths to cross bridge } How much to cross length?



Costs: We decided to compare material costs based on much of a certain material we could get for 1¢.

Material	Amount	Material	Amount
Napkin	1	Cotton String	$8.33ft = (\frac{1ft}{.0012} \cdot .01)$
Notecard (3x5)	$.55 = \frac{1}{.018}(.01)$		
" (5x8)	$.25 = \frac{1}{.04}(.01)$		
Stir Sticks	2		
Small Sticks	$5 = \frac{1}{.002}(.01)$		

- Decision Matrix

The Synthesizers: Decision Matrix

	Weight	Criteria: Woven Paper	Diamond Weaving	Lacrosse Stick Weave	Paper Strips	Stick Breakpoint	Napkin Breakpoint	Notecard Breakpoint + Net	Suspended Bowl	Stick Funnel	Paper Balls at Bottom	Composite Offset Paper Ramp	Net & Multiple Strings Breaking
Ease of Manufacturing	0.1	5	2	1	5	4	3	4	3	3	5	3	2
Ease of Assembly	0.1	4	3	3	4	4	3	5	5	2	5	3	2
Weight	0.2	3	4	4	4	2	3	3	1	1	2	3	3
Cost	0.2	5	3	3	5	2	1	1	1	1	5	4	2
Handles Deflection	0.4	2	5	5	2	5	3	5	4	1	2	4	5
Total	1	3.3	3.9	3.8	3.5	3.6	2.6	3.7	2.8	1.3	3.2	3.6	3.4

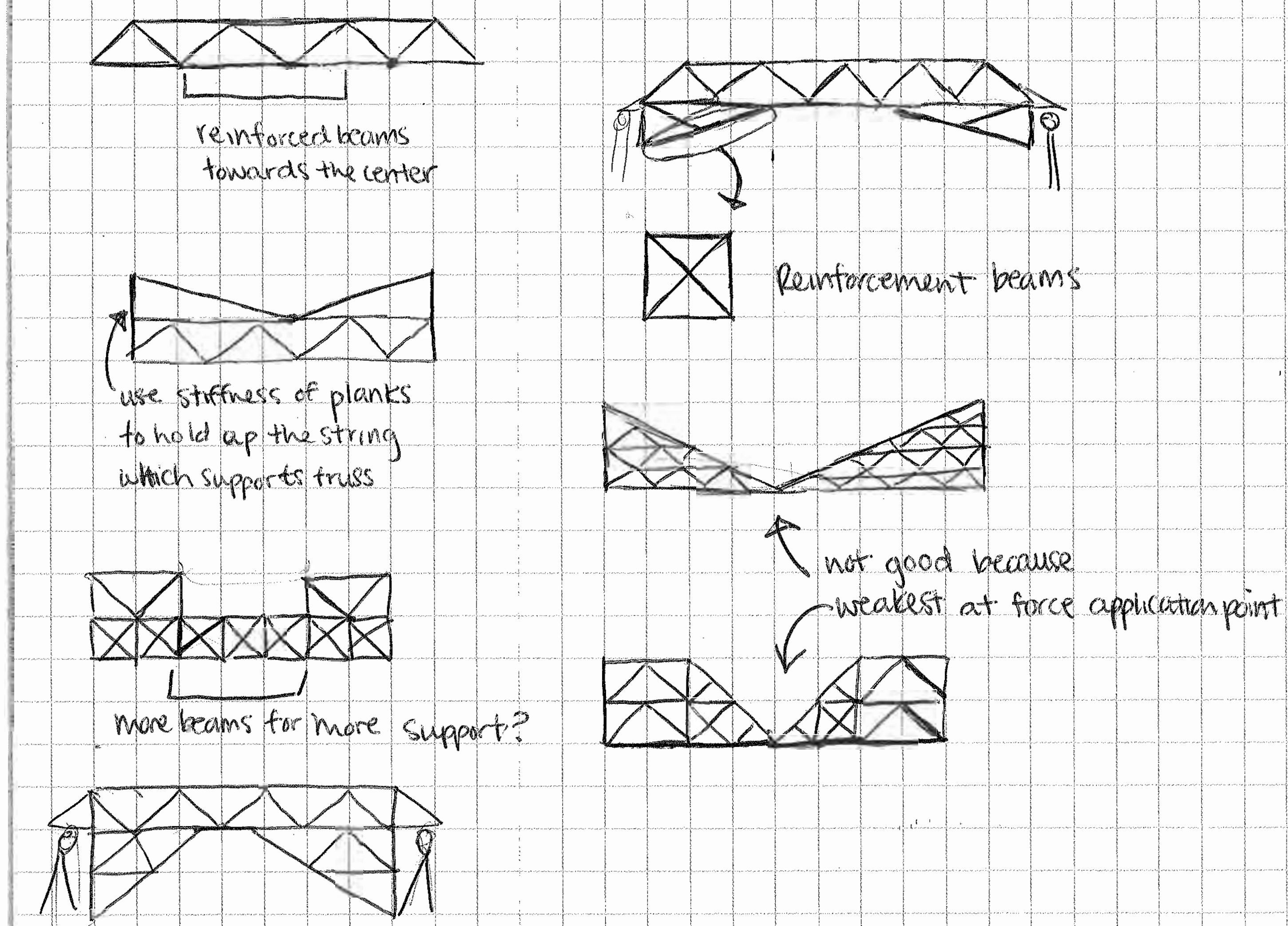
Comments: Ratings are on a 1 to 5 scale based on prior experience and knowledge from previous courses (where 1 is the worst and 5 is the best)
Cost Decisions were based on equivalence ratios (i.e. $.01 is the cost of 1 napkin, 5 small sticks, or 9 ft. of string, etc.)

- 3 Concepts & Presentation to be decided on next meeting 3:30 pm - 2/24/11

Witnessed & Understood by me: Kelsea Ventimiglia | Date: 2/20/11 | Invented by: | Date: 2/20/11
Recorded By: Rebecca Ventimiglia

From Page No. 10 – 2/24/11

Sketches of Truss Ideas



– Synthesizers Meeting – Thursday, 2/24/11 at 3:30 PM. in Duffield
- Start off meeting w/ re-evaluating decisions matrix
  - ↳ Cost of string changed / was updated so now only .83 ft can be bought with 1¢! We updated the matrix to reflect this.
  - ↳ Decision matrix on next page.
- After readjustment, the top 6 designs/concepts to consider due to highest ratings on 5 pt. scale
  1. Diamond weaving 2. Net that breaks 3. Stick breakpoint + net
  4. Composite Net 5. Lacrosse Weave 6. Notecard breakpoint + net
- Then we considered the designs based on scores & similarities in design to create 3 concepts that are unique
  1) Composite Net, ② Breakaway Sticks, ③ Notecard Layering Breakpoint

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	2/24/11	Recorded By Rebecca Ventimiglia	2/24/11

From Page No. 11

Decision Matrix (Final)

The Synthesizers: Decision Matrix

(shaded) = Best
= Second Best

Criteria	Weight	Concepts											
		Woven Paper	Diamond Weaving	Lacrosse Stick Weave	Paper Strips	Stick Breakpoint + net	Napkin Breakpoint	Notecard Breakpoint + Net	Suspended Bowl	Stick Funnel	Paper Balls at Bottom	Composite Offset Paper Ramp	Net & Multiple Strings Breaking
Ease of Manufacturing	0.1	5	2	1	5	4	3	4	3	3	5	3	2
Ease of Assembly	0.1	4	3	3	4	4	3	5	5	2	5	3	2
Weight	0.2	3	4	3	4	2	3	3	1	1	2	3	3
Cost	0.2	5	2	1	5	1	1	1	1	3	5	3	2
Handles Deflection	0.4	2	5	5	1	5	3	5	4	1	2	4	5
Total	1	3.3	3.7	3.2	3.1	3.4	2.6	3.7	2.8	1.7	3.2	3.4	3.4
			①			②		①				②	②

Comments: Ratings are on a 1 to 5 scale where 1 is the worst and 5 is the best. Ratings were based on prior experience and knowledge from previous course
Cost Decisions were based on the equivalence ratios calculated below (i.e. $.01 is the cost of 1 napkin, 5 small sticks, or 1 ft. of string, etc.)

- Next, we discussed truss shapes and types in order to draw consistent sketches. We considered the truss cost for each concept as a fixed cost because it would be standard for all the concepts. We looked up that for a material like wood, it's tensile strength is larger than compressive strength. Therefore, the net would be attached to the truss in a way that put the bars in tension. The structure decided on after discussion of stability, number of joints required, amount of material decided, etc., the chosen structure was:

Truss Analysis: Page 28

For Next time in lab, test:
- glue strength
- manufacturing easibility of designs
- twisting strength (torsion)
- how angle of stick affects breaking strength.

- Assignment of Taskes
  - Lemar - test some trusses / sketch concept ②
  - Jen - sketch concept ③ / Scan in morphological chart
  - Chian - PowerPoint w/ Needs & Specs
  - Rebecca - Sketch ① / look up properties of wood

* We will meet tomorrow during normal scheduled lecture to finalize & run through PDR.

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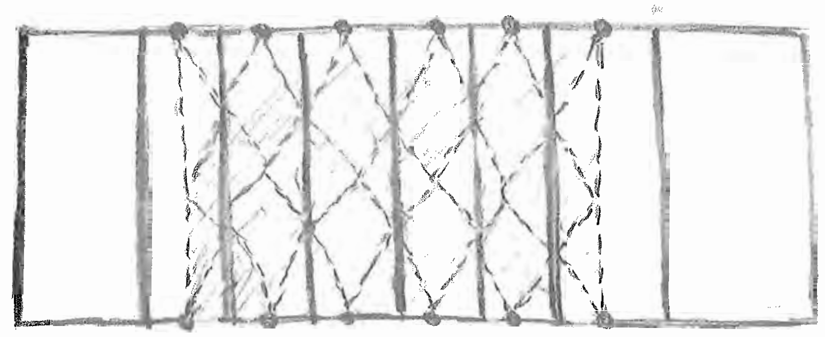
TITLE MAE 2250 : Meteorite Catching Bridge

From Page No. 12

Sketch of Concept 1: Composite Net Bridge / Drawings of Other Concepts on Page 27

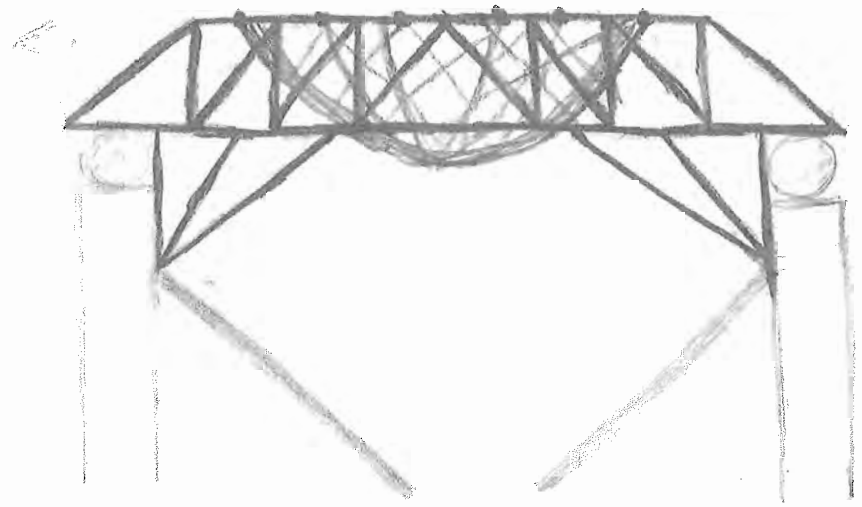
Composite Net Concept

Top:

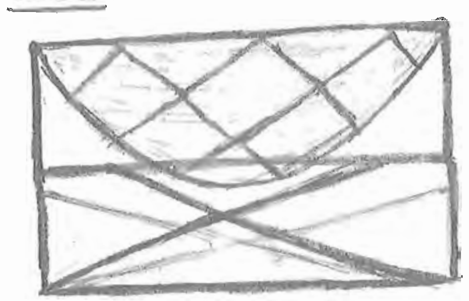


Features:
- Wide Diamond Weave net with piece of paper on top of net
- Supports underneath truss
- Truss over extends supports so that it may rest stably.

Front:



Side:



Research on Material Properties of Wood: Internet Sources

Mat.	wikipedia.org	eng.toolbox.com	
Pine	40 MPa, 8.963 GPa	40 MPa	← Ultimate Tensile Strength, Young's Modulus
Oak (along grain)	11 GPa	11 GPa	← Young's Modulus
Doug. Fir	—	50 MPa	← Ultimate Tensile Strength (compression)
	—	30 GPa	← Young's Modulus

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Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	2/24/11	Rebecca Ventimiglia	2/24/11

From Page No. 13

From Beer & Johnston; ©2010: Mechanics of Materials

Timber	Ultimate Strength (MPA) Tension	Compression	Shear	Modulus of Elasticity (GPa)
Douglas Fir	100	50	7.6	13
Spruce, Sitka	60	39	7.6	10
Shortleaf pine		50	9.7	12
Western white pine		34	7.0	10
Ponderosa pine	55	36	7.6	9
White oak		51	13.8	12
Red oak		47	12.4	12
Western Hemlock	90	50	10.0	11
Shagbark Hickory		63	16.5	15
Redwood	65	42	6.2	9

* Ask about type of wood stirrers are made of...

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Witnessed & Understood by me, Rebecca Ventimiglia Date 2/24/11
Invented by
Recorded By Rebecca Ventimiglia Date 2/24/11

TITLE MAE 2250: Meteorite Bridge Project
GUSSET IT!

From Page No 14

– ~~2/25~~/11 – Meeting in Duffield (11:15 AM – 12:20 PM)

- Discussed drawings for presentation
- Reviewed PDR skeleton created by Chian → ran through slides to check for wordiness
- Went over what each person is to say during the presentation.
- Cleaned up PowerPoint
- See PowerPoint at End (page indicated in Table of Contents)

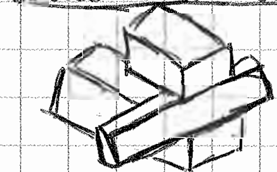
2/25/11 – Lab Section, Taylor Design Studio (2:00–4:30 PM)

- Deflection – think of how much this is relative to Mars
- Stability of keeping ball in net
- Look into cost of notecards
- Label colors on charts / put in key on charts

} More Design Considerations to Consider (what we took away from PDR that we need to check)

- Materials Update: Birch Wood is what coffee stirrers made out of (but data's not in B/J) Beer & Johnston Mechanics of Materials Book

- Online Research (Lemay)
  - Double Gusset Joint the best!



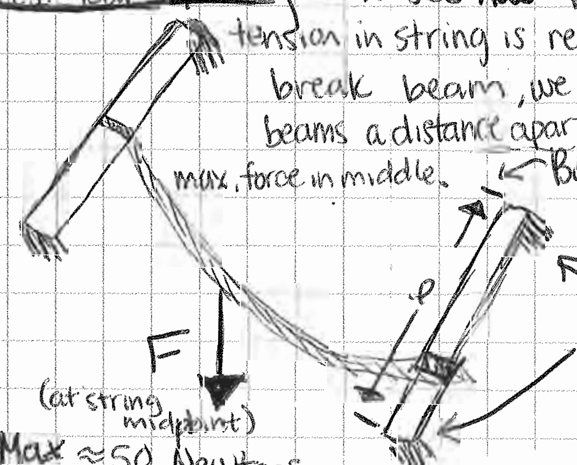
← Two Stirrers Flat/Sandwich against a third stirrer to create strong joint.

Also easy to manufacture

We created a sample joint and tested it by seeing if the stirrers slip when pulled on. Glue holds and joint is strong! Online research confirmed!

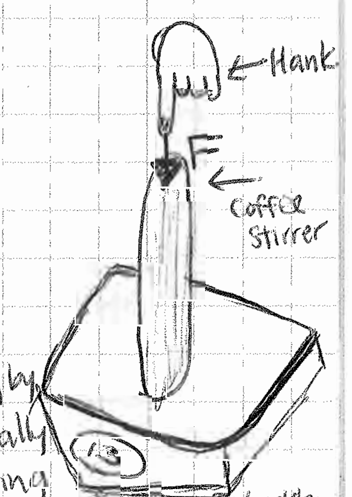
- Tests During Lab
  - Made Gusset Joint ⇒ drying for possible tests, but looks strong so far.
  - Test Bar w/String ⇒ to see how much tension in string is required to break beam, we secured two beams a distance apart and measured max. force in middle.

~~Gusset Joint~~
~~– Look in String~~



FMax ≈ 50 Newtons

Buckling Test
Max ≈ 1.3 lbs
We tested buckling by placing stick vertically on a scale and pushing straight down it. Force recorded when buckle begins



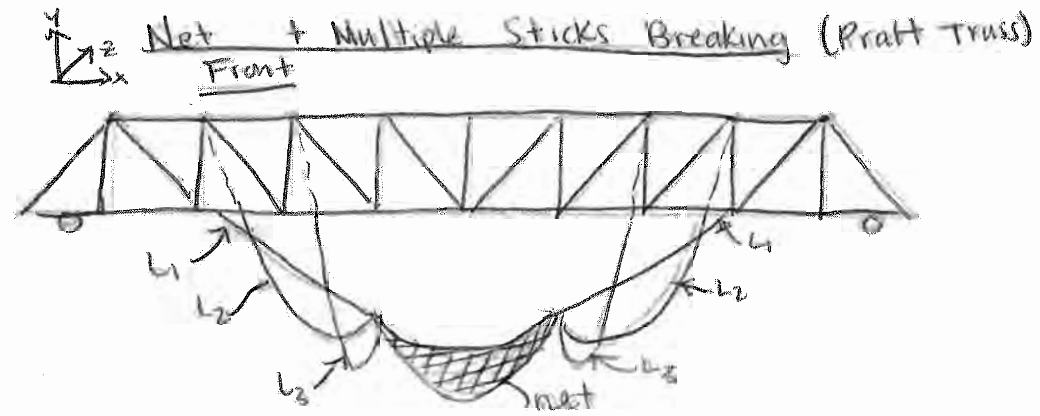
Witnessed & Understood by me, Rebecca Ventimiglia — Date 2/25/11
Invented by
Recorded By Rebecca Ventimiglia — Date 2/25/11

From Page No. 15

For Next Time:
- 10 Minute Presentation (Hard deadline)
- Sell us the design
- Outline design / why you picked it?
- Performance specs
- Weight & cost
- Any changes since PDR
- Keirsey Due week 7

At the end of lab, we decided to go with the breaking sticks idea because it was in the top set of ideas, innovative, analyzable, and easy to manufacture.

Sketch of Final Concept: Purposefully Breaking Sticks Bridge:



Key Features:
- Purposely Breaking Sticks in z-direction.
- Strings of different lengths so that net moves w/ ball when dissipating energy.
- Diamond weave net
- Pratt truss (puts more members in tension & the wood is stronger in tension) (only puts bars farthest away from force application in compression w/ least amount of force)

To Page No. 17

Witnessed & Understood by me: Rebecca Ventimiglia | Date: 2/25/11 | Invented by | Date: 2/25/11
Recorded By: Rebecca Ventimiglia

From Page No. 16

- Saturday, February 26th, 2011

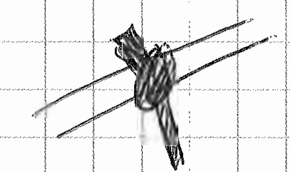
- Since we went w/the sticks breaking purposefully concept, I decided to research net manufacturing & knots for tomorrow's group meeting at Duffield/Taylor Design Studio

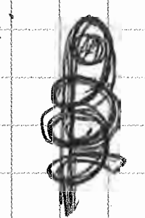
Knots: From www.animatedknots.com (Looking for energy dissipating/dynamic knots)

Prusik:  ← knot allows for sliding along axis

Grapevine:  ← when each string is pulled on w/forces in opposite directions, the knots collide/make contact

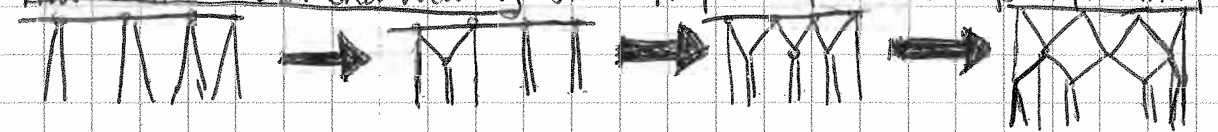
Constrictor Knot:  ← the knot is loose to begin with and then tightens around joint

Rolling Hitch:  ← The knot is tied around an axis so that it can slide about the axis.

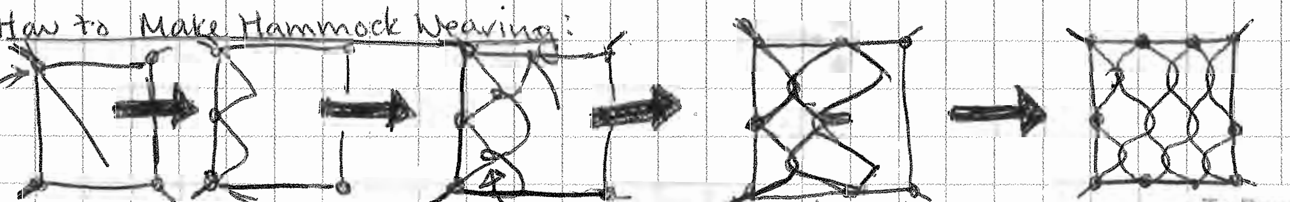
Taut Line Hitch:  ← The knot tightens and holds when force is applied to the string/there is enough tension in string.

Netting: ~~Want~~ to avoid knots in net so that strings of net "move" to "encase" ball.

How to make Diamond Weaving: Start w/loop knots & tie 2 strings in proximity to each other together.



How to Make Hammock Weaving:

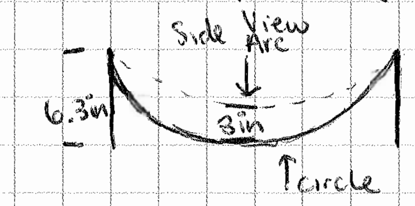


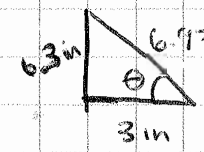
To Page No. 18

Witnessed & Understood by me, Rebecca Ventimiglia | Date 2/26/11 | Invented by | Recorded By Rebecca Ventimiglia | Date 2/26/11

From Page No. 17 Meeting in Duffield at 11:30AM → Taylor Design Studio

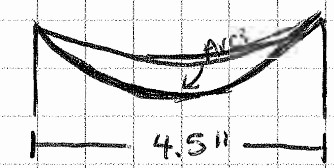
2/27/11 Netting Dimensions – ("Back of Envelope Calculations")
- Account ~~for~~ 3" deflection.
- $A = 4\pi r^2 = 4\pi(1.5in)^2 = 28.27\ in^2$ ← Surface Area of Baseball





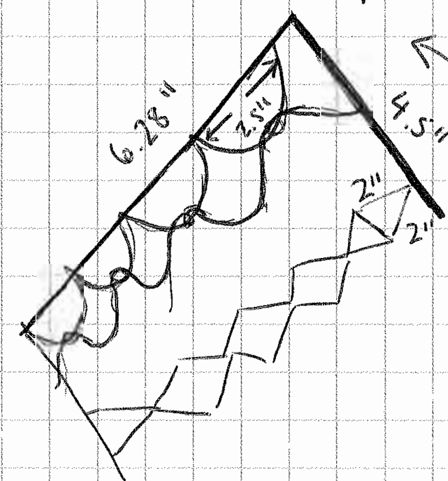
$\cos\theta = 3/7\ in$
$\theta \approx 65°$
} Side of a truss element for height

- Circumference $= 2\pi r = 2\pi(6.3in) = $ ~~249.18in~~ $= 39.56\ in = $ (3.297 ft) ← may be too much



If square net → $l = 4.5"$
$A = lw$
$28.27 in^2 = 4.5"(w)$
6.28" = w

Hammock-Style Netting ✓



model w/ circles or triangles? triangles

~~Energy~~ Disappating Knots?

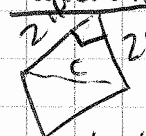
Knots at Joints

≈4" to tie knot around joints
12 critical joints where string needed
4" × 12 = 48" = (4 ft)
cost string ≈ 3 1/3 ¢

if more members needed
20 critical joints
4" × 20 = 80" = (6 2/3 ft)
Cost ≈ 5.56¢

Amount of String $= 2(7.0" + .5") + 2(6.25" + .5")$ (for knot tieing)
$= 23.5"$ = ~~[illegible]~~ ≈ 1 2/3 ¢ ← cost
2.375 ft 1.979

Square Holes



$(2")^2 + (2")^2 = c^2$
$8 = c^2$
too close to 3" → $2.82 = c$

$(1.75")^2 + (1.75")^2 = c^2$
$6.125 = c^2$
Better ✓ $2.5 = c$

Diamond Holes

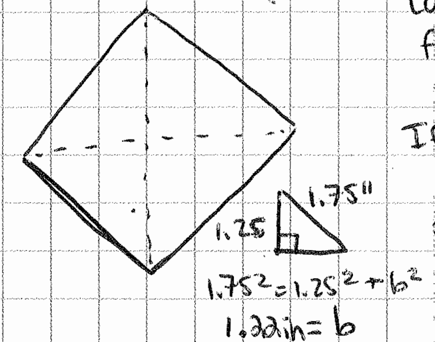
⇒ More work on next page

To Page No. 18

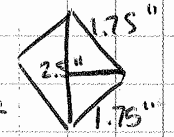
Witnessed & Understood by me, Rebecca Vattimaglia [signature] Date 2/27/11
Invented by
Recorded By Rebecca Vattimaglia Date 2/27/11

From Page No. 18

Law of Cosines for Parallelogram? $c^2 = a^2 + b^2 - 2ab\cos\theta$



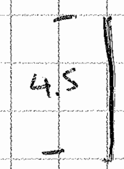
If we use squares to model...



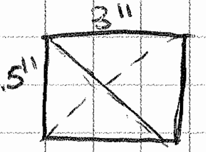
$l \div l_s = 6.25 \div 2.5 = 2.5$ squares across
≈ 3 squares × 3.5" per half of square = 10.5 in
$w \div w_s = 4.5 \div 1.22 = 3.67$ in ≈ 4 rows
4 × 10.5in = 42 in of string

4 ft of string = 3 1/3 ¢ should do.

String on Bottom of Truss? (to hold sides together)

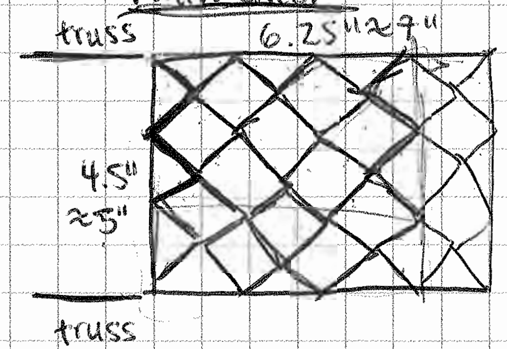


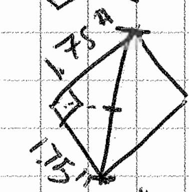
4.5" × 7 = 31.5" = 2.625 ft
Cost = 2.1875 ¢



$3^2 + 4.5^2 = c^2$
$c^2 = 29.25 \text{ in}^2$
c = 5.4 in

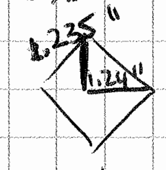
Math Check





$(1.75")^2 + (1.75)" = c^2$
2.47 in = c

$(1.75")^2 = \left(\frac{2.47"}{2}\right)^2 + b^2$



1.24" = b

5" ÷ 1.24" = 4.03
→ 2 squares

6.25" ÷ 1.24" = 5.04
→ 2.5 ~~squares~~ rows

(2·1.75) = 3.5 in for ½ sq.
× 2 squares = 7" for 1 row of ½ squares

~~3.5 × 2 squares × 2.5 rows = 17.5"~~

5 rows × 7" = 35"

7" ÷ 1.24" = 5.64 ≈ 6 = 3 squares

6.25" ÷ 1.24" = 5.04 = 3 squares

(2·1.75") = 3.5 in for 1 ½ square
× 3 squares = 10.5"

* 10.5" × 8 rows = 63" ≈ 5.25 ft = 4.375 ¢

Buy 8 ft = 5.26 for netting / 2.75 for border/knots

To Page No. 19

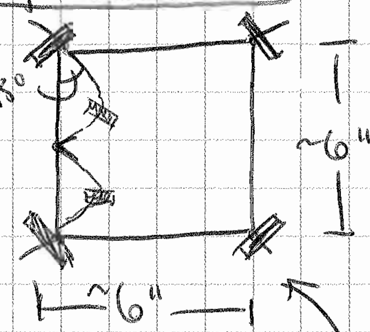
Witnessed & Understood by me, Rebecca Ventimiglia Date 2/27/11

Invented by

Recorded By Rebecca Ventimiglia Date 2/27/11

From Page No. 19

Begin Construction!

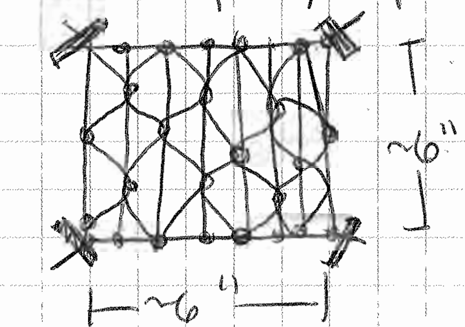


- Tape used to keep knots stable and attached to table during manufacturing
- Taped to cutting board so that 45° where created
- Strings looped once around the previous triangle.
- All string portioned out and taped (so that the right amount of string was ensured)
- No knots around verticle/horizontal components

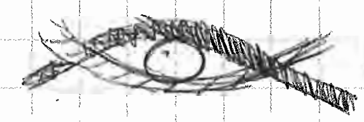
Net Planned to be rectangle, but came out square → more string was needed for knots than expected!

- Tested Net After Construction: Too much slip! There is no way that the size of the hole will be constant, the baseball falls right through the net. The fix is to add more loops in between triangles (to create more stiffness) and knots tied on outside to create more shape stability. Additional strings were added across the holes so that the initial hole size was smaller and less movement is likely amongst string members.

- Net Design w/Improvements:

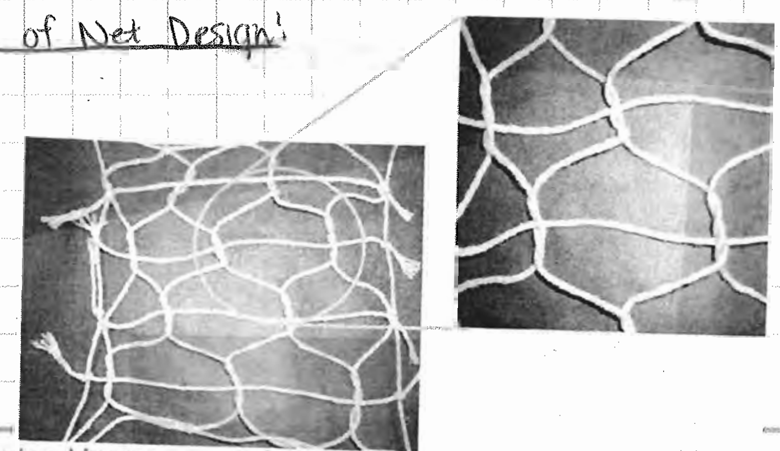


At Joints, verticle string goes in between looped string as shown below:



This design is like the Lacrosse net which was originally turned down. Turns out that this type of net was easier to manufacture than expected and only cost: 6×4" + extra for knots = 3 ft × \$.012/ft = \$.036

- Picture of Net Design:



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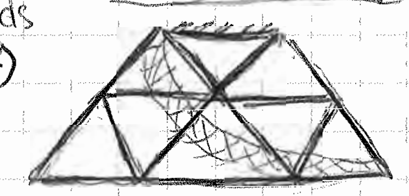
From Page No 26

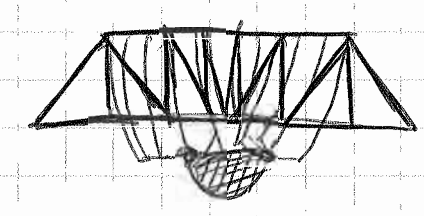
3/4/11 – Test Day in Stairwell of Rhodes Hall! (Lab: 2:00-4:30 PM)

Sketch of Design

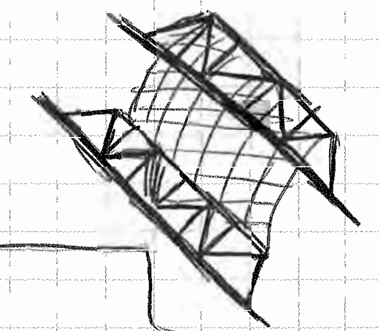
① Team Pineapple – X (Failed) (Did not Catch)
Specs: Weight:, Height:, Length:, Width: } N/A
Force: ① with fracture pads 6.632 (~~lbf~~ lbf) ② 1.559
Cost: $1.032



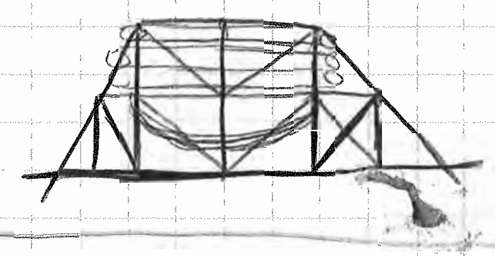
② The Synthesizers – ✓ (Passed) (Caught)
Weight: 3.3oz = .0936 kg
Height: 6"
Length: 24"
Depth Width: 4.5"
Force: ① 7.154 lbf
Cost: 88¢



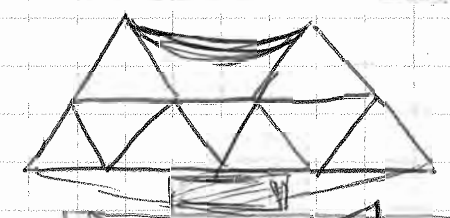
③ Team Watson – X
Weight: 3.3oz = .0936 kg
Force: ① 6.732 lbf
Cost: $.72 = 72¢



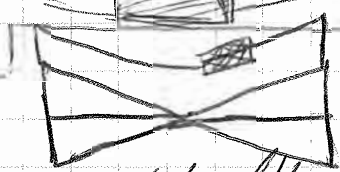
④ Pork Chops, Inc. ✓
Weight: .180 kg
Force: ① 5.61 lbf
Cost: $1.156



⑤ Team KLAM ✓
Weight: .124 kg
Force: 5.507 lbf
Cost: $1.09



⑥ Bob the Builder ✓
Weight: .154 kg
Force: 8.234 lbf
Cost: $1.23



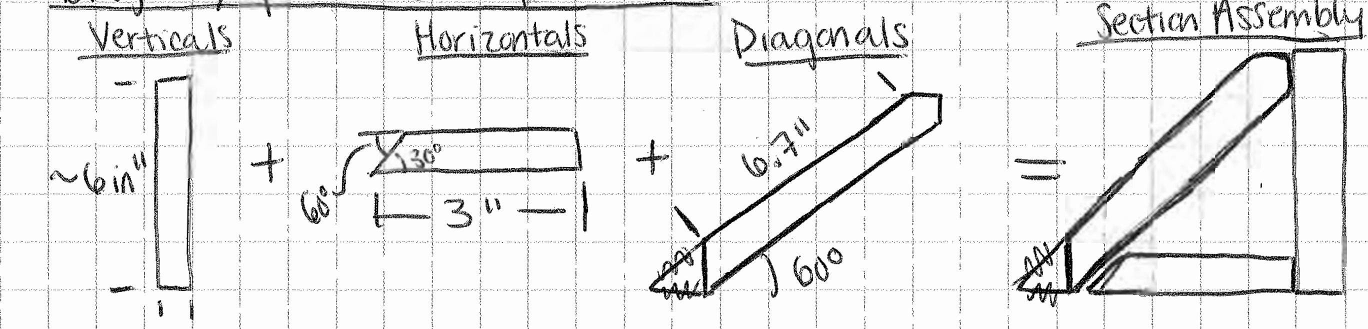
3/4 [signature]

To Page No. 27

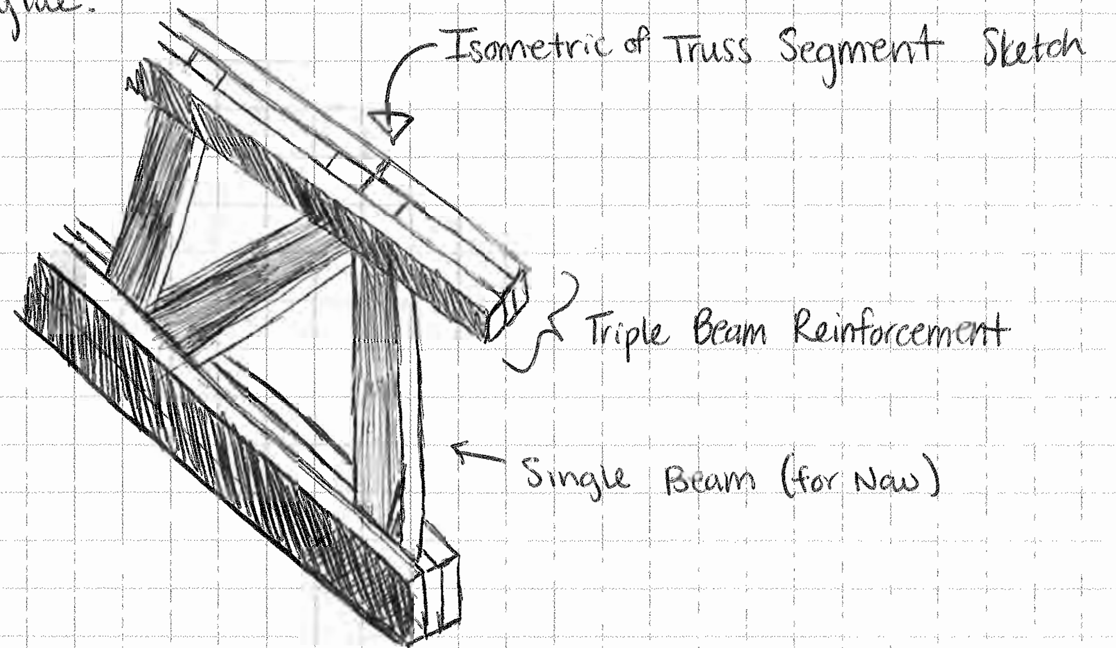
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/4/11	Recorded By: Rebecca Ventimiglia	3/4/11

From Page No. 22

- 2/27/11 (Continued) Taylor Design Studio
  - Start Manufacturing of Truss -
    - ↳ We went w/ a template method so that parts could be prefabricated and standardized w/ little deviation. Also allows for simple, easy to follow fabrication/assembly.
    - ↳ Parts were cut with an exacto-knife/box cutter
    - ↳ Per truss: 8 diagonals, 7 verticals, 14 horizontals, 14 outside pieces of various length
  - Diagram/Specs of 3 Template Parts:



- Once proper amount of each template part was manufactured, assembly of one side of the truss began. In order to create strong joints, coffee stirrers were used to cover the joints on both the front and back of joints. Every section assembly was placed according to the Pratt truss design. Joints were held in place by glue.



- At the end of team meeting, one side of truss was created.
- Agreed to meet around 2pm the next day.

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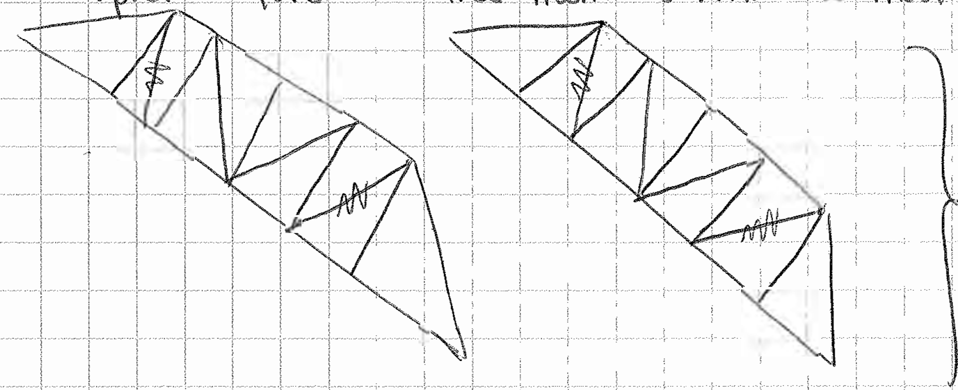
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/10/11	Recorded By: Rebecca Ventimiglia	3/10/11

From Page No. 22

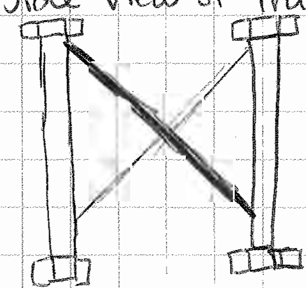
- 2/28/11 - Meeting in Upson (2:00 pm)
  - While using the template and scissors to cut new members, the second half of the truss was constructed.
  - We noticed that our half of truss had a slight curve in it due to the truss' weight in the drying process. We flipped the truss around to let the weight of the truss ~~bending~~ it back into place.
  - On the 1st half of the truss we glued another stick support to the outside of the farthest diagonal members. We did this in order to add extra support and prevent torsion on the members with the most tensile force.



Members which are etched out have double reinforcement.

- 3/1/11 - Meeting Taylor Design Studio (10:10pm)
  - We met to finish the second truss and discuss how the two sides will be attached to each other, we decided to use alternating diagonal members, as shown below. Will manufacture the two beams

Side View of Truss



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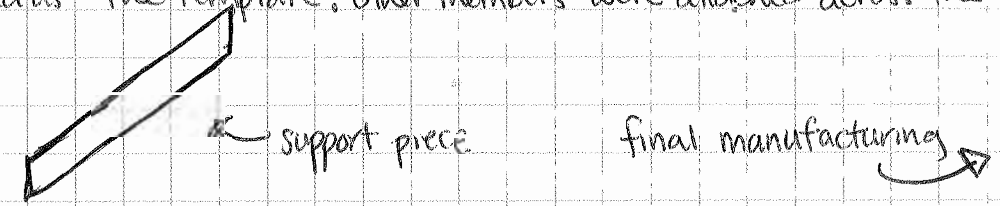
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/10/11	Recorded By Rebecca Ventimiglia	3/10/11

From Page No. 23

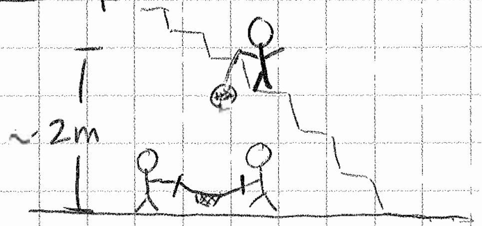
3/2/11 Meeting in Taylor Design Studio (7 pm)

- Manufactured supports in between truss sides using template method. We eyeballed the angle at which the supports should be cut by taking a full stick and placing it in the desired position in the truss, and tracing over the angle in pen. This piece was then used as the template. Other members were attached across the top.



- Once the glue had dried, the beams were tested with a preliminary set up as shown below. The ball was dropped from a height of 2 m and truss structure's purposely breaking beams broke. However, difficulty in getting the ball to land in the net led us to revise our net design so that it was larger.

Test Set Up:



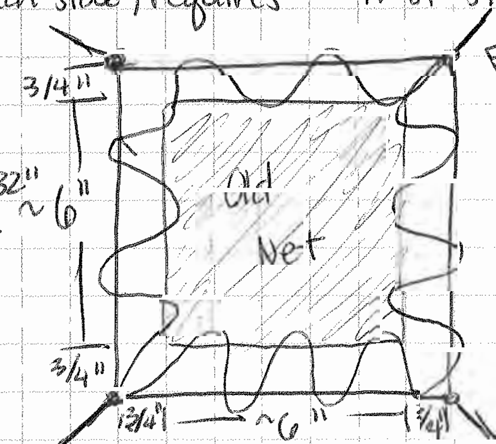
- Once the test was complete, we knew about how much force would be required to break the beams using our string/net set-up.

- Revised Net Design - 3/4" wider on each side, requires ft of string

Calculation for String Needed

6" + 1" on each side = 8" sides x4=32"
4 sides × 7" for weaving on each side = 28"

28"+32" = 60" of string = 5ft.

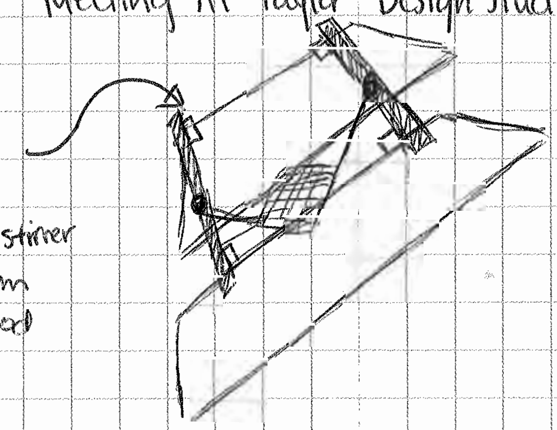


- Manufactured using tape method from before. A frame was created around the square net and another string was looped between the new and old frames to provide suspension. All strings secured with knots. Also contained 4 pull strings to control placement of net on truss base for testing

To Page No. 25

From Page No. 24

- 3/3/11 – Meeting At Taylor Design Studio (4:30 pm)

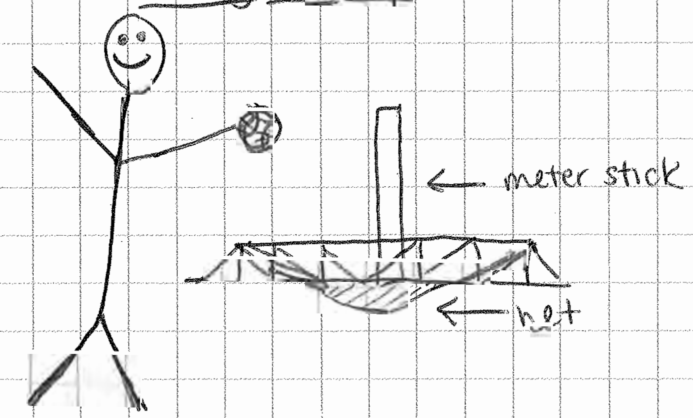


- The group used this day for more conclusive testing. We performed testing with the actual truss structure in order to again determine the amount of force required to break a beam.
- We decided to add more support at joints/connection point for each beam that would be breaking in order to ensure that the beams would break at the midpoint, as planned. This extra support involved another stick glued to the top of the end of the beam at the joint and small squares glued to the side of the truss to keep the joints in place. We chose this over buying string to secure joints because it was cheaper and would do the same job → keep joints in place so that force is applied in middle of beam.

- Results of Testing – We dropped baseball from heights, increasing by .2 m each time to determine when the sticks would break. Height measured from bottom of net upwards

Height (m)	Did it Break?
.5m	No
.8m	No
1.0m	No
1.2m	No
1.4m	No
1.6m	No
1.8m	No
2 m	Yes!

Testing Set Up



- This data was used in our MatLab code (see page 29) in order to determine the number of breaking sticks needed.
- MATLAB code determined [5] breaking sticks needed.

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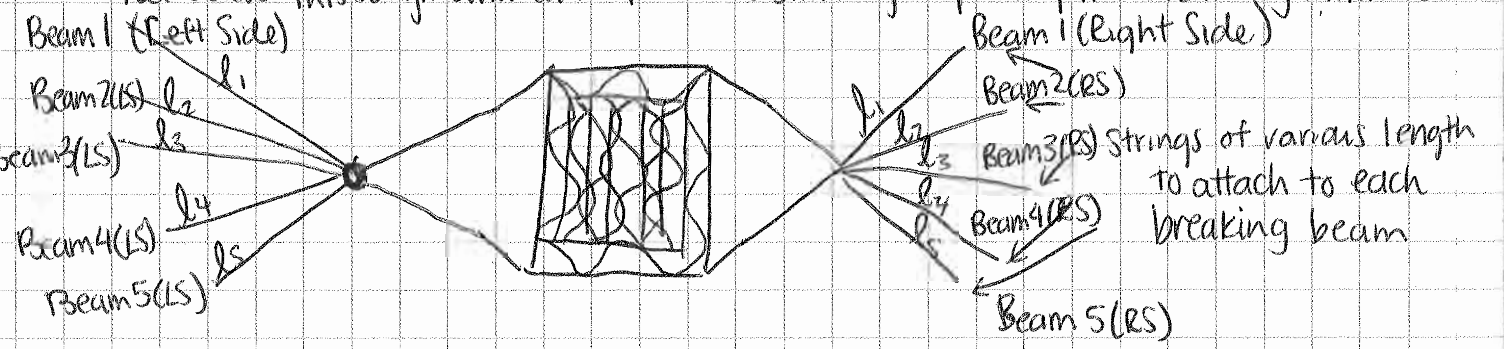
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/10/11	Recorded By Rebecca Ventimiglia	3/10/11

From Page No. 25

- Next, we manufactured the breaking sticks (~5" wide) and attached them to the truss with glue.
- The two sticks holding up the net in the end were double sticks to ensure breaking would not occur when the ball was being held up by the net.

- Net Attachment:
  - Strings of approximately the same length attached each corresponding breaking stick to a point on the net. At this point was a group of knots coming from each string. These knots were glued into place for extra support. See diagram of top view of net below. This design allowed for the net to still hang despite any non-breaking members.



- Knots attaching net to beam were also glued for extra support.

- FINAL DESIGN: THE DISSIPITATOR

Cost Analysis:	Quantity	Unit Cost	Total Cost/Expenses
① sticks (given)	86	\$.005	\$.205
② sticks (bought)	4		
③ string (bought)	29 ft	\$.012/ft	\$.348
④ paper (R&D)	1	\$.01	\$.01
			\$.539
Maintenance & Repair ~~\$.05~~ 10 sticks	10	\$.005	\$.05 per meteoroid
		TOTAL COST OF BRIDGE	**\$.878**

- **FINAL SPECS**

Cost: 88¢ Length: 24" Height: 6"

Weight: 3.3 oz ≈ .0936 kg Width: 4.5"

*See FDR Page

- Created FDR & assigned slides w/group. Agreed to meet before lab for dry run.

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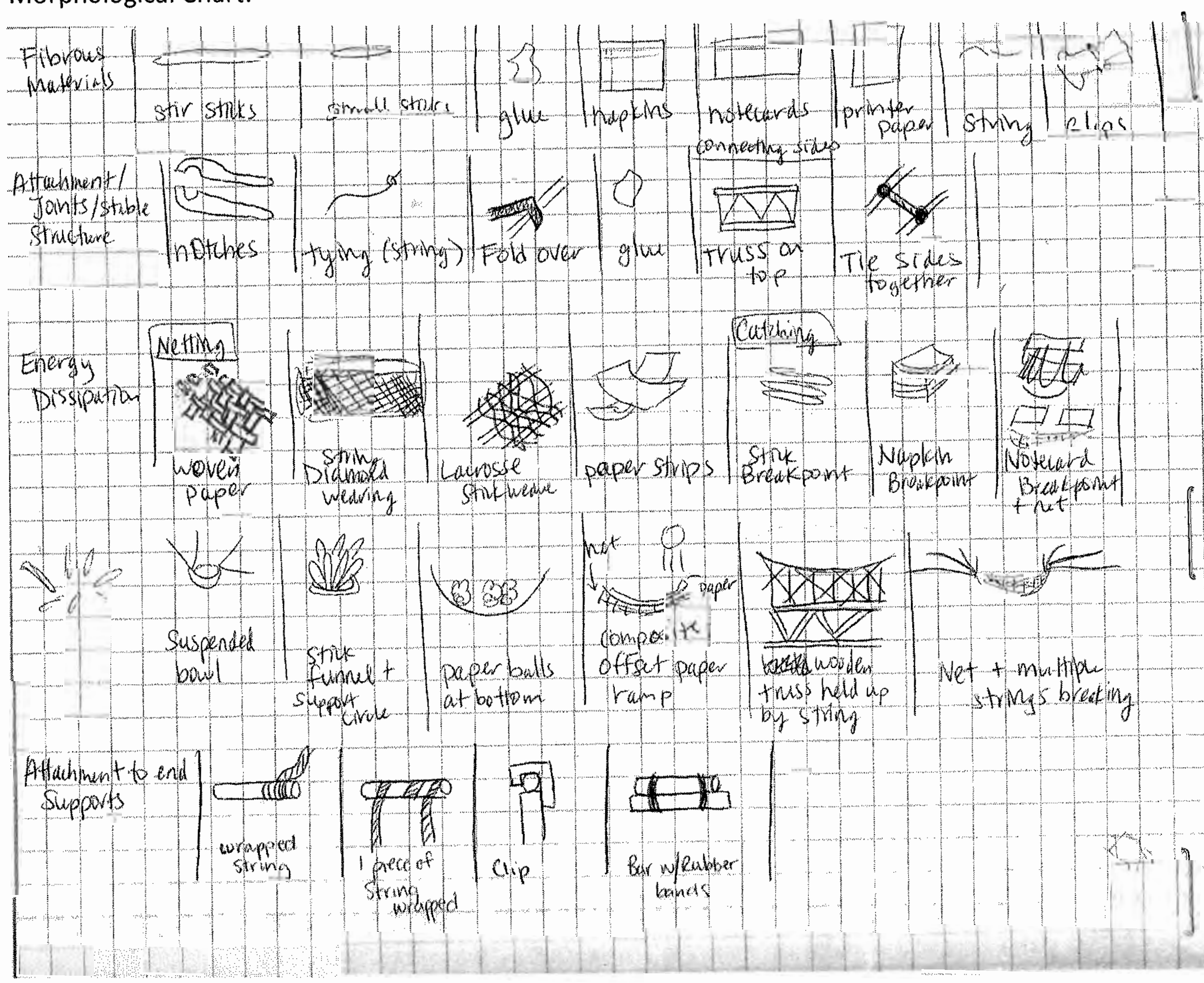
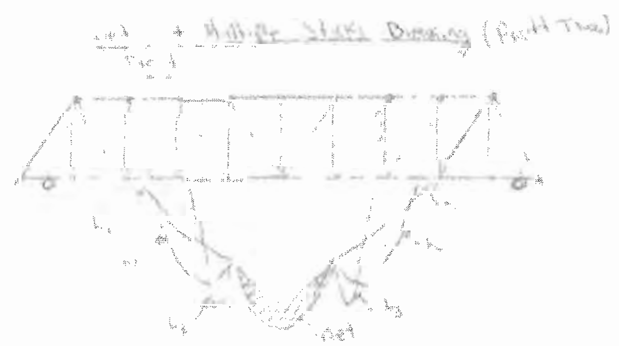
From Page No. 25

Morphological Chart

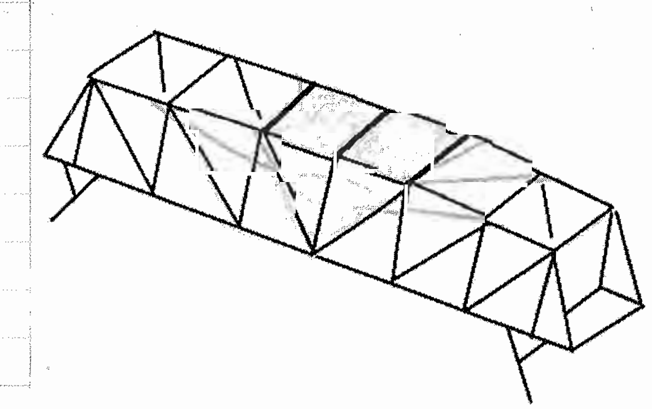
Morphological Chart:



Concept #2 for PDR Sketch:



Concept #3 for PDR Sketch:



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Witnessed & Understood by me, Rebecca Ventimiglia — Date 3/10/11

Invented by

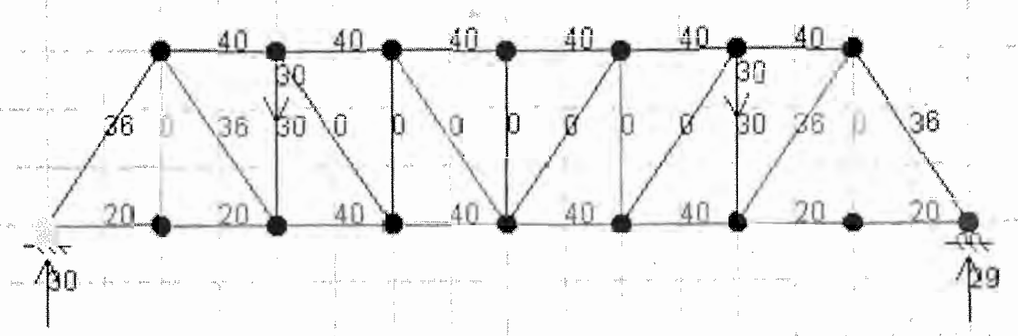
Recorded By Rebecca Ventimiglia — Date 3/10/11

From Page No. 27

Pratt Truss Analysis: ← Diagonal Bars

Note: Bars closest to impact area are in tension, bars in compression carry less load, bars w/higher loads reinforced

Red: tension
Blue: compression



Physical Analysis/Force Equation Analysis: (From Lemay's Notebook)

Initial: $v_f^2 = v_0^2 + 2a\Delta x$, $v_0 = -11\,m/s$, $v_f = v_0/2 = -7.78\,m/s$, $\Delta x = .025\,m/s$ (from deflection test)

$$a = \frac{v_f^2 - v_0^2}{2\Delta x} = \frac{60.5\,m^2/s^2}{2(.025)}$$

$$a = \frac{\Delta v}{\Delta t} = \quad \Delta t = \frac{\Delta v}{a} = \frac{\sqrt{2}-2}{2}\frac{v_0}{a} = .0027s$$

$2T\sin\theta_1 = ma$, $m = .142\,kg$ (mass of baseball)

$$T\sin\theta_1 = \frac{ma}{2} = 85.91\,N$$

Final: We needed to find a more realistic Δx from testing

$m = .142\,kg$, $v_0 = \sqrt{2gh}$ ← we will vary h to find Δx at which breaking occurs

$T_{max} = 30N$, $a = 2 \cdot T_{max}/m = -42\,m/s^2$

$v_f = 0\,m/s$ $\quad v_f - v_0^2 = 2a\Delta x$

$$\Delta x = \frac{-2gh}{2a} = -\left(\frac{g}{a}\right)h, \; h = \text{height of break}$$

$$\Delta x = \frac{h}{42} = \frac{2m}{42} = .04762m$$

Using ~~MATLAB code (page 29)~~ physics, we found that our possible range of Δx was

$.0452m \leq \Delta x < .0476m$

$v_0 = \sqrt{2gh_{break}}$, $v_f = 0$, $\Delta x = \sqrt{v_f^2 - v_0^2/2a}$

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Witnessed & Understood by me, Rebecca Ventimiglia | Date 3/10/11 | Invented by | Recorded By Rebecca Ventimiglia | Date 3/10/11

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MATLAB code analysis:

```
%Calculates the velocity, acceleration, and force during/after each pair of
%sticks breaks. Basically just calls a loop calculating the final velocities
%after each break using the equation Vf^2 = V0^2 +2aX and uses these values
%to find the force on each stick breaking. The acceleration comes directly
%from the experimental Tmax=30N of each stick.

functionConceptAnalysis(Breaks,v0,delX) %# of breaks/Magnitude of initial velocity/Stopping distance.
clc
Vmax = zeros(1,Breaks+1);
aMax = zeros(1,Breaks);
Gmax = zeros(1,Breaks);
Vmax(1) = v0;

m = 0.142;
g = -10;
Tmax= 30; %Experimentally found.

fprintf(' Number of Breaks: %2.0f\n delX= %.4f [m]\n V0= %.2f [m/s]\n\n',Breaks,delX,v0)
disp('Break #       Initial Velocity [m/s]       Final Velocity [m/s]         Gmax [m/s^2]        Vertical
Tention [N]');
disp('------------------------------------------------------------------------------------------------------
-----');

for i= 1:Breaks
aMax(i) = -Tmax*2/m; %Multiplied by two since two sticks.
Vmax(i+1) = (aMax(i)*delX + Vmax(i)^2)^(0.5);
ifVmax(i+1) < 0.1 %Last stick doesn't break, so find values from V0 and Vf=0.
aMax(i) = -(Vmax(i)^2)/(2*delX);
end
Gmax(i) = aMax(i)/g;
Fmax(i)= -aMax(i)*m/2;
fprintf('%2.0f                 %5.2f                        %5.2f                      %2.0f
%2.2f \n',i,Vmax(i),Vmax(i+1),Gmax(i),Fmax(i));
end
```

MATLAB Output:

Number of Breaks: 6
delX= 0.0452 [m]
V0= 10.00 [m/s]

Break #	Initial Velocity [m/s]	Final Velocity [m/s]	Gmax [m/s^2]	Vertical Tention [N]
1	10.00	8.99	42	30.00
2	8.99	7.86	42	30.00
3	7.86	6.53	42	30.00
4	6.53	4.86	42	30.00
5	4.86	2.12	42	30.00
6	2.12	0.00	5	3.54

Number of Breaks: 5
delX= 0.0476 [m]
V0= 10.00 [m/s]

Break #	Initial Velocity [m/s]	Final Velocity [m/s]	Gmax [m/s^2]	Vertical Tention [N]
1	10.00	8.94	42	30.00
2	8.94	7.73	42	30.00
3	7.73	6.30	42	30.00
4	6.30	4.42	42	30.00
5	4.42	0.00	21	14.58

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Date 3/10/11
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Date 3/10/11

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Materials Bought/Purchases Made:

5 popsicle sticks
1 Sheet of paper (RSD)
8 ft of String (Net)
10 sticks
2 ft of string (Net)
} 2/27/11 Initial Truss Construction

13 sticks
6 sticks
} 3/1/11 Truss construction

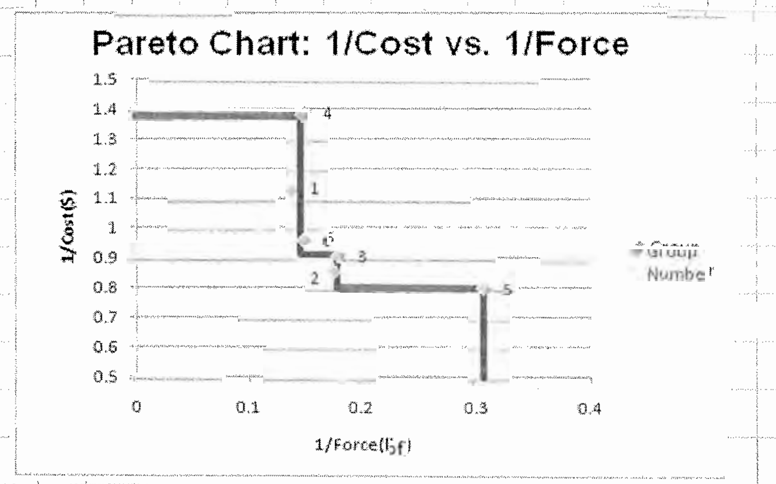
5 ft string
7 sticks
} Net Refinement + Truss Construction 3/2/11

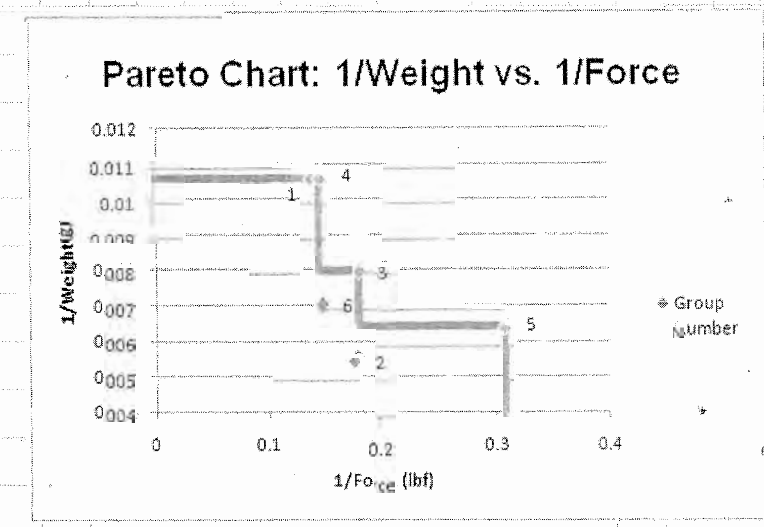
2 ft String
5 ft String
2 ft String
} Net Attachment - 3/8/11

Totals:
- 41 sticks
- 29 ft of string
- 1 Sheet of paper

Cost Analysis on Page 26!

Pareto Charts





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Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/10/11	Rebecca Ventimiglia	3/10/11

TITLE MAE 2250: Meteorite Catching Bridge

From Page No. 30

Appendix: Preliminary Design Review (Page 1 of 2)

The Synthesizers

Preliminary Design Review

Jen Gass, Chian Yeh Goh
Lemay Perez, Rebecca Ventimiglia

Interpreting Customer Needs

Customer Statements	Functional Requirements
The structure will be built entirely of fibrous materials provided by the instructors and Elmer's glue.	The structure is made up of only natural, non-man-made materials.
The structure must be lightweight.	The structure minimizes the amount of material used.
The structure must be simple to manufacture.	All steps toward assembly of the structure are easy to follow.
The structure must be able to catch a baseball.	The structure is able to dissipate 6-8 Joules of energy that results from the impact of a baseball.

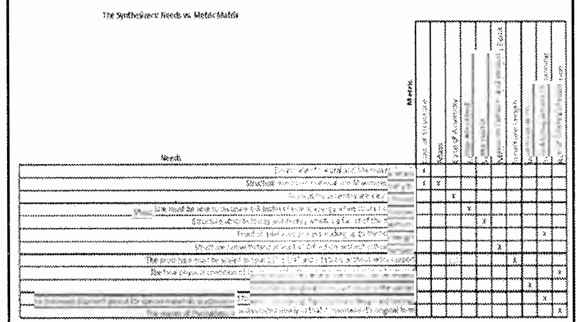
Interpreting Customer Needs

Customer Statements	Functional Requirements
The structure must provide a margin of safety.	The structure can absorb forces and energy to a factor above the expected maximum.
The structure must be innovative.	The structure is a result of a detailed thought process.
The structure must be able to be used after catching the meteoroid.	The structure can withstand a 3 inch deflection without critical damage.
The prototype must be scaled to span 21" ±1/4" and sit stable between two flat surfaces.	The structure coves a distance of 21" ±1/4" and can rest between two flat surfaces without extra support.

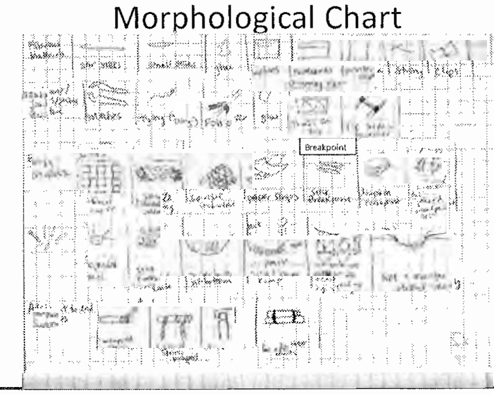
Interpreting Customer Needs

Customer Statements	Functional Requirements
The meteoroid must not damage on impact.	The structure keeps the final state of the meteoroid the same as before the impact.
Baseballs almost always hit the center of the bridge.	The bridge is designed for impact close to the center.
"Some" specialty shipments of materials may be made, but requests must be 1 week in advance.	A one-week shipment period for specialty materials is accounted for in the design planning of the structure.
The meteorite cannot 'shatter' on impact.	The structure dissipates the meteoroid's energy slowly so that it maintains original form.

Needs vs. Metric Matrix



Morphological Chart



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Witnessed & Understood by me, Rebecca Ventimiglia
Date 3/10/11

Invented by

Recorded By Rebecca Ventimiglia
Date 3/10/11

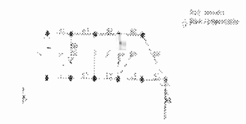
From Page No. 31

Appendix: Preliminary Design Review (Page 2 of 2)

Design Considerations

- Safety Factor = 5.0
- Cost Analysis
- Prior Experience/ Previous Courses
- Testing

Item	Amount
Napkin	1
Notecard (3X5)	0.55
Notecard (5X8)	0.25
Stir Sticks	2
Small Sticks	5
Cotton String	.833 ft

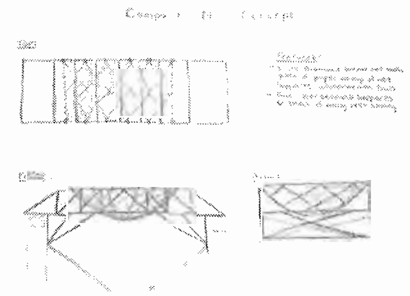


Decision Matrix

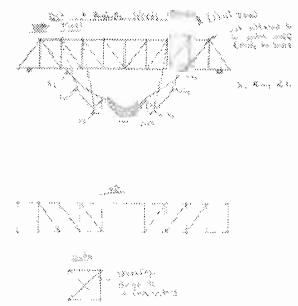
Ranking:
1 – least favorable
5 – most favorable

Criteria	Weight	Woven Paper	[illegible]	Lacrosse Stick Weave	Paper Strips	Stick Breakpoint + net	[illegible]	Suspended Bowl	Stick Funnel	Pa[illegible] Bottom	Compo[illegible]Paper Ramp	Net & [illegible]ngs Breaking
Ease of Manufacturing	0.1	5	[illegible]	1	5	4	3	[illegible]	3	3	5	3	2
Ease of Assembly	0.1	4	[illegible]	3	4	4	3	[illegible]	5	2	5	3	2
Weight	0.2	3	[illegible]	3	4	2	3	[illegible]	1	1	2	3	3
Cost	0.2	5	[illegible]	1	5	1	1	[illegible]	1	3	5	3	2
Handles Deflection	0.4	2	[illegible]	5	1	5	3	[illegible]	4	1	2	4	5
Total	1	3.3	[illegible]	3.2	3.1	3.4	2.6	[illegible]	2.8	1.7	3.2	3.4	3.4

Concept No. 1

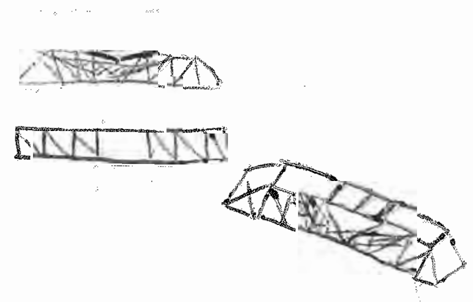


Concept No. 2



Key Features:
- Purposely breaking members
- Unique net design

Concept No. 3



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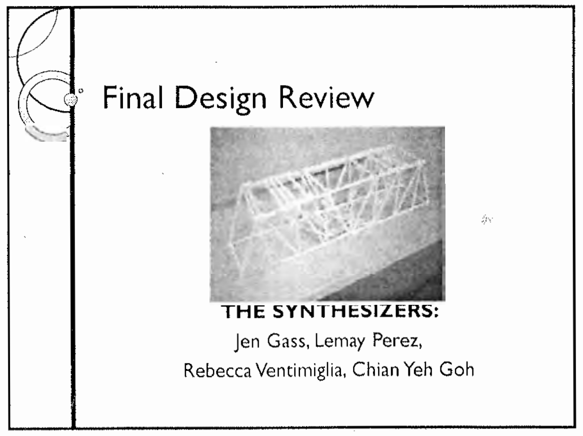
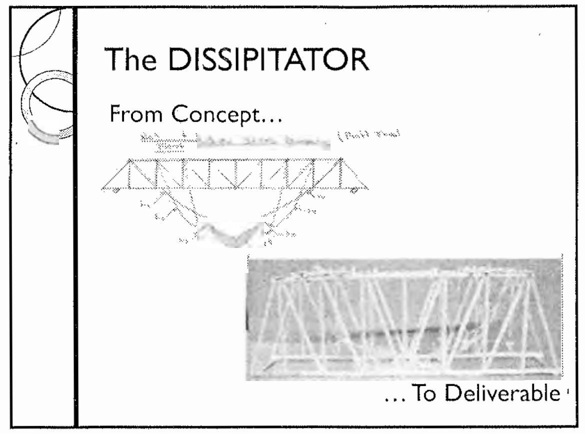
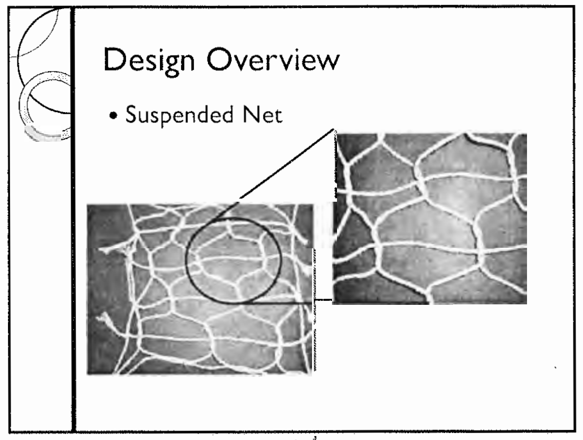
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/10/11	Rebecca Ventimiglia	3/10/11

TITLE MAE 2250: Meteorite Catching Bridge

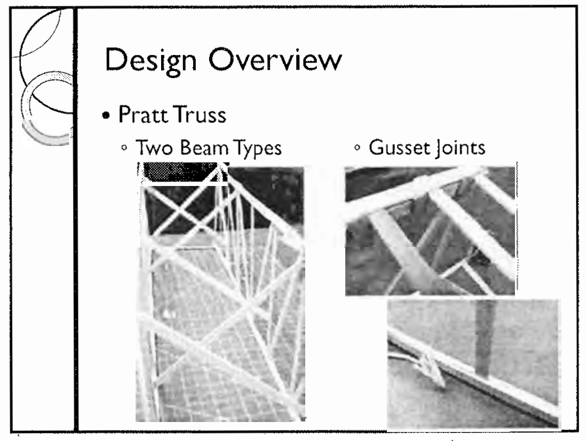
From Page No 32 Appendix: Final Design Review + Notes (Page 1 of 2)



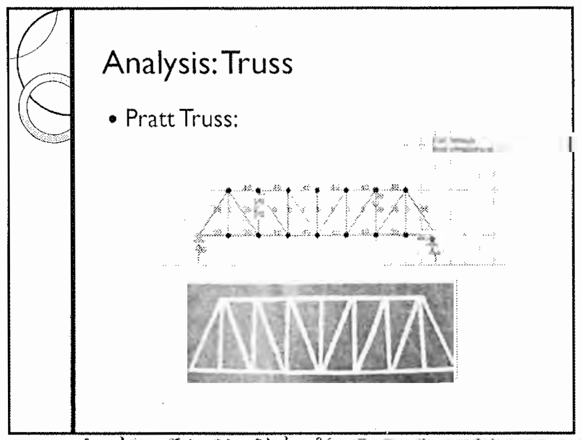




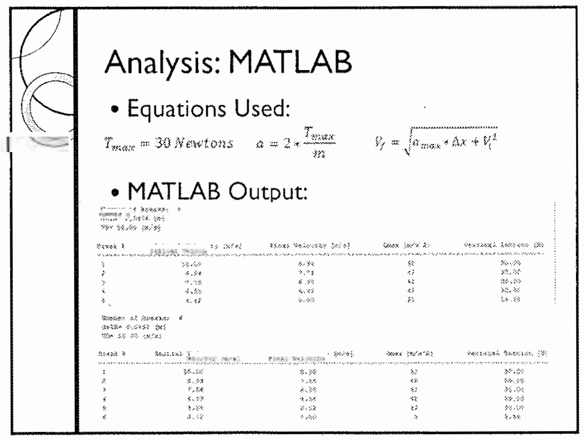
- Lacrosse/Diamond/Hammock weave.
- Allows for suspension & energy dissipation.



- Diagonal beams prevent torsion
- Reinforced members for sturdiness
- Gusset joints limit DOF

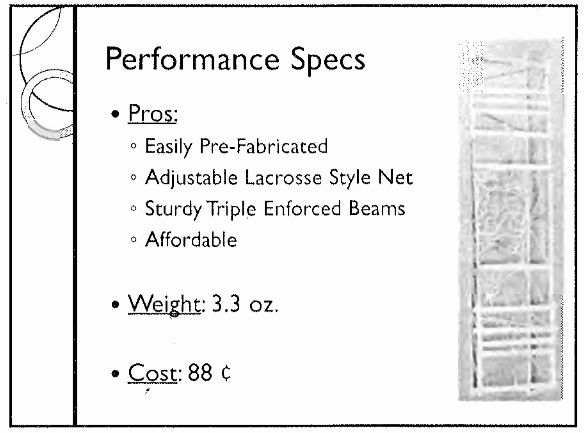


- Pratt truss put more critical bars in tension



To Page No. 34

From Page No. 33 Appendix: Final Design Review + Notes (Page 2 of 2)



Notes for "Ready for Mars Slide"

- Only built of wood, cotton string & glue
- Lightweight: only weighs 3.3 oz, is less than 1 kg
- Inexpensive → cost less than a $1, total cost was only 60% of budget.
- Prefabrication & templates allowed for easy to manufacture design
- Unique Design instills pride
- Triple reinforced beams make truss stable, diagonal connections prevent torsion.
- Dissipation occurs as opposed to a dead stop.

Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/10/11	Recorded By Rebecca Ventimiglia	3/10/11

From Page No. –

Date: 3/4/2011 (Lab Section 2:00-4:30)

Today in lab we received our groups/partners for the windpump project. The names and contact info of my team members is listed below:

Name:	Net ID:	Phone Number:
① Rebecca Ventimiglia	rv88	(203) 695-7208
② Catherine (Kai Weng) Wong	kw358	(408) 896-0214
③ Andre Vazquez	aav28	(908) 448-9612
④ Ryan Westover	rrw57	(781) 775-9772
⑤ Christian Segarra	cas397	(917) 406-2759

After exchanging contact information, we agreed to meet up during the following week. This meeting would be coordinated by e-mail.

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/4/11	Recorded By: Rebecca Ventimiglia	3/4/11

From Page No. 35

Date: 3/10/2011 (Initial Team Meeting in Duffield – 9pm to 10 pm)

- While waiting for everyone to arrive, the topic of meeting times was discussed. The best days for the group to meet, based on schedules were Tuesdays, Thursdays, and Saturdays in the evening.

- The schedule for the pump project was also looked over, in order to familiarize ourselves with deadlines:
  - Team Assignment: Week 6 (3/4/11)
  - Planning, Customer Specs, Brainstorming, Wind Turbine Tests: Week 7 (3/11/11)
  - Preliminary Design Review: Week 8: (3/18/11)
  - Analysis: Week 9: (3/25/11) → Spring Break
  - Final Design Review: Week 10 (4/01/11)
  - Qualifiers: Week 12 (4/15/11)
  - Pump Presentation: Week 13 (4/22/11)
  - Pump Testing: Week 14 (4/29/11)

- The problem statement was reviewed:
  The team must create a water pump powered by a wind turbine. The prototype must be efficient, ~~and be a~~ consist of a piston, and be compatible with supplied plate and sprocket. Included specifications for the wind turbine are that it will spin at a speed of 7m/s and the blades have a radius of .75m.

- Next, customer needs were translated.

① "The prototype should pump water from an input reservoir w/ water level at the height of the drive shaft to an output reservoir with water level at an elevation at least 1.5 m above the axis of the drive shaft at a rate of at least 1 L/min.

The windpump can have water input at the height of it's drive shaft and transport water to a height at least 1.5m above the shaft at a minimum rate of 1 L/min.

② "The cylinder bore diameter is fixed at 1.875", wall thickness .125", due to material availability.

The waterpump's cylinder will have a diameter of 1.875", wall thickness of .125" (so that the inner diameter is 1.5"), due to the material available.

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/10/11	Recorded By Rebecca Ventimiglia	3/10/11

TITLE MAE 2250: Wind Pump Project : Customer Requirements

From Page No. 36

3/10/2011 (continued)

(3) "The pump must sit stably on a 7"x7" horizontal plane supplied by customer."

The pump's center of mass coincides with the 7"x7" horizontal plate's center of mass (supplied by customer, must also consider height of pump)

(4) "The output drive shaft must be a 1/2" diameter rod extending 2 1/2" beyond the supplied face-plate (1/2" thick). It's axis will be located 5±2" above the horizontal plate. The pump will be attached to the face plate by 4, 1/4"-20 thread screws located on the face plate as shown on sketches provided on Blackboard."

The windpump's output drive shaft has a diameter of 1/2" extending 2 1/2" beyond the horizontal plate. The windpump's drive shaft axis is located between 3" and 7" above the horizontal plate. The windpump is attached to the face plate by 4, 1/4"-20 thread screws.

(5) "The overall dimensions of the pump must be such that it fits into a volume no greater than 14"x14"x14". It will sit on the 7"x7" horizontal plate (see sketch on Blackboard). The height of the horizontal plate is adjustable so that the distance from the horizontal plate to the drive shaft accomodates your motor within the range specified in the previous paragraph. The pump will be surrounded by ambient air, and placed in a tub to collect possible water leaks. Water will be fed to and from the pump through 3/8" lines connected to the input and output reservoirs. The elevation of the input reservoir water level will be the same as the shaft's.

The volume of the wind pump is at most 2,744 in³. The pump works in an open-air environment and can be connected to water lines of 3/8" diameter. The pump's operating height is that it coordinates with the specified requirements. The pump must also tolerate leaks and pump from an input height that is even with the shaft height.

(6) "The input torque will be provided by the customer-supplied wind turbine. You will have measured the torque-power characteristics of the turbine in weeks 7 or 8."

The windpump receives input torque from a customer-supplied wind turbine, whose power and torque characteristics will be measure in weeks 7 or 8.

*Next meeting: 4 pm on Saturday, March 12, 2011.

To Page No. 38

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/10/11	Recorded By Rebecca Ventimiglia	3/10/11

From Page No. 37

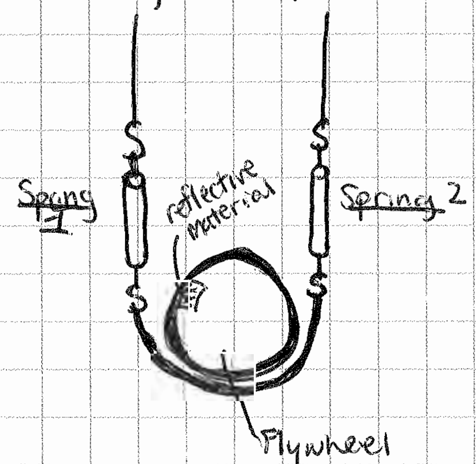
Date: 3/11/2011 (Lab Section 2:00-4:30 pm)

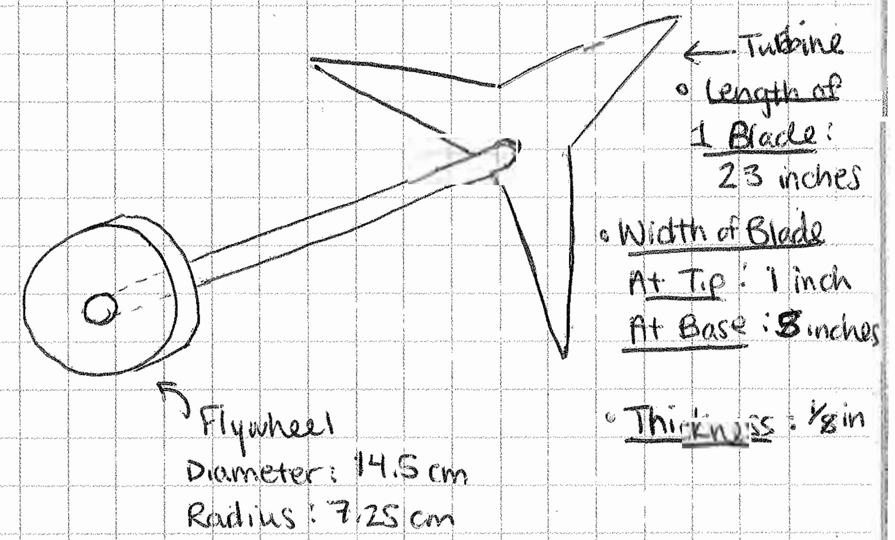
Wind Turbine Testing

Procedure:

1. ~~Start~~ Obtain an rpm measurement device (Tachometer)
2. Zero out the springs in the testing set-up.
3. Remove belt from around the flywheel and start the wind turbine.
4. Obtain the maximum number of RPM for the turbine while the belt is disconnected.
5. Add the belt to the wind turbine fly wheel and record the RPM and the spring measurements for each spring. Be sure that ~~these~~ springs are not so tight that the turbine stalls.
6. ~~Rep~~ Tighten the springs and repeat step 5. Use slight increments of spring tightening and continue to repeat until stalling.
7. Once a stall point is reached, take down measurements of the flywheel dimensions and record.

Testing Set-Up:





Data Group 2:

	RPM	Spring 1 (N)	Spring 2 (N)	Net Force (N)
Max:	1210	0	0	0
	1027	4	0	4
	945	6	0	6
	865	8	.2	7.8
	727	11	.4	10.6
	640	13	.7	12.3
	544	14	.8	13.2
Stall:	530	14.5	.7	13.8

Group 1:

	RPM	Spring 1 (g)	Spring 2 (g)	Net Force (N)
Max:	1235	0	0	0
	1130	220	20	1.962
	1030	450	25	4.169
	960	600	25	5.641
	915	650	25	6.131
	845	840	25	7.995
	730	1100	80	10.00[illegible]
	640	1300	100	11.77[illegible]
	0	1400	100	12.75[illegible]
Stall:	0	1500	[illegible]	13.[illegible]

To Page No. 39

Witnessed & Understood by me, Rebecca Ventimiglia
Date 3/11/11
Invented by
Recorded By Rebecca Ventimiglia
Date 3/11/11

From Page No. 38 (3/11/2011 Continued)

After Obtaining the Wind Turbine Data, we decided to write a MATLAB m-file to plot the data and analyze it.

- Pseudo code for Power Curve Analysis:
  - Define constants (radius of flywheel = .0725 m)
  - Define vectors for rpm and forces on each spring
  - Convert rpm to rps and then define ω (angular frequency = 2π rps).
  - Find delta for Torque (the differences between the forces on the springs) and then use this delta to find torque (radius of flywheel multiplied by ~~frequency~~ difference in spring forces)
  - Calculate ~~torq~~ power (Torque multiplied by frequency)
  - Plot frequency vs. power.

- By the time the code was written, it was time to exit the lab. The group agreed to set up a few meetings for the next week and to communicate through a wiggio account. The next meeting would be on Saturday, March 12th, 2011 at 4 pm. Team members would prepare by reading through lecture notes on turbine performance.

Net-Print rv88 C:\...\Temp\powerCurve.m Net-Print

3/31/11 8:23 PM C:\Users\labuser\AppData\Local\Temp\powerCurve.m 1 of 1

```
function powerCurve()
radius = .0725;

rpm = [1210 1027 945 865 727 640 544 530]';
rps = rpm /60;
w = 2 * pi * rps;

T1 = [0 4 6 8 11 13 14 14.5]';
T2 = [0 0 0 0.2 0.4 0.7 0.8 0.8]';

delT = T1 - T2;

Torque = delT * radius;

Power = Torque .* w;

hold on
axis equal
axis on
plot(w, Power);


end
```

To Page No. 40

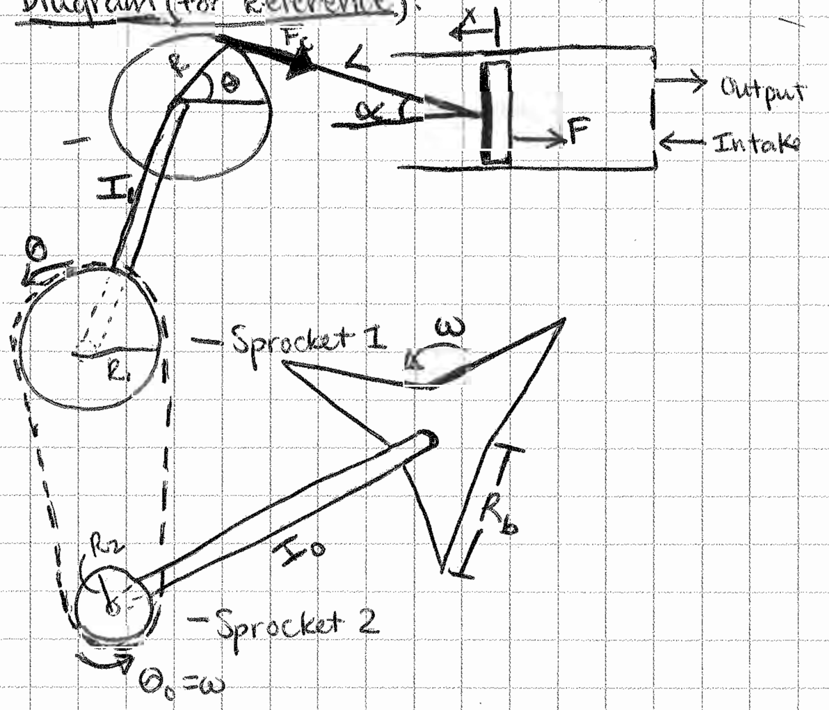
Witnessed & Understood by me:	Date	Invented by	Date
Rebecca Ventimiglia	3/11/11	Recorded By: Rebecca Ventimiglia	3/11/11

From Page No. 39

Date: 3/12/2011 (Meeting in Project Team Lab by Whiteboard Wall (4:30-6:30 PM))

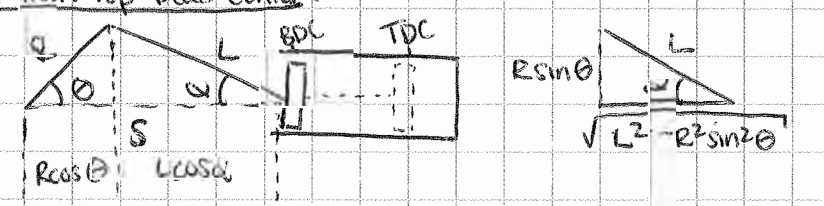
In order to get a better feel for the project and the way the turbine/pump works, we rederived the equations from lecture.

Diagram (for Reference):



Key:
- α = angle of drive shaft w/ horizontal
- F_c = Force of crankshaft
- L = length of driveshaft
- F = force of piston
- R = Radius of crankshaft
- θ = angle of crankshaft w/ horizontal
- I_1, I_0 = moment of inertia of connecting rods
- ω = angular frequency
- R_b = radius of blade
- $\dot{\theta}$ = tangential velocity at sprocket 1
- $\dot{\theta}_0$ = tangential velocity at sproket 2

Distance from Top Dead Center:



Distance = Total Distance − Current/Instantaneous Position

$$x = R + L - [L\cos\alpha + R\cos\theta]$$
$$x = R + L - [R\cos\theta + \sqrt{L^2 - R^2\sin^2\theta}]$$

Speed of Piston:

$$\dot{x} = \frac{d}{d\theta}\left[-\sqrt{L^2-R^2\sin^2\theta} - R\sin\theta\right]$$
$$\dot{x} = -\tfrac{1}{2}(L^2 - R^2\sin^2\theta)^{-1/2}(-2R^2\sin\theta(\cos\theta)) + R\sin\theta$$
$$\dot{x} = \frac{R^2\sin\theta\cos\theta}{\sqrt{L^2-R^2\sin^2\theta}} + R\sin\theta = R\sin\theta\left[\frac{R\cos\theta}{\sqrt{L^2-R^2\sin^2\theta}} + 1\right]$$

Note: We did not follow Prof. Lange's assumption since we wanted to do out the proof completely.

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(3/12/2011 Continued)

Volume Flow Rate/Volume Pumped

$$\dot{Q} = A\left[R\sin\theta\left(\frac{R\cos\theta}{\sqrt{L^2-R^2\sin^2\theta}}+1\right)\frac{d\theta}{dt}\right]$$

$$\int\dot{Q} = \int_0^{\pi} A\left[R\sin\theta\left(\frac{R\cos\theta}{\sqrt{L^2-R^2\sin^2\theta}}+1\right)\frac{d\theta}{dt}\right]$$ ← For 1/2 cycle, the volume pumped

$$Q = \frac{1}{2}A\frac{d\theta}{dt}\int_0^{\pi}\frac{du}{\sqrt{u}} + AR\frac{d\theta}{dt}\int_0^{\pi}\sin\theta\, d\theta$$

$$Q = \tfrac{1}{2}A\frac{d\theta}{dt}\int_0^{\pi}u^{-1/2} + AR\frac{d\theta}{dt}\int_0^{\pi}\sin\theta\, d\theta \; ; \quad u = L^2-R^2\sin^2\theta,\ du = -2R^2\sin\theta\cos\theta$$

$$Q = \tfrac{1}{2}A\frac{d\theta}{dt}\left[u^{-1/2}\right]_0^{\pi} - AR\frac{d\theta}{dt}\cos\theta\Big|_0^{\pi}$$

$$Q = A\frac{d\theta}{dt}\left(L^2-R^2\sin^2\theta\right)^{1/2}\Big|_0^{\pi} - AR\frac{d\theta}{dt}(-1-1)$$

$$Q = 2AR\, d\theta/dt$$ ← Volume pumped for one cycle

$$\dot{Q} = \frac{AR}{\pi}\, d\theta/dt$$

Sprocket Connections

Between the two sprockets, tangential velocities are the same, ~~therefore~~ and the angular velocities are the same between the shaft connections!

$$R_2\omega = R_1\dot{\theta}$$

$$\dot{\theta} = \frac{R_1}{R_2}$$ ← This can now be substituted into the equation for volumetric flow.

$$\dot{Q} = \frac{AR}{\pi}\left(\frac{R_1}{R_2}\right)\omega$$

Power:

$$P = Fv = F\frac{dx}{dt}$$

$$P = \rho g h A\frac{dx}{dt}$$

$$P = \rho g h\dot{Q} = \rho g h\left(\frac{AR}{\pi}\right)\left(\frac{R_1}{R_2}\right)\omega$$ ← so the key variable is r because all other variables are constants.

- By going through these proofs, it was realized that a mostly/complete linear motion was desirable for efficiency. Also, we obtained ideas for materials and design. We would consider gears as well as a dual action piston.
- Other considerations: friction between sprocket & drive shaft/flywheel, look to maximize torque & minimize resistance in overall motion equation:

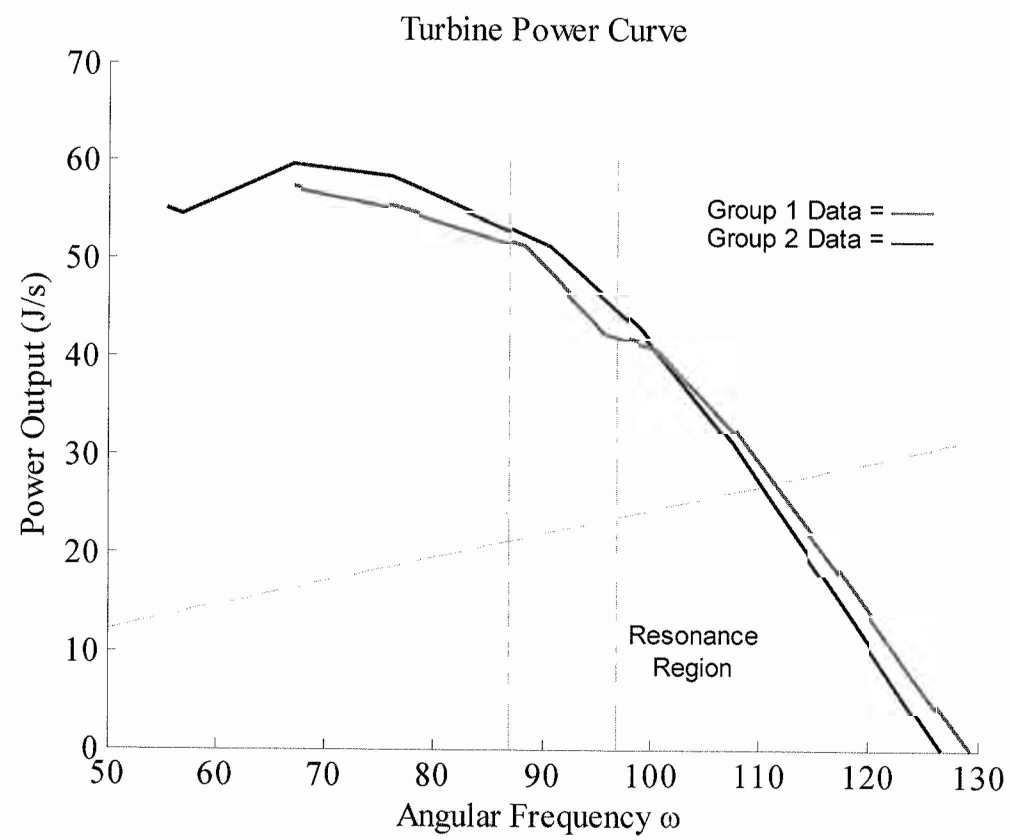
$$\left[I_1 + I_0\left(\frac{R_1}{R_2}\right)^2\right]\ddot{\theta} = \overbrace{\left(\frac{R_1}{R_0}\right)^2 T_m\left(\frac{\dot{\theta}}{\omega_m}\right)\left[2-\left(\frac{R_1}{R_0}\right)\frac{\dot{\theta}}{\omega_n}\right]}^{\text{Torque}} - \overbrace{\frac{F R\sin\theta + \theta_c}{\cos\theta_r}}^{\text{Resistance}}$$

To Page No. 42

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia (signature)	3/12/11	Recorded By: Rebecca Ventimiglia	3/12/11

From Page No. 41 (3/12/2011 Continued)

- MATLAB code
  - After analyzing the MATLAB program, which had been revised since our last meeting. The new code included a reasonance region between 87 - 97 rad/s (Angular Frequency) Also included was a line for the power required for certain angular frequency. We decided that we should aim for the ~~lower~~ higher end of the reasonance region of a little more. This is because we would minimize the power required and avoid reasonance. The curve that we looked at is shown below



To Page No. 43

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/12/11	Recorded By Rebecca Ventimiglia	3/12/11

TITLE MAE 2250: Windpump Project: Priority of Customer Needs/Memo Project No. 2 Book No. 1

From Page No. 42

Date: 3/14/2011 (Meeting at Project Team Whiteboard Wall: 7-9 PM)

Priority of Customer Needs/Functional Requirements

#	Aspect of Pump	Importance (3>2>1)	Dimension Requirement	Metric
1	Δ between drive shaft & output reservoir	**	$\Delta x \geq 1.5m$	Meters
2	Volumetric Flow Rate	***	$\dot{Q} > 1\ L/min$	ΔVolume/Δtime (m^3/s)
3	Center of Mass	***	Concentric/No Vibration	Meter
4	Distance from Faceplate	**	$\Delta x \geq 2.5''$, length $\geq 3''$	Inches → Meter
5	Axis of Output Shaft	*	5 ± 2" above horizontal plate	Meter
6	Attachment	***	Compatible with face plate	Meter / Screw Size & Dimensions
7	Volume of Pump	*	14"x14"x14" w/face plate	$Meter^3$
8	Input/Output Dimension	**	3/8" Diameter	Inches → Meters
9	Power	***	Generate at V=7m/s	Watts
10	Cost Efficiency	**	Total Budget ≤ $30, Efficient Machinery	USD ($)
11	Ease of Production	**	Minimize components & complicated shapes	Machining Hours

In the chart above, aspects with 3 stars were given the highest priority and aspects with 1 star were given the lowest priority.

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Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/14/11	Rebecca Ventimiglia	3/14/11

π day!

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Date: 3/14/2011 (Continued)

Generated Aspects to Focus on for A Morphological Chart

Tubing
- Junctions
- Sizes
- Shapes
- Positions

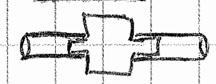
Operating Machinery
- # of Pistons
- Valves
- Crankshaft
- Drive Mechanism
- Position of Pistons

Stability

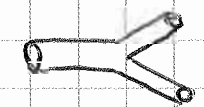
Date: 3/17/2011 – My Ideas for Morphological Chart (5 – 5:30 PM)

Junctions:

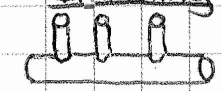
Valve:



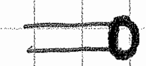
Y-Junction:



Branching

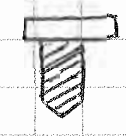


Rubber/O-Ring



Hydraulic Tape/Teflon

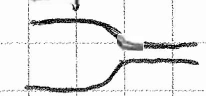
Threaded:



Rubber Stoppers

Sizes

Large to Small (Nozzle)



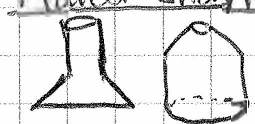
Same Throughout

Shapes

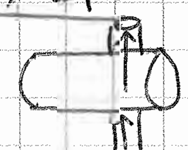
Tapered Holes

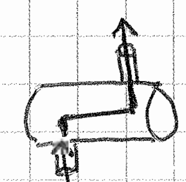
(cross section of tapered hole)

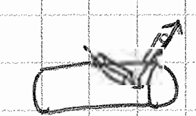
Fluted Ends/Nozzled Ends

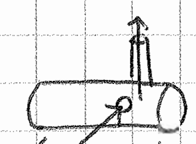


Positions on Input / Output:









(90° offset)

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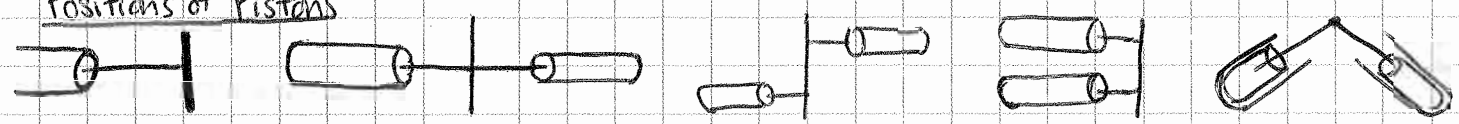
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/14/11	Recorded By: Rebecca Ventimiglia	3/14/11

From Page No. 44

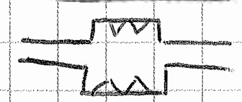
Date 3/17/2011 (continued)

Positions of Pistons

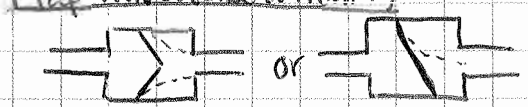


Valves

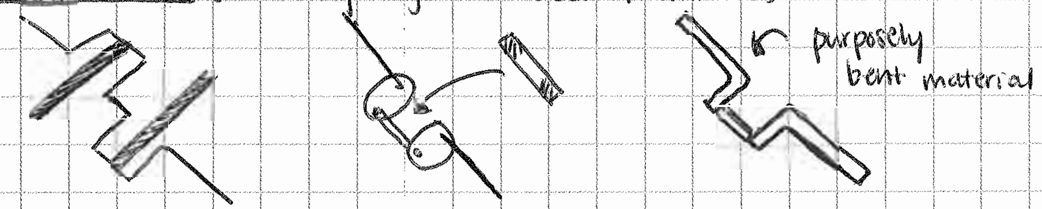
Check Valves



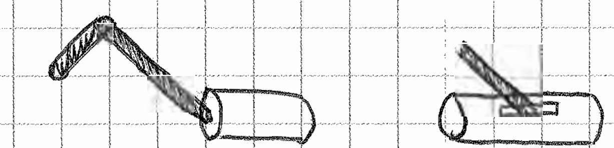
Flap Valves (Like a Heart)



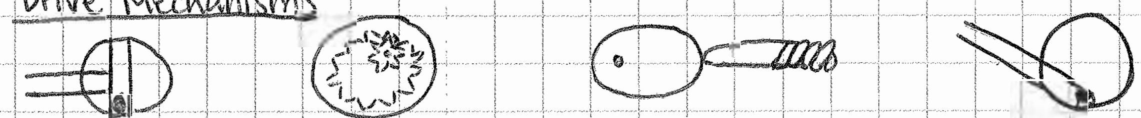
Crank Shaft (can vary angles between members)



Drive Shaft Connections



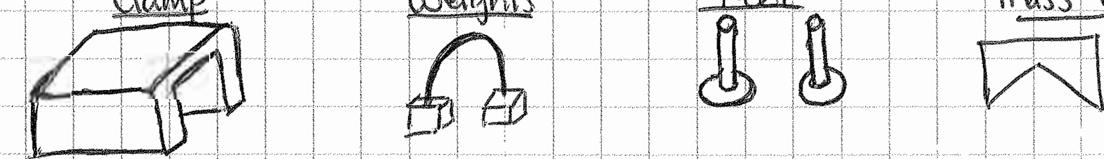
Drive Mechanisms



Yoke | Gears | Cam-Driven | Slider Crank

Stability

Clamp | Weights | Feet | Truss Like



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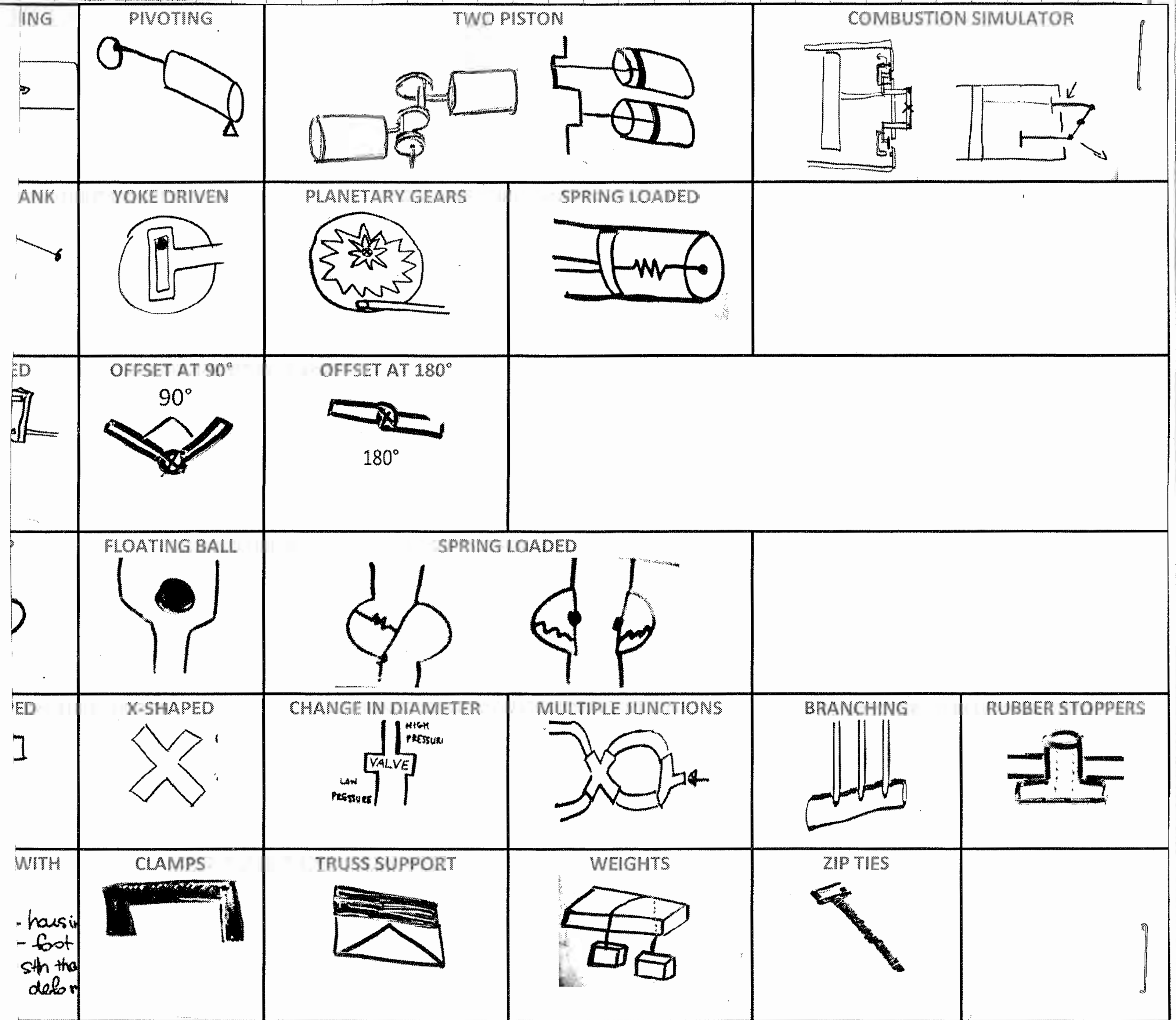
From Page No. 45

Date: 3/17/2011 – Team Meeting in Duffield (6:30 PM – 9:15 PM)
At this meeting, we created our Morphological Chart and Decision Matrix

MORPHOLOGICAL CHART:



To Page No. 47

Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/17/11	Recorded By Rebecca Ventimiglia	3/17/11

From Page No. 46

DATE: 3/17/2011 (Continued)

MACH 5 Decision Matrix (Numbers highlighted represented top choices for each category).

Mach 5: Decision Matrix

		Concepts																		
		Piston Concepts								Valve			Tubing			Stability				
Criteria	Weight	Two Piston	Dual Acting Piston	Slider Crank w/ Pivoting Cylinder	Yoke Driven	Cam Following	Gear Driven	Spring Loaded	Combustion Simulated	Flap Valve	Floating Ball Valve	Spring Loaded Valves	Junctions in Tubing	Large to Small	Branching	Housing with Feet	Clamps	Wieghts	Truss-Like Support
Volumetric Flow Rate	0.3	5	4	4	3	1	1	2	3	5	5	3	2	4	5				
Stability	0.2															3	5	4	2
Compatibiltiy with Given Dimensions	0.15	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Amount of Material	0.1	2	3	5	4	3	1	3	2	4	3	2	3	4	2	4	3	1	2
Cost Efficiency	0.15	4	3	5	4	2	2	4	1	4	5	2	2	3	3	5	4	3	1
Ease of Production	0.1	5	2	4	4	1	1	4	1	4	5	2	3	3	3	4	5	3	1
Total	1	3.25	2.6	3.3	2.75	1.45	1.25	2.35	1.8	3.35	3.5	2.05	2	2.8	3	2.6	2.9	2.1	1.3

Ratings are on a 1 to 5 scale where 1 is the worst and 5 is the best. Ratings were based on prior experience and knowledge from previous courses

From the results of our decision matrix, we decided on drawing the top 3 concepts for the PDR design review. The sketches of the 3 concepts are shown in the following pages.

To Page No. 48

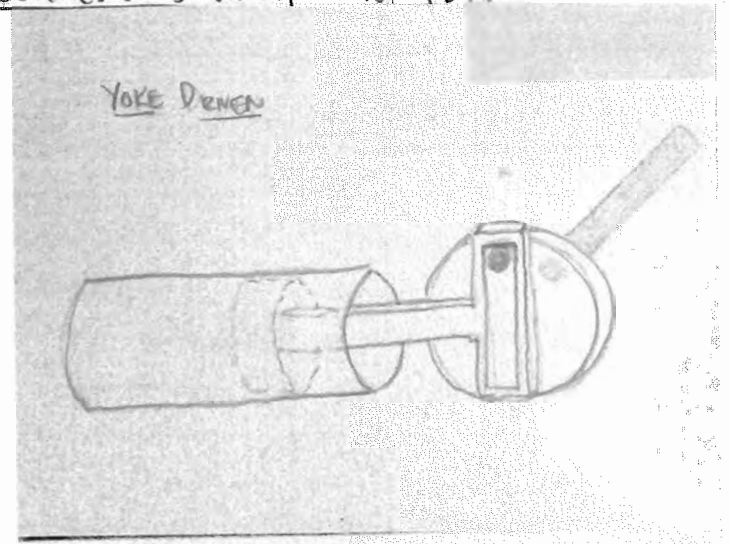
Witnessed & Understood by me.	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/17/11	Recorded By Rebecca Ventimiglia	3/17/11

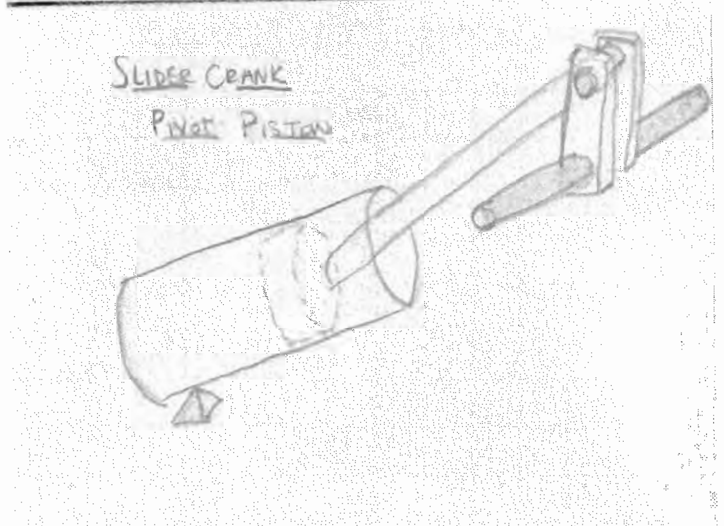
TITLE MAE 2250: ~~Meteor~~ Windpump Project: PDR Sketches

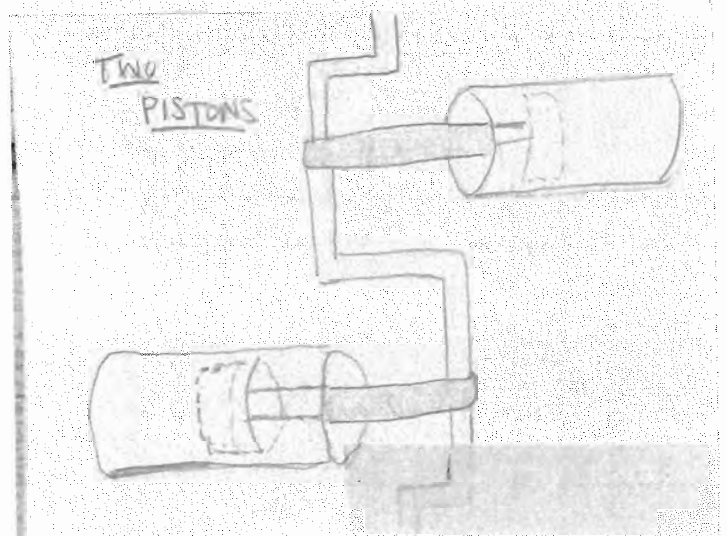
From Page No. 47

Date: 3/17/2011

Sketches of 3 Concepts for PDR:







To Page No. 49

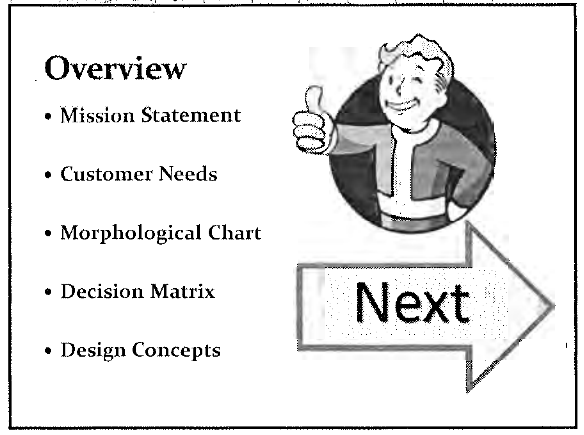
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/17/11	Recorded By Rebecca Ventimiglia	3/17/11

From Page No. 48

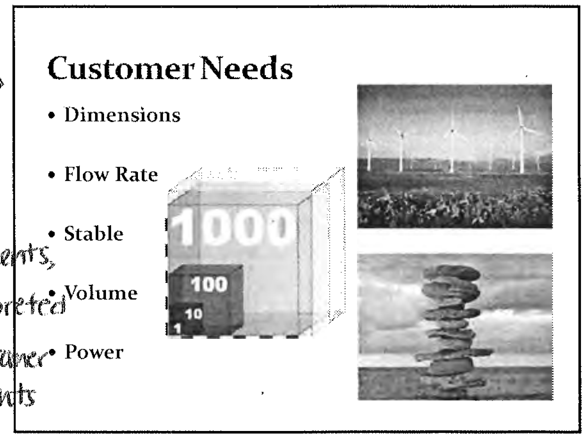
Date: 3/18/2011 (Meeting in Duffield 1:00 ~ 1:30 PM)
We met to practice the PDR and go over what we wanted to discuss with the PDR.

Slide 1:
Rebecca → talk about MACH 5 speed / intro

Slide 2:
Catherine → talk about the presentation in general, mention motto



Slide 3:
Catherine → discuss the main customer requirements, as interpreted from customer statements

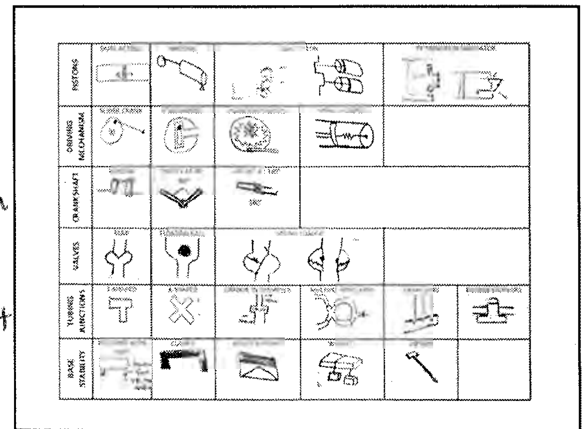


Slide 4:
Catherine → Show that we took into account dimensional requirements from customer statements

Numerical Specifications

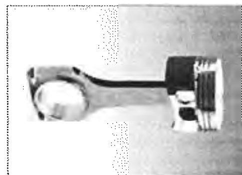
Aspect of Pump	Dimension	Metric
Height between drive shaft and output reservoir	≥ 1.5 meters	Meters
Volumetric flow rate	≥ 1 liter/minute	ΔVolume/ΔTime
Cylinder bore diameter	1.875 inches	Meters
Wall thickness	.125 inches	Meters
Center of mass	Concentric with COM of horizontal plate	Meters
Output drive shaft	.5 inch diameter, length 2 inches	Meters
Output drive axis	3-5 inches above horizontal plate	Meters
Compatible with screws	.25 inches, 20 thread	Meters, Threads
Volume of pump	≤ (14 inches)^3	Meters^3
Compatible with lines	.375 inches	Meters
Power	Wind at speed of 7 meters/second	Watts

Slide 5:
Catherine → Discuss ideas which are unique to Mach 5, hit at least one item per row



Slide 6:
Rebecca → Discuss criteria, priority weighting, why two decisions matrices / no values for stability

Decision Matrices



	Weight	Two Piston	Dual Acting Piston	Slider Crank w/ Pivoting	Yoke Driven	Cam Following	Gear Driven	Spring Loaded	Combustion Simulated
Volumetric Flow Rate	0.3	5	4	4	3	1	1	2	3
Stability	0.2								
Compatibility with Given Dimensions	0.15	3	3	3	3	3	3	3	3
Amount of Material	0.1	2	3	5	4	3	1	3	2
Cost Efficiency	0.15	4	3	5	4	2	2	4	1
Ease of Production	0.1	5	2	4	4	1	1	4	1
Total	1	[illegible]	2.6	[illegible]	[illegible]	1.45	1.25	2.35	1.8

To Page No. 50

Witnessed & Understood by me,
Rebecca Ventimiglia
Date 3/18/11
Invented by
Recorded By
Rebecca Ventimiglia
Date 3/18/11

From Page No. 49

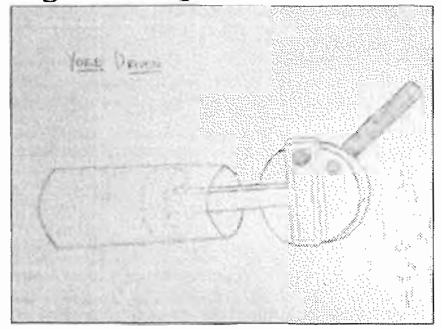
Date: 3/18/2011 (Continued)
PDR Part 2

Slide 7:
Rebecca →
Again, explain why there are two matrices, top concepts will go with each top concept from previous decision matrix

Decision Matrices

	Weight	Valve			Tubing			Stability			
		Flap Valve	Floating Ball Valve	Spring Loaded Valves	Junctions in Tubing	Large to Small	Branching	Housing with Feet	Clamps	Wieghts	Truss-Like Support
Volumetric Flow Rate	0.3	5	5	3	2	4	5				
Stability	0.2							3	5	4	2
Compatibility with Given Dimensions	0.15	3	3	3	3	3	3	3	3	3	3
Amount of Material	0.1	4	3	2	3	4	2	4	3	1	2
Cost Efficiency	0.15	4	5	2	2	3	3	5	4	3	1
Ease of Production	0.1	4	5	2	3	3	3	4	5	3	1
Total	1	3.35	3.5	2.05	3	2.8	[illegible]	2.6	[illegible]	2.1	1.3

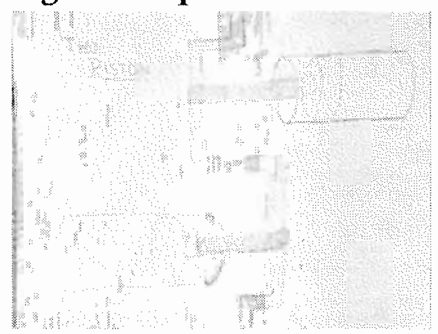
Design Concept 1:



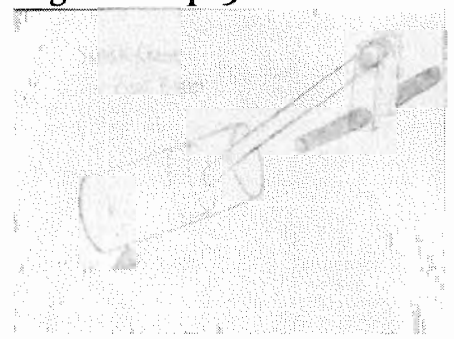
Slide 8:
Rebecca →
describe yoke driven concept, explain drawing

Slide 9:
Catherine →
explain two piston design concept

Design Concept 2:



Design Concept 3:



Slide 10:
Catherine →
explain dual acting ability of this concept

Slide 11:
Rebecca →
explain pros & cons of each design

Moving Ahead

- 1)Yoke Driven PROS: Simple to manufacture/analysis CON: Not competitive
- 2)Two Piston PROS: Simple, more Q CON: More manufacturing
- 3)Slider Crank PROS: Duality, competitive CON: Difficult to manufacture and analyze.

Questions?

Slide 12:
Closing/
Field Questions

To Page No. 51

Witnessed & Understood by me, Rebecca Ventimiglia | Date 3/18/11 | Invented by | Recorded By Rebecca Ventimiglia | Date 3/18/11

From Page No. 50

Date: 3/18/2011 Lab Section (2:30-4:30 PM - Taylor Design Studio)

Easel Design/Concept Review from Peers/TAs

Below is the name of the concept and the feedback we received for the concept.

① Slider Crank Pivot Piston
- Hard to House?
- Easy to break?
- Might be too unstable?
- Angle is good for pumping out, harder for drawing in.
- Seems hard to make advantageous?
- Maybe a vertical driver?

② Two Piston Slider Crank
- Watch corners for stress points.
- How is shaft made?
- Check for engine balance.

③ Yoke Driven
- Where are these commonly used?
- One piston, most effective use of energy?
- Tricky to manufacture
- Good flow rate
- Lots of frictional resistance?

④ Morphological Chart
- Joints may be hard to manufacture
- Branching → clever, could help w/ pressure.
- We're already provided a base.
- What valves are you using for each design?
- Planetary gears are complicated.
- Considering analysis → maybe different gear orientations.

We reviewed the comments given to us by our peers and considered their expressions and advice in our design process.

To Page No. 52

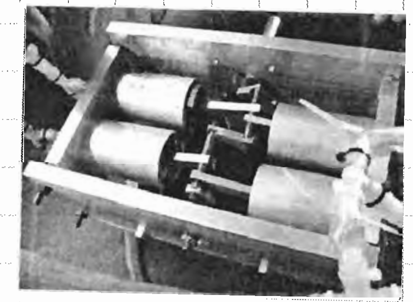
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/18/11	Recorded By: Rebecca Ventimiglia	3/18/11

From Page No. 51

Date: 3/18/2011 (continued)

After PDR presentations were given (see pages 49 & 50 for PDR), we analyzed pumps from previous years:

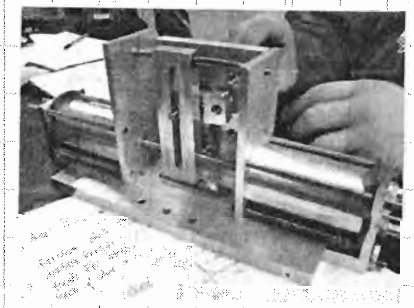
① 4-Piston Yoke Driven Design.
- Strong middle joint
- Alignment geometry are very significant!
- Notches cause a lot of stress
- Open bottom → reduce material / save money
- Gapers for alignment
- Bore out plates to hold pistons
- Rotation w/ cylinders

① 

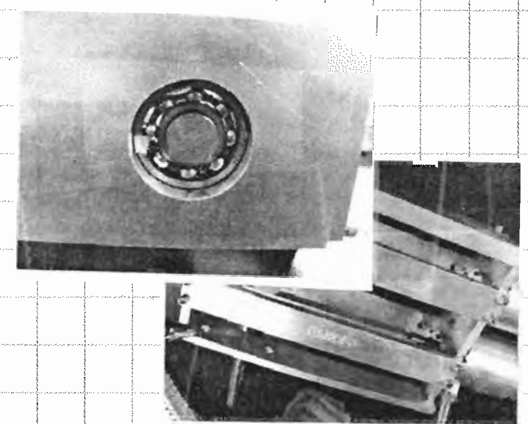
② Dual Acting (Unsuccessful)
- Rubber pads → bad idea for sealing
- Housings compacted cylinders
- Yoke in one direction → no rotation!
- Washers used in spacing

② 

③ Dual Acting (Success)/Yoke Driven
- Must minimize gap
- A lot of boring → easy to manufacture?
- Washers for less friction

③ 

④ Antilla Big 6
- Notched joints →
- Ball bearings = less friction
- Pins to hold joints together
- Additional extra strips for friction/fill gap

④ 

The group used the pros and cons of each design & design elements when designing the pump

To Page No. 53

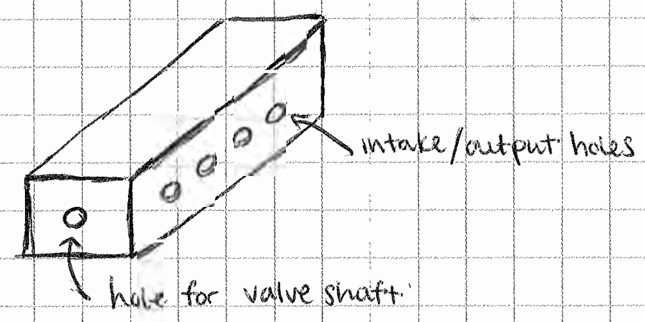
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/18/11	Recorded By: Rebecca Ventimiglia	3/18/11

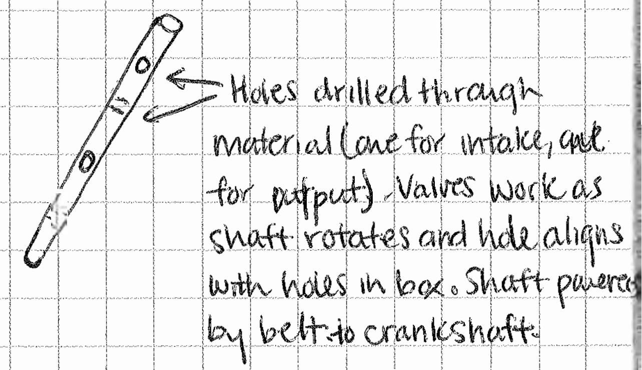
From Page No. 52

Date: 3/29/11 (Team Meeting in Duffield : [illegible]PM~11:30PM)

At today's team meeting, we discussed different valve box ideas, as well as different ideas of parts for ordering.

Valve Box Idea:





Parts to Consider Ordering:

1 O-Ring (for seal)
1 Belt (to drive our valve shaft)
? E-clips (to hold rods in place while rotating)
4 Hose Fittings (to control flow into hoses)
? Gears / Acrylic for making gears.
2 Belt Pulleys

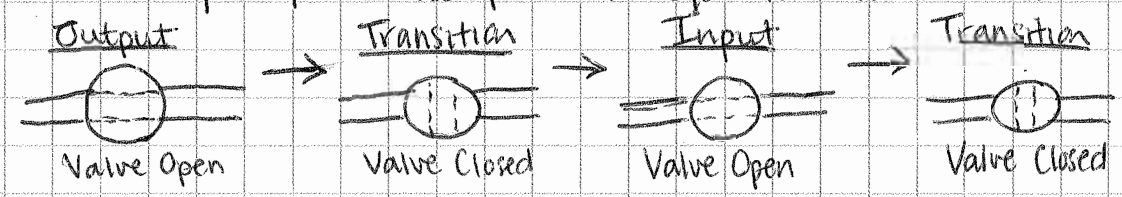
To Page No. 54

Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/29/11	Recorded By: Rebecca Ventimiglia	3/29/11

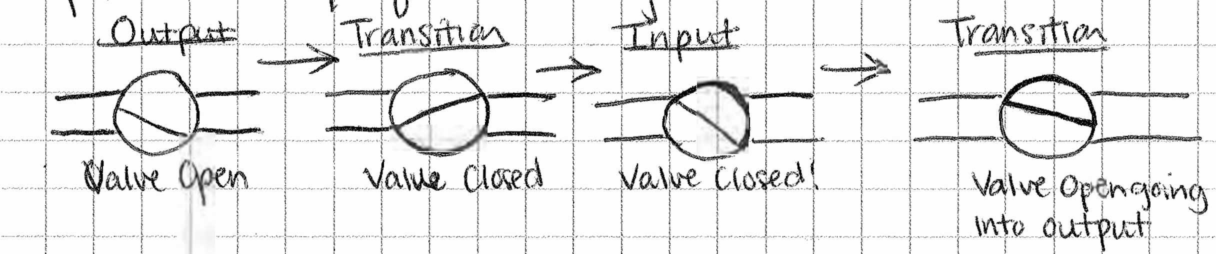
From Page No. 53

Date: 3/30/2011 (Meeting in Upson Basement (2:30 pm - 4:15 pm))

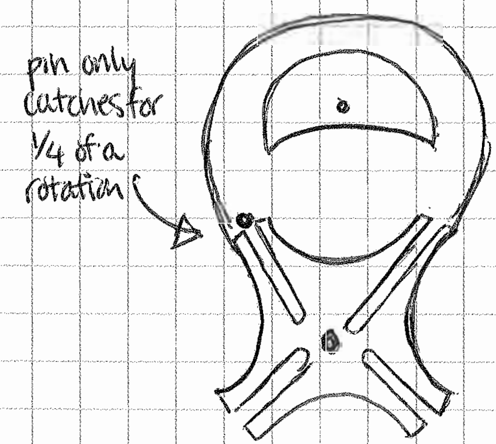
- It was brought up that our original design for the valve box shaft may not work. This is because the valve would be open on both the intake and output strokes, as shown below. We need the valve to only be open on one part of the cycle for each rotation.



- In order to fix this, we came up with a half circular shaft idea that allowed for an open valve for only a quarter of the cycle.



- Another idea that we considered was manufacturing a Geneva gear, as shown below. This would only allow for the value to be open for 1/4 of a cycle. The original valve shaft design would be used with this design so that the valve would only be open on intake or output, but not both.



- Decided to come to another team meeting tomorrow to draw parts, fully dimensioned in CAD. Members expected to create design with dimensions.

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Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	3/30/11	Recorded By: Rebecca Ventimiglia	3/30/11

From Page No. 54

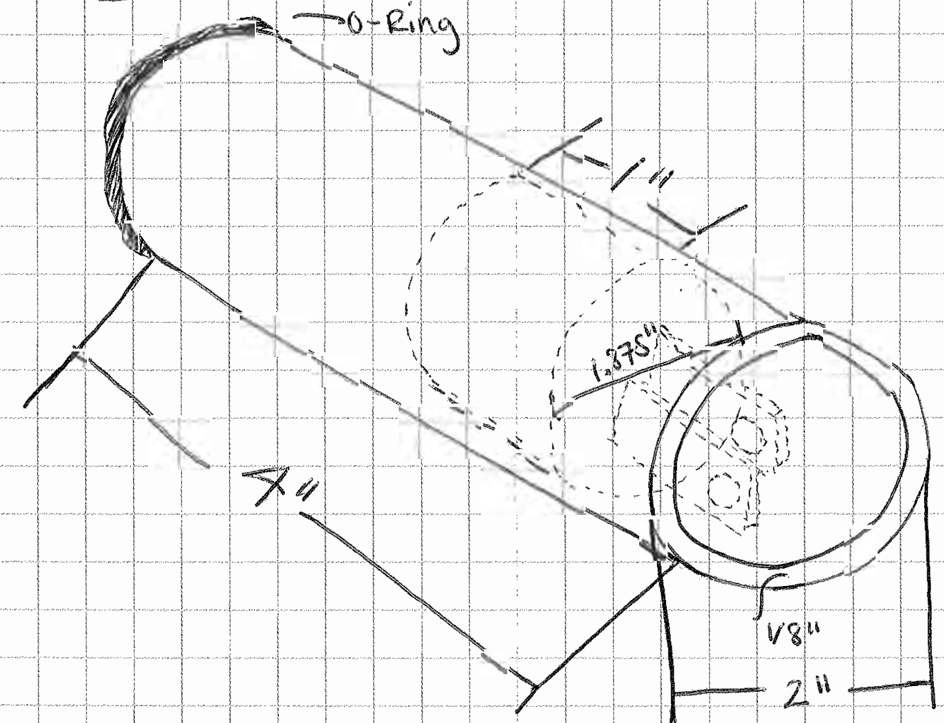
Date: 3/30/2011

The following are my original design concepts with dimensions. I took the list of provided material, and worked with it to create a design.

Provided Material:

- Stock: Aluminum 6061 T6 & Steel 1012
- 1.875" PVC Round Stock
- 2" O.D. Aluminum Tubing, nominally 1.75" ID.
- 1" x 2" Aluminum Flat Stock 10"
- 1/2" diameter Aluminum Rod
- 1/2" x 4" Aluminum Flat Stock 10" (Base)
- ~~1" x 2" Aluminum Flat Stock 10"~~
- 1/4" x 1" Aluminum Flat Stock 10"
- 2 1/4" x 2 1/4" Aluminum Flat Stock 10"

CYLINDERS/PISTONS



MATERIAL USED:
1 - O-Ring
8" - Aluminum Cylinder/Tubing
2" - PVC Piston Round Stock

*Note: Dimensions were not chosen yet, because it was dependent on the geometry of the rod for the brackets connecting to the rod.
The brackets will be manufactured from remaining stock.

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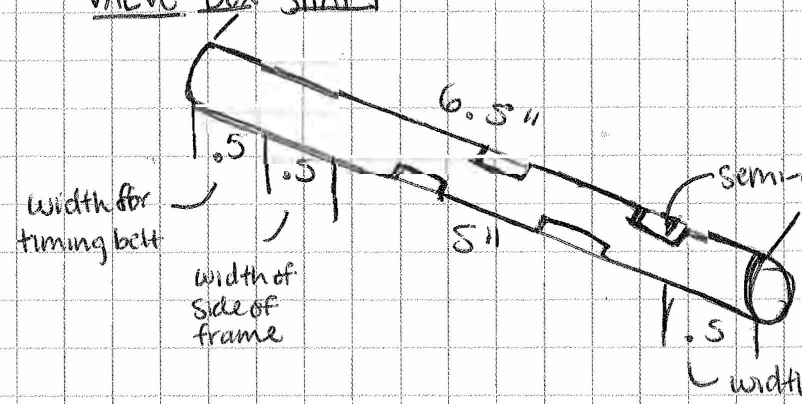
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/30/11	Recorded By Rebecca Ventimiglia	3/30/11

From Page No. 55

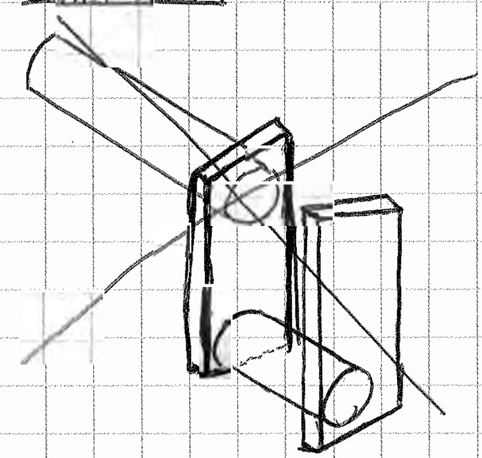
Date: 3/30/2011 (Continued)

VALVE BOX SHAFT

MATERIAL USED:
6" of 1/2" Aluminum Stock



CRANKSHAFT



⟹ Please see next page!

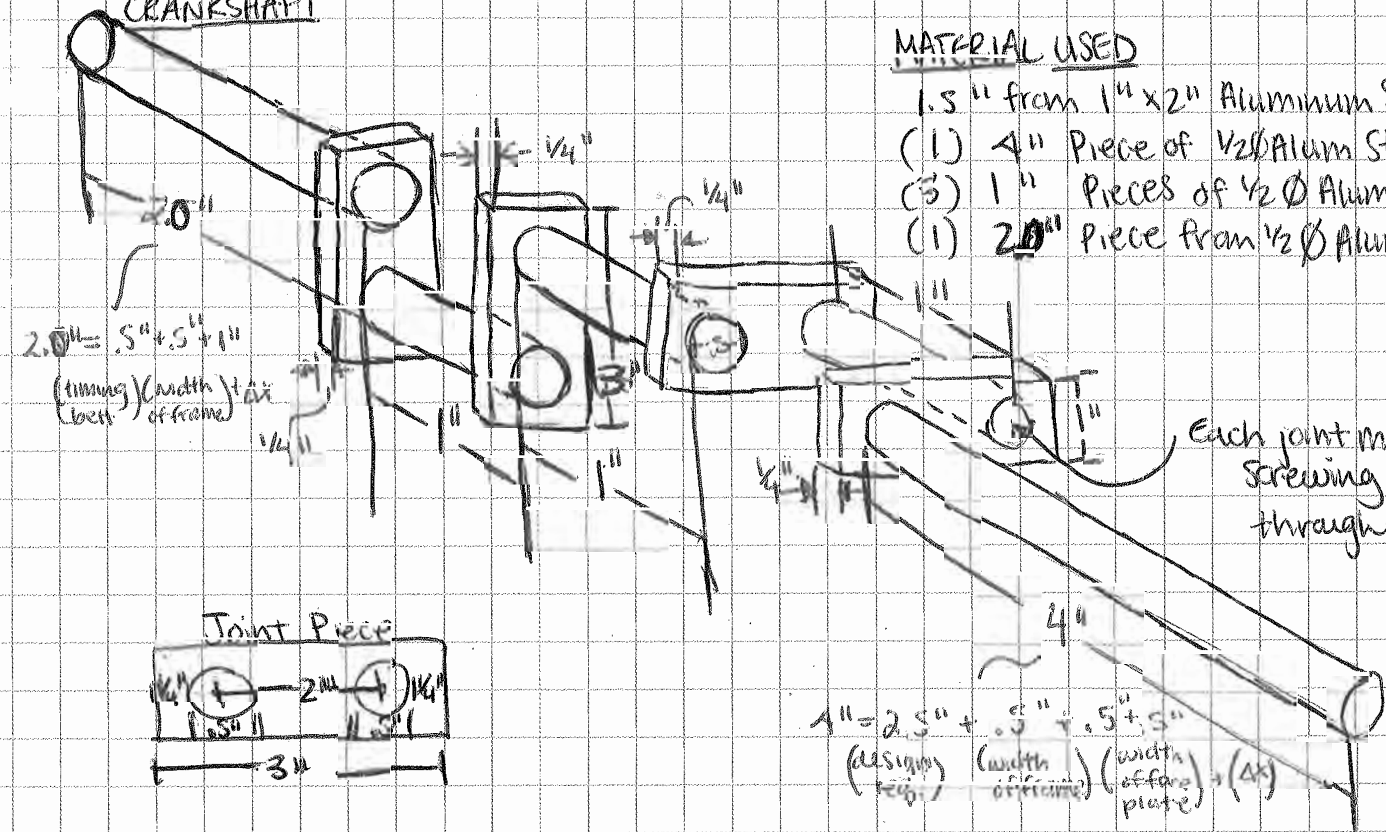
To Page No. 57

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/30/11	Recorded By: Rebecca Ventimiglia	3/30/11

From Page No. 56

Date: 3/30/2011

CRANKSHAFT

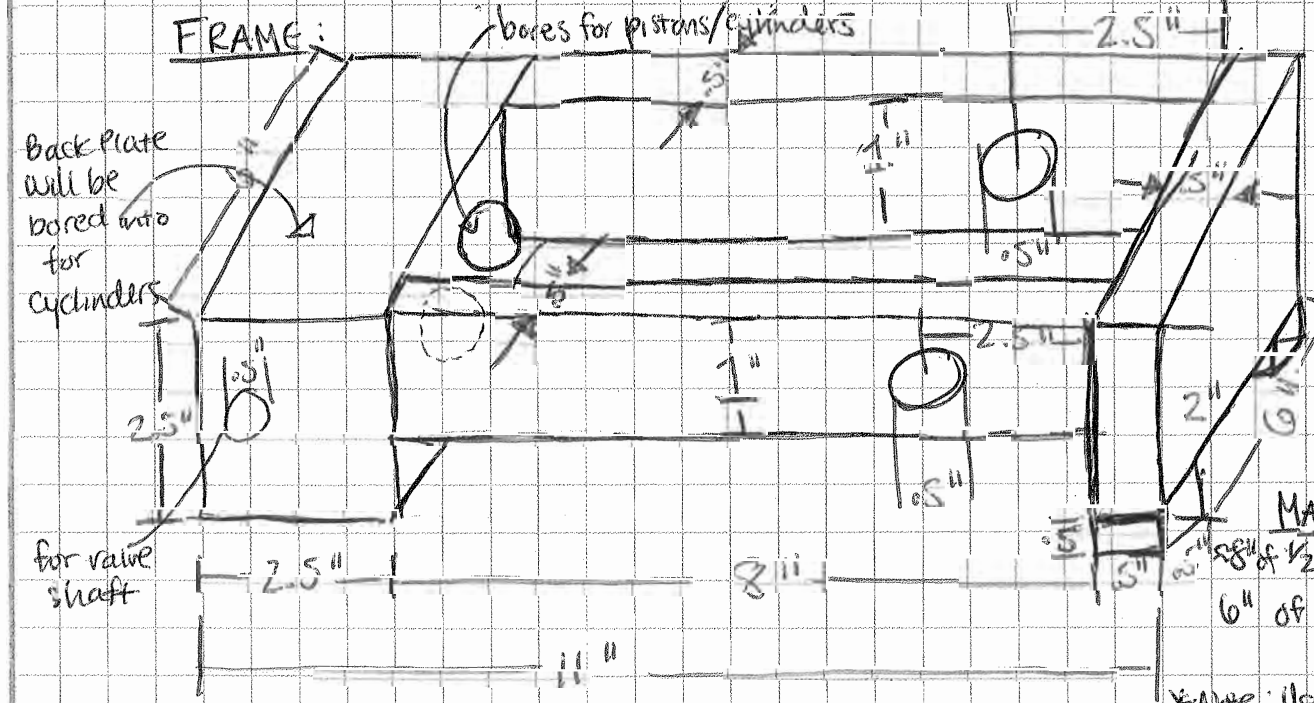


Each joint made by screwing into cylinder through the plate

MATERIAL USED

1.5" from 1" x 2" Aluminum Stock
(1) 4" Piece of 1/2 Ø Alum Stock
(3) 1" Pieces of 1/2 Ø Alum Stock
(1) 2.0" Piece from 1/2 Ø Alum Stock

FRAME:



MATERIAL USED:

.5" of 1/2" x 4" x 10" Alum Stock
6" of 2 1/4" x 2 1/4" x 10" of Alum

*Note: Use extra cylinders to create feet.

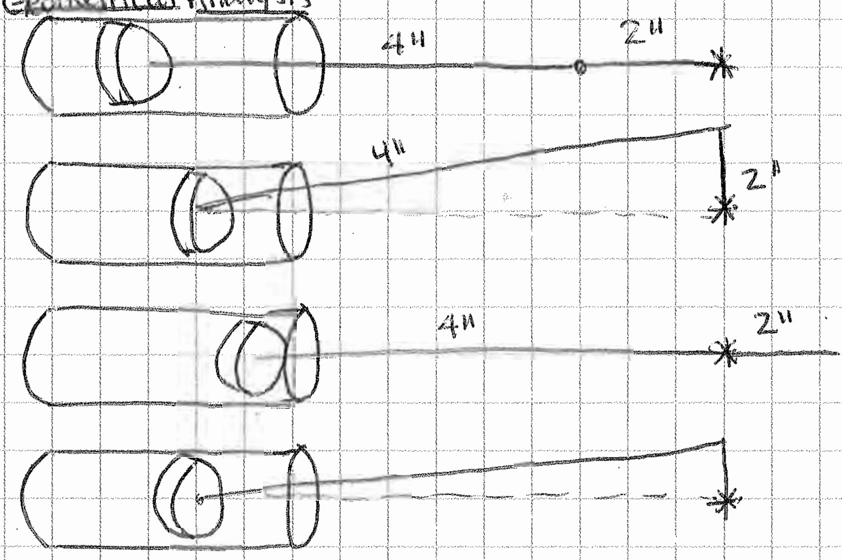
To Page No. 58

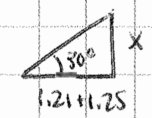
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/30/11	Recorded By Rebecca Ventimiglia	3/30/11

From Page No. 57

Date: 3/30/2011

Geometrical Analysis





$= \tan 30° = \frac{x}{1.46}$

$x = .84$ in < .5 in X

$\tan\theta = \frac{x}{\sqrt{x^2+y^2}} < .5$ in

we will need to manipulate data in order to ~~use~~ find an R and L value ~~which~~ fits geometric properies

What Material is Used Where?

- ½ Ø Aluminum Rod – All
- 1.875" PVC Stock – Pistons
- 2 OD Alum. Cylinder – 8" for Cylinder, 4" for stands
- ½" x ¼" x 10" – Frame
- 2¼" x 2¼" x 10" – Valve Box, Rods
- ¼" x 1" x 10" – Crankshaft Joints

To Page No. 59

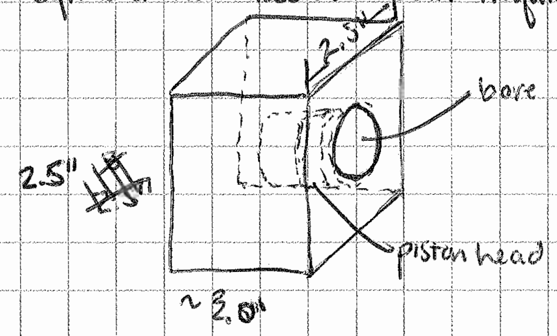
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	3/30/11	Recorded By Rebecca Ventimiglia!	3/30/11

From Page No. 58

DATE: 3/30/2011 Team Meeting in Upson Basement (8:30 - 11:30 PM)

- At today's meeting, we collaborated on our dimensionalized sketches in order to create a full working 3D model of our pump in SolidWorks. These dimensions are preliminary, and the pump was created in order to see how everything fits together. Also, it gives us a model we can manipulate, as well as a way we can easily see how changing dimensions affects the design.

- Also, we considered only using the cylinders as feet to the base. Since we are boring out a hole for the cylinder and piston head, then why don't we just use the base as our piston cylinder as below: We will inquire about this.



- We also looked into the prices for buying e-clips, O-rings, pulleys, timing belts, and hose fittings.

~~- Picture of Initial Pump CAD.~~

To Page No. 60

From Page No. 59

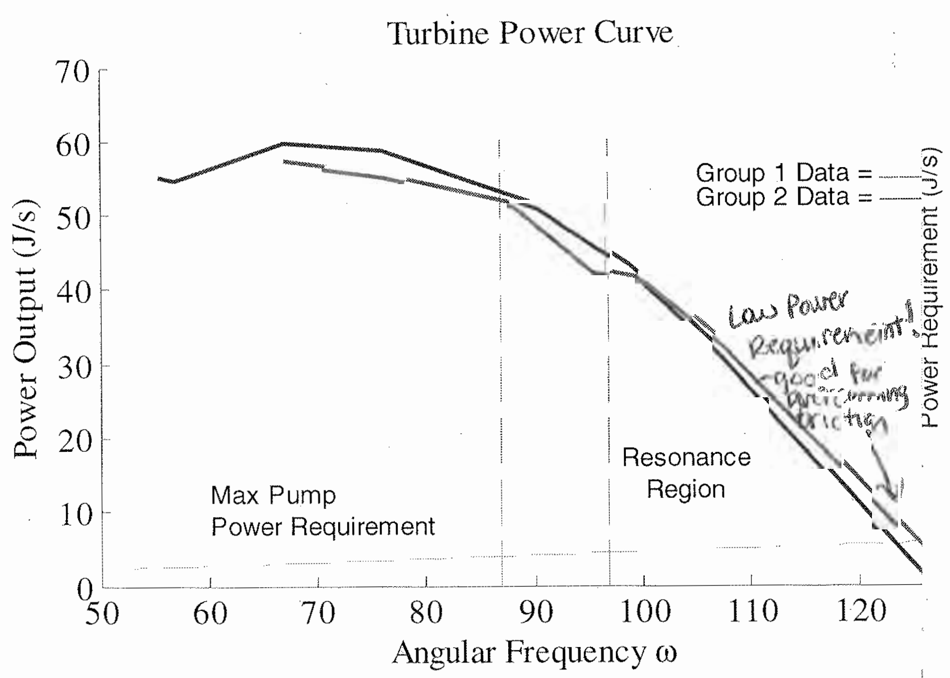
Date: 3/30/2011:

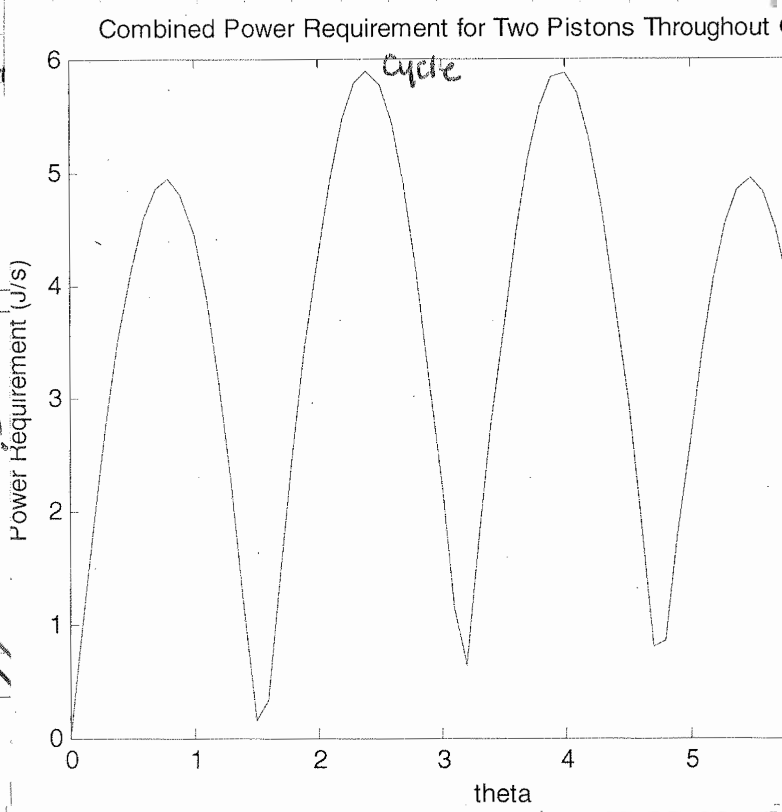
MATLAB ~~Analysis~~: Earlier in the week, Andre posted a finalized MATLAB code to model our pump. The code is 5 pages long, so I will write the pseudocoder here. We used this code to calculate τ, ω, and power for any given L and R value (dimensions which were at our discretion).

Pseudo Code:

- Initialize variables (radius, R_i, R_o, ρ, g, h, A, Radius of crankshaft, Length of Rod)
- Calculate ω and rps, net force from lab turbine data,
- Plot ω vs. power (label axes, create key, identify resonance region)
- Plot a line representing Power requirement for certain ω $\left(P = \rho g h \cdot \frac{AR}{\pi}\left(\frac{R_o}{R_i}\right)\cdot \omega\right)$
- Plot position of piston head with theta (use $x = L + R - \sqrt{L^2 - R^2 * \sin^2(\theta)} + R\cos(\theta)$) (label axes again).
- Plot position of piston head with time (use $X = L + R - \sqrt{L^2 - R^2\sin^2\theta} + R\cos(\theta)$), where $\theta = time * R_o/R_i * omega$) (label axes again)
- Plot volume pumped with time (label axes again)

Plots from Code: ~~Note that units on volume p...~~





To Page No. 61

Witnessed & Understood by me: Rebecca Ventimiglia
Date: 3/31/11
Invented by
Recorded By: Rebecca Ventimiglia
Date: 3/31/11

TITLE MAE 2250: Windpump Project - Gantt Chart (4/1/11

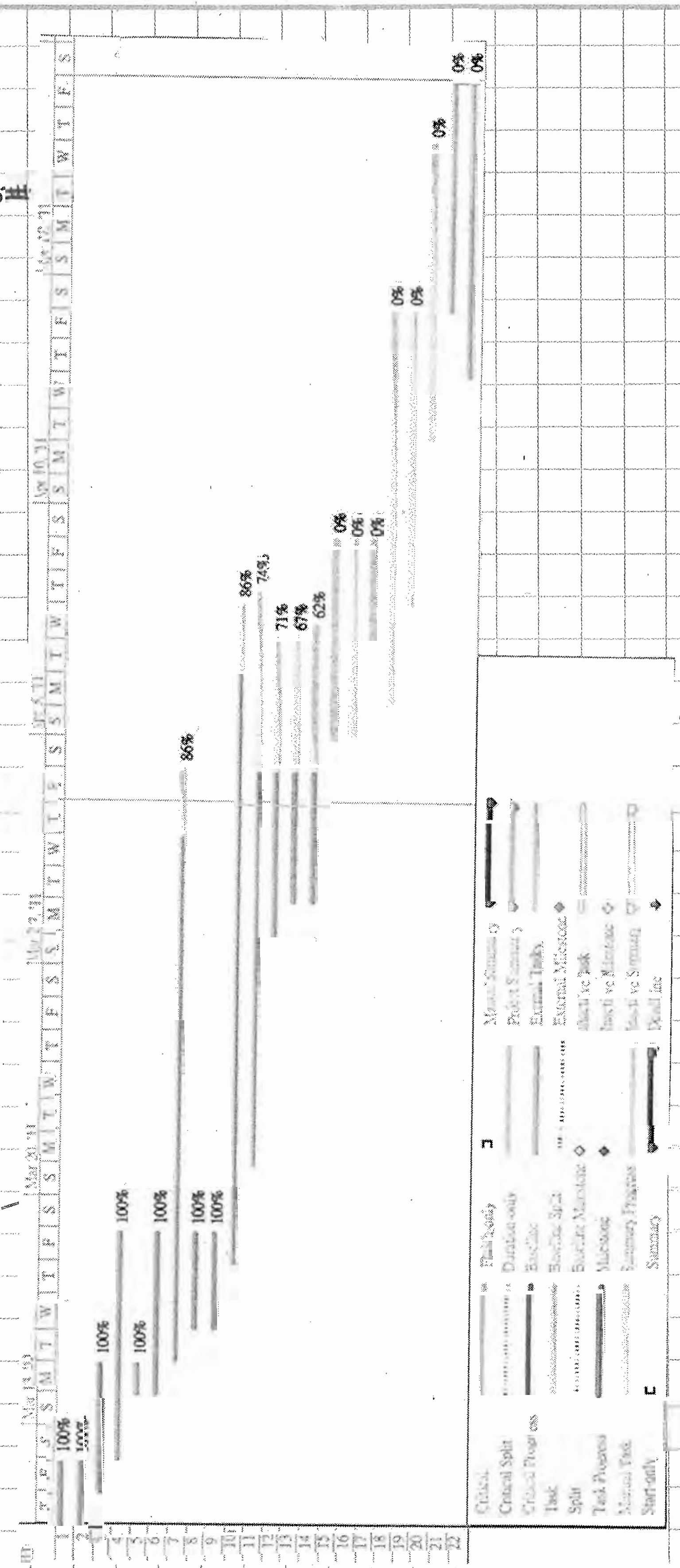
From Page No. 60

Date: 4/1/2011

Gantt Chart as of April 1st, 2011: (ID#

PRELIMINARY ESTIMATES FOR DUE DATES/ TASKS

ID	Indicators	Task Mode	Task Name	Duration	Start	Finish
1	✓		customer needs	2 days	Thu 3/10/11	Fri 3/11/11
2	✓		coding	2 days	Thu 3/10/11	Fri 3/11/11
3	✓		theory analysis	2 days	Fri 3/11/11	Mon 3/14/11
4	✓		test data analysis	6 days	Sat 3/12/11	Fri 3/18/11
5	✓		functional requirements	1 day	Mon 3/14/11	Mon 3/14/11
6	✓		morphological chart	5 days	Mon 3/14/11	Fri 3/18/11
7			MATLAB analysis	14 days	Tue 3/15/11	Fri 4/1/11
8	✓		decision matrix	3 days	Wed 3/16/11	Fri 3/18/11
9	✓		preliminary concepts	3 days	Wed 3/16/11	Fri 3/18/11
10			pump design draft	14 days	Fri 3/18/11	Wed 4/6/11
11			valve design draft	13.5 days	Mon 3/21/11	Thu 4/7/11
12			material selection	7 days	Mon 3/28/11	Tue 4/5/11
13			cost analysis	6 days	Tue 3/29/11	Tue 4/5/11
14			performance estimation	6.5 days	Tue 3/29/11	Wed 4/6/11
15			failure analysis	6 days	Sun 4/3/11	Fri 4/8/11
16			final design (CAD)	6 days	Sun 4/3/11	Fri 4/8/11
17			final design review	3 days	Wed 4/6/11	Fri 4/8/11
18			machining	10 days	Mon 4/4/11	Fri 4/15/11
19			first pump testing	7 days	Thu 4/7/11	Fri 4/15/11
20			design modification	7 days	Tue 4/12/11	Wed 4/20/11
21			design presentation	6 days	Sat 4/16/11	Fri 4/22/11
22			product development file	7 days	Thu 4/14/11	Fri 4/22/11



Chris Patterson

To Page No. 62

Witnessed & Understood by me, Rebecca Ventimiglia — Date 4/1/11

Invented by

Recorded By Rebecca Ventimiglia — Date 4/1/11

From Page No.__

Date: 4/1/2011: (Lab Section: 2:00-4:30 PM)

- Signed Up for 3 Mill Slots and 1 lathe Slot for manufacturing
  - ↳ saw most of work would be done on the mill, so we signed up for more slots on the mill

- Attempted to look into dimensions on the CAD of the pump → associate dimensions with stock, finalize the CAD. At this point, we have a working CAD model, we just need to check that it is feasible.

- Looked to edit code so that it would be more accurate in terms of volume pumped.

- Also considered how to manufacture pulley/purchase parts for belt

Preliminary Cost Analysis / Materials to Purchase from McMaster:
* Note: Can Order Parts for first 3 weeks! (Manufacturing)

PRELIMINARY COST ANALYSIS

Component	Type	Price
E-Clips	Magnetic Stainless Steel - 98408A138 Non-Magnetic Beryllium Copper - 92725A560	100@$6.12 1@$1.86
O-Rings	EPDM Standard Polyurethane Standard	100@$5.21 100@$7.66
Pulley	Drive Pulley	1@$14.17
Pulley Timing Belt	Single Sided with Trapezoidal Teeth	1@$3.07
Hose Fittings	Barbed- 1/4" Barbed- 3/8"	2@$6.53 2@$7.03

From our cost analysis, we realized our driving system for the valves might cost us alot. Would have to look for cheaper alternative because on a $30 budget, pulleys alone would take up entire budget...

To Page No.__

Witnessed & Understood by me. Rebecca Ventimiglia Date 4/1/11

Invented by

Recorded By Rebecca Ventimiglia Date 4/1/11

From Page No. 62

4/1/11 (continued): Dimensions for parts to consider ordering: (to see if compatible w/proposed design)

E-Clips- Magnetic and Non-Magnetic

For Shaft Dia.	Dia.	Width	(A)	Thick.
1/2"	0.396"	0.046"	0.8"	0.042"

O-Rings

AS568A Dash Number	014
Type	O-Ring
O-Ring Type	Standard
Cross Section Shape	Round
System of Measurement	Inch
Width	1/16"
Inside Diameter	1/2"
Outside Diameter	5/8"
Material	EPDM(Ethylene Propylene) - 9557K466 Polyurethane - 9558K19
Durometer	Hard
Durometer Shore	Shore A: 70

Pulley

Pulley Type	Drive Pulley - 1375K53
Number of Teeth on Pulley	60
Pulley Design	Solid
Outside Diameter	1.73"
Bore Type	Finished Bore
Bore Size (Inner Diameter)	1/4"
W Dimension	.16"
X Dimension	.276"
Y Dimension	.531"
Z Dimension	1.222"
V Dimension (Pitch Diameter)	1.528"
Pitch	.08"
Pulley Material	Aluminum

Note: Includes a set of screws

Timing Belt

Timing Belt Type	Single-Sided with Trapezoidal Teeth - 1375K53
Material	Neoprene
Cord Material	Fiberglass
Number of Teeth	300
Outer Circle	24"
Belt Width	1/8"
Pitch	.08"

Barbed Hose Fittings

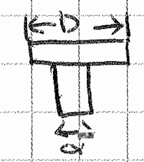
Pipe Size	1/4" - 5346K29 3/8" - 5346K31
Shape	Adapter
Adapter Type	Male Pipe Swivel Adapter
Material	Brass
Thread Type	NPTF (Dry Seal)
For Hose Inside Diameter	3/8"
Maximum Pressure at 72°F	250 psi
For Hose Type	Reinforced Rubber
Clamp With	Hose Ferrule and Worm-Drive Clamp

To Page No. 64

From Page No. 63

Date: 4/2/2011 Group Meeting in Upson Lounge (6-8pm)

Stress Analysis (Catherine's Notebook)

(1)  → #8-32 Screws:
$d = .164''$
Material: Steel
$D = .265''$

★ Aluminum

Shear Strength (lbf/in²)	2.00×10^4	3.60×10^4
Yield Strength (lbf/in²)	1.60×10^4	3.50×10^4

★ Unit Conversion:
$1\ N/m^2 = 6894.76\ psi$
$1\ N = .2248\ lbf$

★ Steel:
$\sigma_{steel} = 440\ MN/m^2$
$30336944.4\ psi$

★ $F_{shear} = 2.00 \times 10^4 \times Ar/4$
$= 16650\ lbf\ in^2/4$
$= 74065/4\ N$
$= 18516\ N$

(2)  $A = ld$ (cross sectional Area)

★ For 1" screws:
$A = 1 \times .164\ in^2 = .164\ in^2$ (cross-sec. area)
$Ar = 2\pi D \cdot L = 1.665\ in^2/2 = .8325\ in^2$ (area around cross section)
$Ai = 2\pi D \cdot L = 1.030\ in^2/2 = .515\ in^2$ (area inside plate)

$A = \pi(D/2)^2 - \pi(d/2)^2 = .0340\ in$

★ Max Shear: $3.03 \times 10^6 \cdot A$
$= 497525\ lbf = 2213193\ N$

★ Max F $= 1.600 \times .0340 \times 10^4$
$= 544\ lbf \times 10^4 = 2419\ N \times 10^4$

To Page No. 65

Witnessed & Understood by me, Rebecca Ventimiglia Date 4/2/11

Invented by

Recorded By Rebecca Ventimiglia Date 4/2/11

From Page No. 64

4/2/11: continued

Torsional Analysis: (Ryan's Notebook)

$\sigma = \frac{Mc}{I} = \frac{(Fa \cdot L_1 + Fa \cdot L_2) R}{\pi/4 R^4} = \frac{Fa(L_1+L_2)}{\pi/4 R^3}$ → disregard $\frac{VQ}{It} = \tau$ & no $\frac{P}{A} = \sigma$

max. effective Stress: $\bar{\sigma}_M = \frac{1}{\sqrt{2}} \sqrt{\left(\frac{Fa(L_1+L_2)}{\pi/4 R^3}\right)^2 + 6\left(\frac{(P/2\pi f) + (\sqrt{2} R Fa)}{\pi/2 R^3}\right)^2}$

Values: $R = .5$ in $= .0127$ m, $Fa = 54$ N, $L_1 = 4.305''$, $L_2 = 6.605''$, $P = 8$ W, $2\pi f = \omega = 124 \frac{rad}{s}$

$\bar{\sigma}_M = \frac{1}{\sqrt{2}} \sqrt{\left(\frac{54N(4.305 \cdot .0254 + 6.605 \cdot .0254 m)}{\pi/4 (0.0127 m)^3}\right)^2 + 6\left(\frac{8/124 rad/sec) + \sqrt{2} \cdot .0127 m \cdot 54N}{\pi/2 (.0127 m)^3}\right)^2}$
$= 787407$ Pa

$\sigma_0 = 200$ GPa (Steel)

$X = \frac{\sigma_0}{\bar{\sigma}_M} = \frac{200 \times 10^9 Pa}{787407 Pa} = 2.54 \times 10^5$

Worst Case: Assume full force applied 45° to crankshaft

① Torques → applied torque (T_a), T_1 from arm 1, T_2 from arm 2, $T_1 = T_2$

② Assume friction is negligible at pivots that arms turn about and where crank shaft turns in the side plating (F_f exerts no torque)

1+2 → we know that the largest T appears at the opposite end from T_a, as there, $T_{sum} = T_a + T_1 + T_2$

T_{sum} ⇒ $T_a: T = P/2\pi f$
$T_1 = T_2: = FR = Fa \sin 45 R = \sqrt{2}/2 \, FaR$
$T_{sum} = (P/2\pi f) + (\sqrt{2} RFa)$

at this critical points: Bending Moment ⇒ $M = Fa \cdot L_1 + Fa \cdot L_2$

$\tau = \frac{T_{sum} c}{J} = \frac{[(P/2\pi f) + (\sqrt{2} RFa)] R}{(\pi/2) R^4} = \frac{(P/2\pi f) + (\sqrt{2} RFa)}{\pi/2 R^3}$

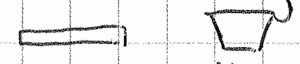
To Page No. 66

From Page No. 65

Date: 4/4/11 (Group Meeting in Upson Basement: 8-10 pm)

- Worked on finalizing CAD → will we buy pulleys or a belt?
  - If belt, must manufacture pulleys, tensor.
  - If pulleys, no extra money left in budget for other stock, valve fittings, etc. which are critical to pump.

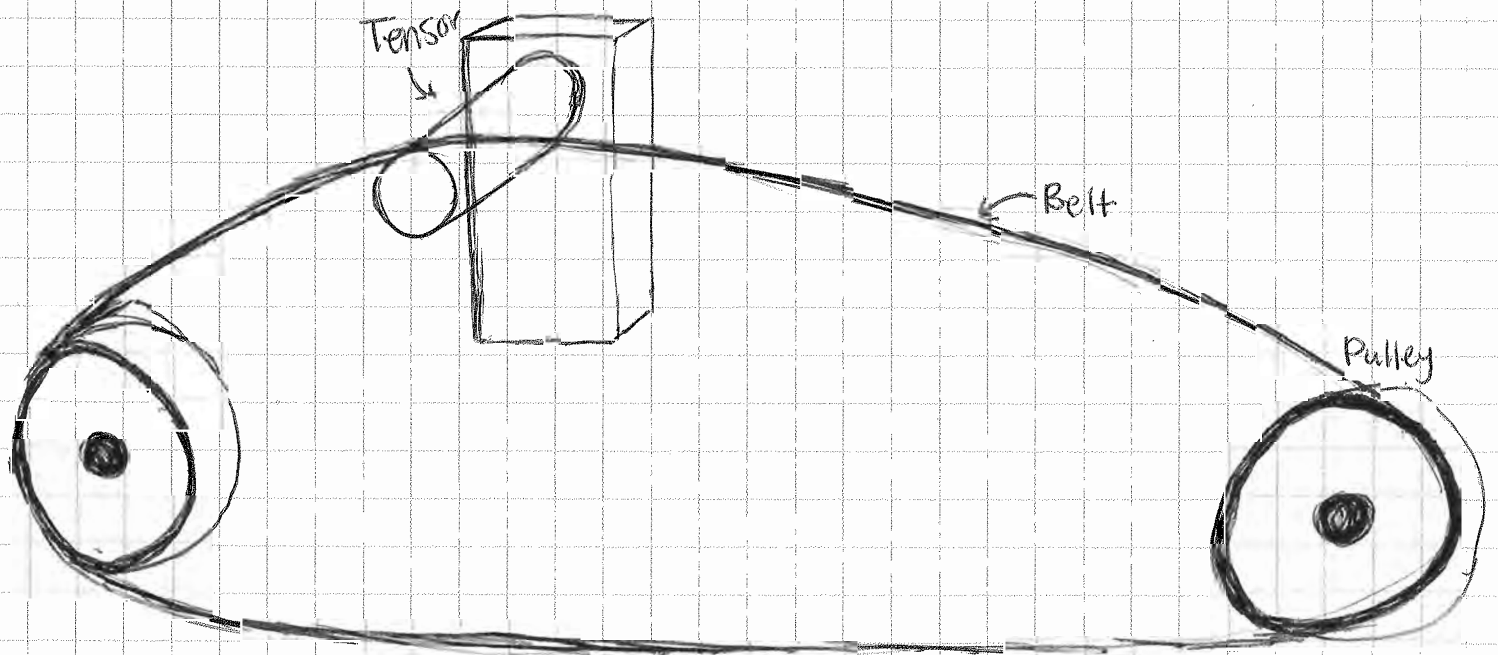
- Decide to manufacture pulleys + update CAD
  - Type of belt to buy



- Flat = Simple, easy/simple to machine for, but maybe not enough friction & too much slip
- V-Shaped = more contact, less slip, but hard to accurately machine for w/ current time limits

- We decided to go with a flat belt as long as there is a way to reduce friction without slip. In order to do this, we added a tensor to our design in order to ensure belt is tight at all times. It did not require too much additional stock either. We want to be reasonable and practical with our design, knowing that we are not experienced machinists.

Tensor Design



→ It was also realized that mounting for the pump would have to be added because as of currently, our design does not have a way to connect to the faceplate.

To Page No. 67

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	4/4/11	Recorded By Rebecca Ventimiglia	4/4/11

From Page No. 66

Date: 4/6/11

Although CAD for our design is created, we still need to make sure we have enough material to produce the design and stay within the budget. We decided to add an extra 1/8" to each ~~part~~ edge to ensure straight, parallel edges, and exact/close to exact sizing. (Extra 1/8" not given to stock faces)

~~Preliminary Material Allotment~~:

Material Given:	Is Used for:
• 1.875" PVC Round Stock	2 Pistons
• 16" of 1/2 ϕ Steel Rod	Valve Shaft, Crankshaft, Middle Rod, Piston Pins, Tensor Roller
• 1" x 2" x 10" Al Plate	Crankshaft Connectors, tensor plate
• 1/4" x 1" x 10" Al Plate	2 Piston Head Attachments, 2 Linkages
• 2 1/4" x 2 1/4" x 10" Al. Plate	2 Valve Housings / Cylinder Enclosure
• 1/2" x 4" x 10" Al. Plate	Back Housing, 2 Side Housings, 2 Small Pulleys, Mounting, Large Pulley
• 12" of 2" OD. Al. Tubing	N/A

*Please refer to appendix for pictures & names of parts
= used from stock

Dimensioning:

16" - 1/2" ϕ Steel Rod

Estimate

20.9875" = 6.75" (Valve Shaft) + 2.75" (Crankshaft - Timing Belt Side) + 1.75" (Middle Rod) + 4.0075" (Face Plate Side Crankshaft) + 2 * 1" (Intermediate Crankshaft Pieces) + 2 * .725 (Piston Pins) + 2.25 (Tensor Roller)

Actual: Given 16" of 1/2 ϕ Steel Rod

(6.75" + 1/8") [Valve Shaft] + (1/8" + 4.0075" + 1/8") [Crankshaft Face Plate] + (1/8 + 1.75" + 1/8") [Middle Rod] = 13.0075"

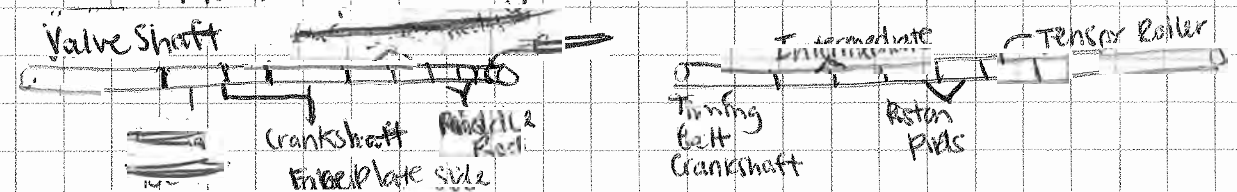
To spare = 2.9925"

Purchase 16" of 1/2" ϕ Steel Rod

(2.75 + 1/8") [Crankshaft - Timing Belt Side] + 2(1 + 1/8" + 1/8") [Intermediate Rods] + 2(.725 + 1/8") [Piston Pins] + (2.25 + 1/8") [Tensor Roller] = 9.44"

To Spare = 6.56"

Total: 19.94"



To Page No. 68

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	4/6/11	Recorded By: Rebecca Ventimiglia	4/6/11

From Page No. 67

Date: 4/6/11

= used ~~from~~ stock

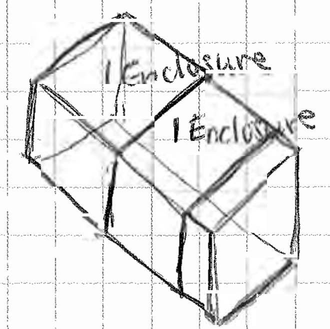
Dimensioning → Continued

10" × 2 1/4" × 2 1/4" Aluminum Block:

(4 + 1/8") + (4 + 1/8" + 1/8") = 8.25" Used

(2) Cylinder Housings / Enclosures

To Spare = 1.75"

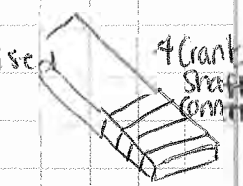


1" × 2" × 10" Aluminum Plate:

(1/4" + 1/8") + (1/8" + 1/4" + 1/8") + (1/8" + 1/4" + 1/8") + (1/8" + 1/4") = 1.75" Used

4 Crankshaft Connections

To Spare = 6.56"

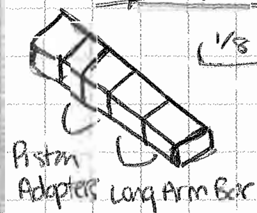


1/4" × 1" × 10" Aluminum Stock:

(1/8" + 1.625" + (1/8" + 1.625" + 1/8")) + (3" + 1/8" + 1/8") + (3" + 1/8" + 1/8") = 9.375" Used

Piston Adapters — (2) Long Arm Bar

.525" to Spare



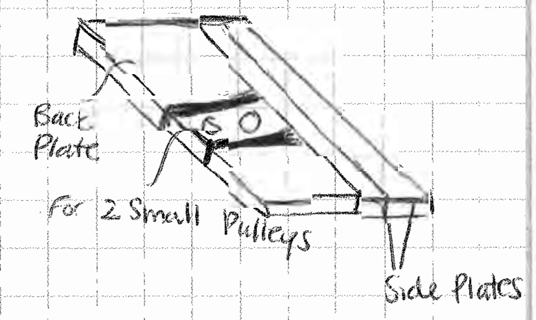
1/2" × 4" × 10" Aluminum Plate:

Given: ~~5.5" + 1/8"~~ + 9 + 1/8" = 9.125" Used For Length

Side Plate — .875" to Spare

2 (7/8" + 1/8") + (1.75" + 1/8" + 1/8") = 4" Used for Width

Side Plates — 0" to Spare



Purchased:

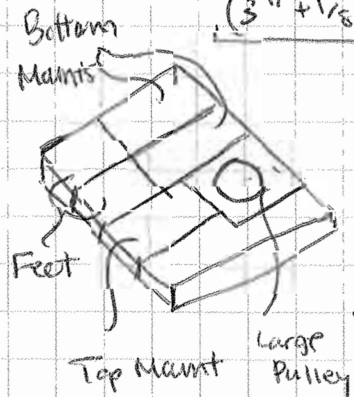
(3" + 1/8") + (1/8" + 3" + 1/8") + (2" + 1/8" + 1/8") = 8.625" = Used in Length

(2) Bottom Mounts — Top Mounts

1.375 = to Spare

2.6 + 1/8" + .75 + 1/8" = 3.6" used in width

.4 to Spare

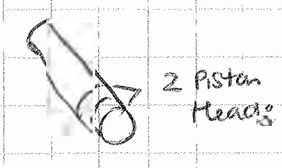


1.375" PVC Stock

2 * (1/2 + 1/8" + 1/8") = 1.50" used ~~for~~ PVC

Piston Heads

8.50" to Spare



To Page No. 69

From Page No. 68

4/7/11 – Cost Analysis for FDR

– After Dimensions & Design Considerations were decided, a preliminary cost analysis was performed to see if budget was met. Additional parts considered for cost analysis were screws (we decided to use #8-32 because their diameter was close to the size of the holes we wanted to make ~ .125"), snap rings (used to keep to crankshaft aligned), hose fittings (for fluid transport), 1/4"-20 threaded rod (for connecting mounting), and the timing belt to drive the pulleys and valve shaft.

Material Given:

Material	Quantity	Parts Manufactured	Stock Used	Stock to Spare	Cost per Unit	Total Cost
16" of ½" Diameter Steel Rod	1.333	Valve Shaft, Crankshaft- Face Plate Side, Middle Rod	13.0075"	2.9925"	1.65	2.19945
2 ¼" X 2 ¼" X 10" Aluminum Plate	1	2 Valve/ Cylinder Housings	8.25"	1.75"	11.79	11.79
1"x2"x10" Aluminum Plate	1	4 Crankshaft Connectors, Tensor Plate	1.75'	8.25"	5.58	5.58
¼"x1"x10" Aluminum Plate	1	2 Piston Head Attachment Plates, 2 Linkages	10"	0"	1.83	1.83
½"x4"x10" Aluminum Plate	1	Back Housing, 2 Side Housings, 2 Small Pulleys	9.125"	0.875"	5.03	5.03
9" of 1.875" PVC Round Stock	1	2 Pistons	1"	8"	6.8	6.8
12" of 2" O.D. Aluminum Tubing	0	-	-	-	-	0
						26.42945

Material to Purchase:

Material	Quantity	Parts Manufactured	Stock Used	Stock to Spare	Cost per Unit	Total Cost
16" of ½" Diameter Steel Rod	1	Crankshaft- Timing Belt Side, Intermediate Joints, 2 Piston Head Joints, Tensor Roller	9.44"	6.56"	1.65	1.65
1" 8-32 Screws	32	-	-	-	0.0423	1.3536
Snap Rings	18	-	-	-	0.0916	1.6488
Hose Fittings	4	-	-	-	1.19	4.76
Timing Belt (6082K111)	1	-	-	-	7.04	7.04
1/4-20 Threaded Rod	1	Connections for Mounts	-	-	1.41	1.41
½"x4"x10" Aluminum Plate	1	Top Mount, 2 Bottom Mounts, 4 Feet, 1 Large Pulley	8.825"	1.175"	5.03	5.03
						22.8924

NOTES:
If the Steel Rod is sold by foot, we will buy 2 ft.
We have some stock on the 1" x 2" x 10" piece to create a center stabilizer for the crankshaft. (approx. 7")

To Page No. 70

From Page No. 69

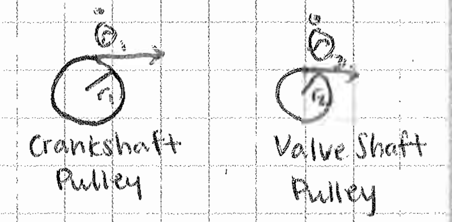
Date: 4/7/11 - Group Meeting in Duffield from 7:00 PM to 9:00 PM

- Met to polish up design for FDR & consider odds & ends.

- Relationship between crankshaft speed and valve shaft speed - in order for valve shaft to work, it must spin 2x as fast as the crankshaft.

Crankshaft → $r_1 \dot{\theta}_1 = r_2 \dot{\theta}_2$ ← Valveshaft

tangential velocitys equal

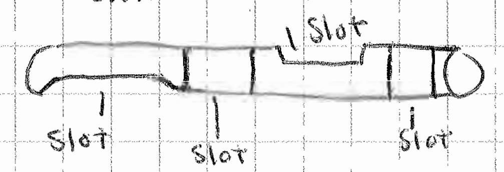


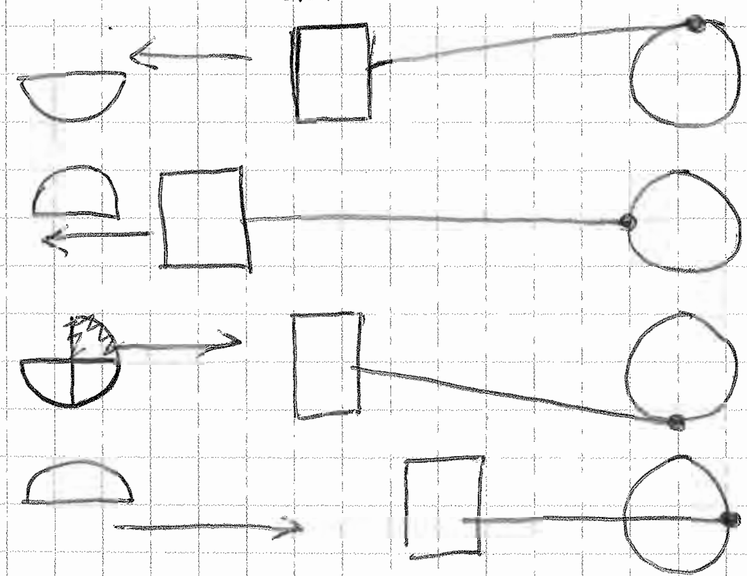
$r_1 \dot{\theta}_1 = r_2 (2\dot{\theta}_1)$

$r_1 = 2r_2$

$\boxed{\frac{1}{2} r_1 = r_2}$ ← Size of valve shaft pulley must be ½ size of crankshaft pulley!

- It was decided that in order for the valve shaft to spin 2x as fast and still work, the slots on the shaft must be 90° out of phase or perpendicular. This way, water is moving at all times.





- Assignment of tasks to complete for FDR was made → Machining Timeline, Chart, Current Gantt Chart, Finish up CAD (add mounts | take screen shots)

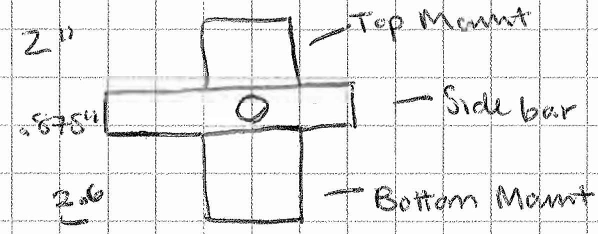
To Page No. 71

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	4/7/11	Recorded By Rebecca Ventimiglia	4/7/11

From Page No 70

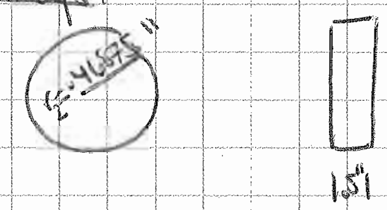
4/7/11: Meeting in Duffield Continued

- CAD Cleanup: We added pulleys and mounting to our design. Originally, we planned on using the aluminum tubing for feet, but we had extra stock to create mounting
- Mounting:
  Does it meet the height requirement: Axis is 5 ± 2" above horizontal plate

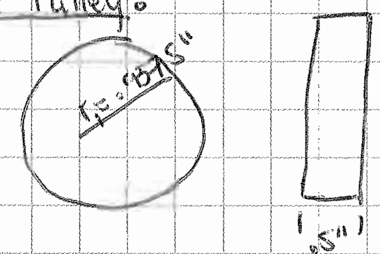


3.0375" > 3" ✓ Height Requirement Met.

- Small Pulleys:



- Large Pulley:



Check Radii for Speed Relation Guarantee:

$2r_2 = r_1$

$2(.46875) = .9375$

$.9375" = .9375"$ ✓

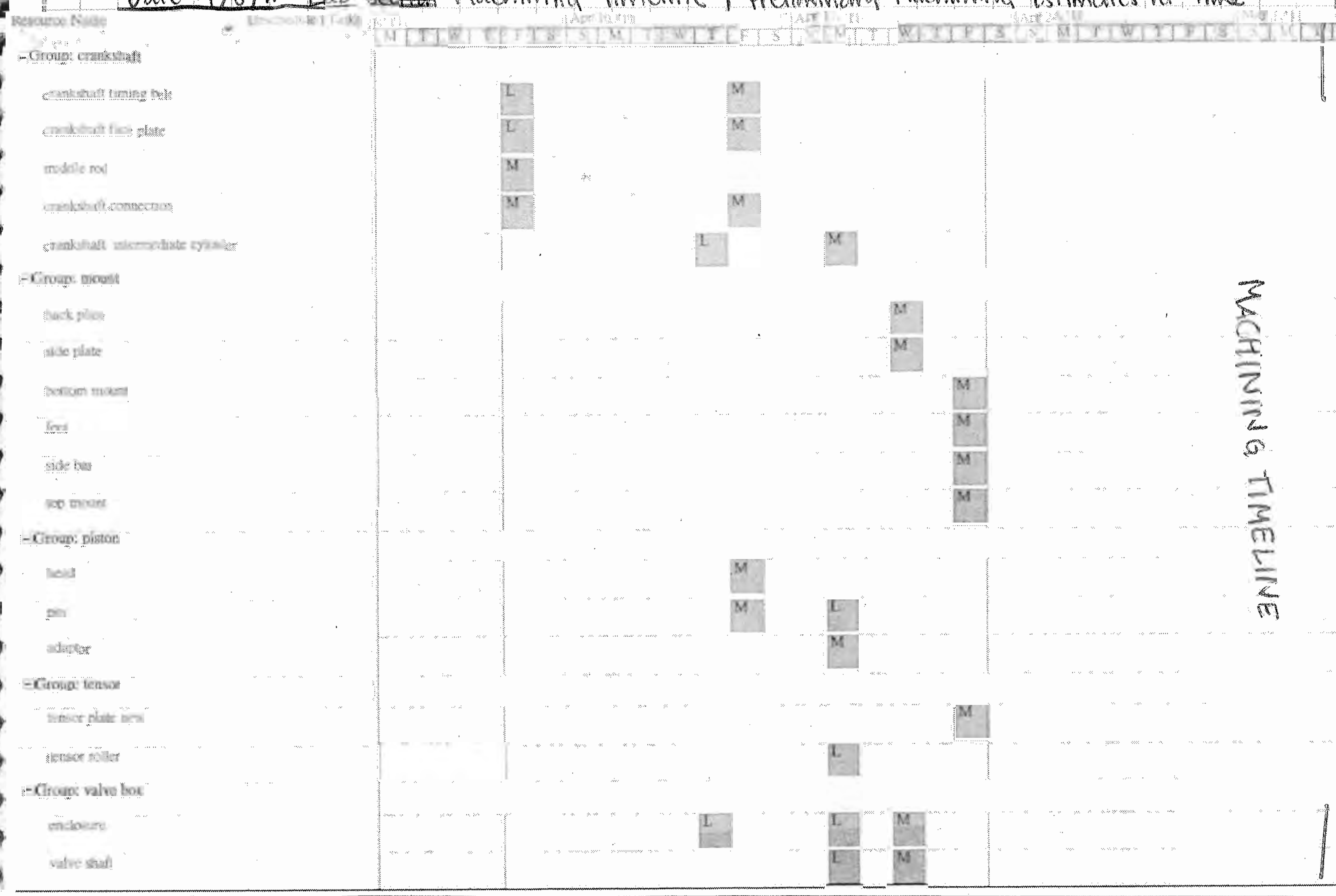
To Page No. 72

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	4/7/11	Recorded By Rebecca Ventimiglia	4/7/11

TITLE MAE 2250: Windpump Project : Machining Time Estimates

From Page No.

Date: 4/8/11 ~~1st Section~~ Machining Timeline & Preliminary Machining Estimates for Time



Part	subpart	quantity	Time(min)	
			Mill	Lathe
Crankshaft	crankshaft-connection	4	60	N/A
	crankshaft-Timing Belt	1	30	30
	crankshaft-faceplate	1	30	30
	crankshaft-Intermediate cylinders	2	45	45
	middle rod	1	45	N/A
piston	Head	2	45	N/A
	pin	2	30	45
	adaptor	2	75	N/A
valve box	enclosure	2	60	90
	valve shaft	1	75	45
plates	back plate	1	60	N/A
	side plates	2	75	N/A

Witnessed & Understood by me, Rebecca Ventimiglia

Date 4/8/11

Invented by

Recorded By Rebecca Ventimiglia

Date 4/8/11

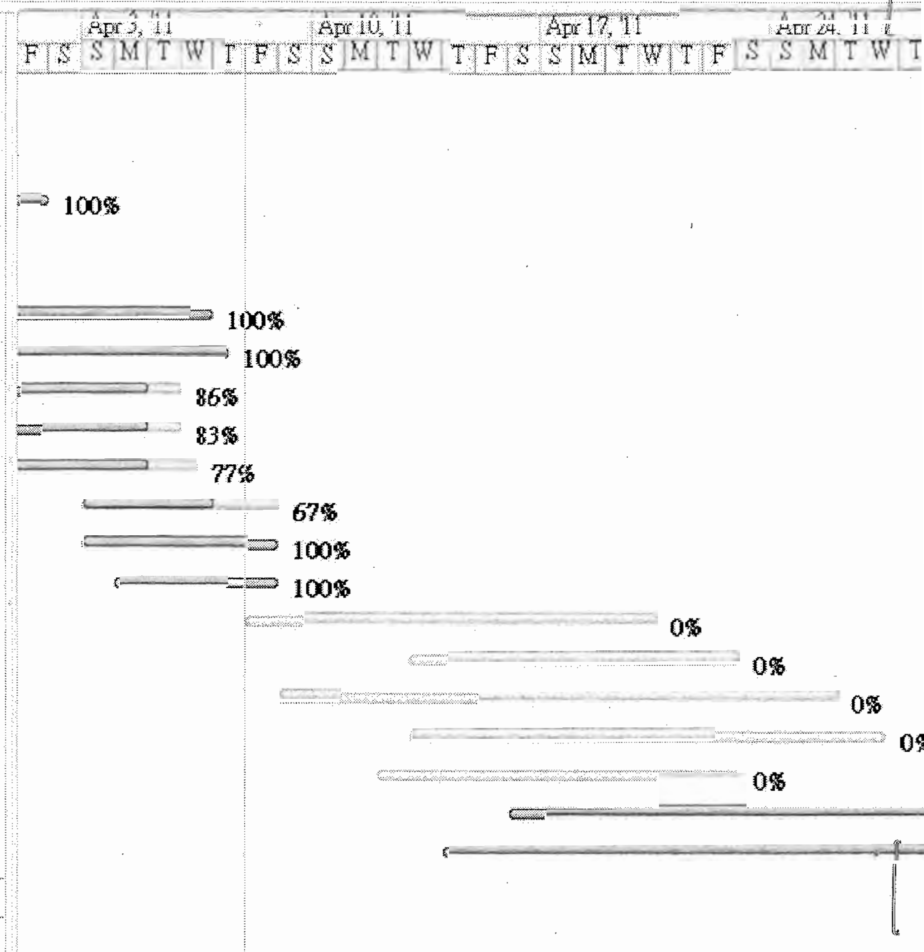
Project No. 2
Book No. 1

TITLE MAE 2250 : Windpump Project : Gantt Chart – 4/8/11

From Page No. 72

Date: 4/8/11 – Gantt Chart + Progress Since Last Week

Task Name	Duration	Start	Finish
test data analysis	6 days	Sat 3/12/11	Fri 3/18/11
functional requirements	1 day	Mon 3/14/11	Mon 3/14/11
morphological chart	5 days	Mon 3/14/11	Fri 3/18/11
MATLAB analysis	14 days	Tue 3/15/11	Fri 4/1/11
decision matrix	3 days	Wed 3/16/11	Fri 3/18/11
preliminary concepts	3 days	Wed 3/16/11	Fri 3/18/11
pump design draft	14 days	Fri 3/18/11	Wed 4/6/11
valve design draft	13.5 days	Mon 3/21/11	Thu 4/7/11
material selection	7 days	Mon 3/28/11	Tue 4/5/11
cost analysis	6 days	Tue 3/29/11	Tue 4/5/11
performance estimation	6.5 days	Tue 3/29/11	Wed 4/6/11
failure analysis	6 days	Sun 4/3/11	Fri 4/8/11
final design (CAD)	6 days	Sun 4/3/11	Fri 4/8/11
final design review	5 days	Mon 4/4/11	Fri 4/8/11
machining(crankshaft)	8.5 days	Fri 4/8/11	Wed 4/20/11
first pump testing	8 days	Wed 4/13/11	Fri 4/22/11
machining(piston)	12 days	Sat 4/9/11	Mon 4/25/11
machining(valve box)	10.5 days	Wed 4/13/11	Wed 4/27/11
design modification	9 days	Tue 4/12/11	Fri 4/22/11
design presentation	11 days	Sat 4/16/11	Fri 4/29/11
product development file	12 days	Thu 4/14/11	Fri 4/29/11

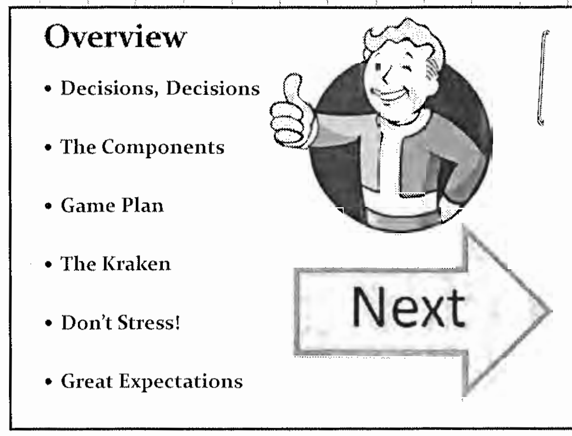


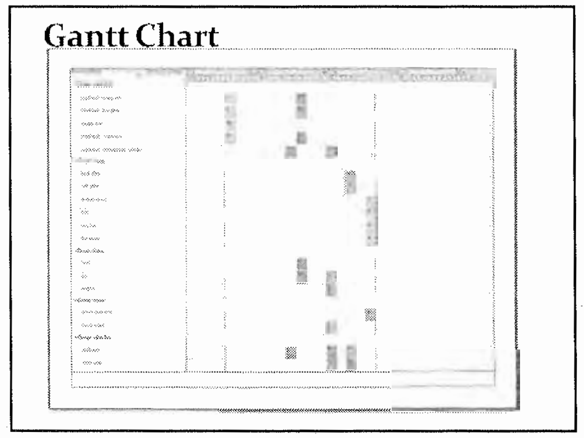
To Page No. 74

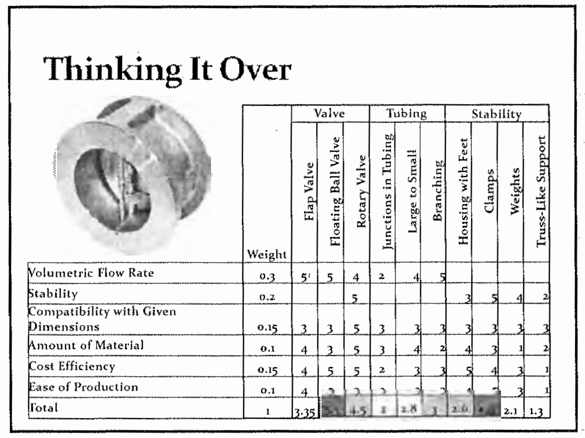
Witnessed & Understood by me, Rebecca Ventimiglia
Date 4/8/11
Invented by
Recorded By Rebecca Ventimiglia
Date 4/8/11

From Page No. 73

Date: 4/8/11 – Lab Section in Taylor Studio (2-4:30 pm)
FDR Presentation

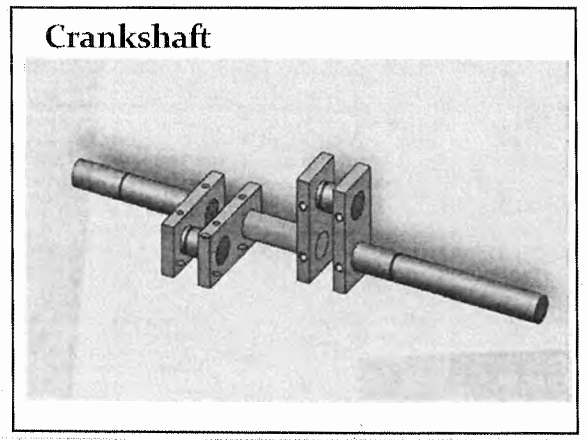


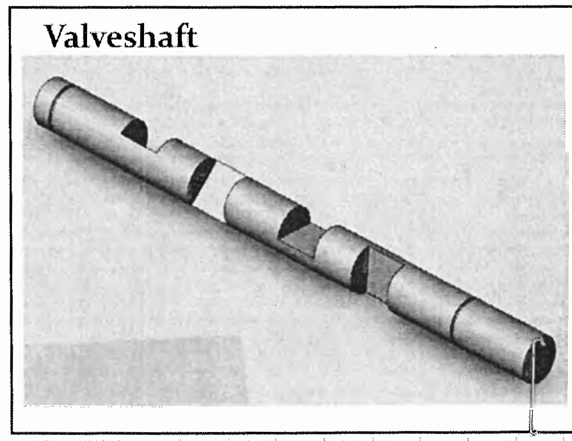




	Weight	Valve			Tubing			Stability			
		Flap Valve	Floating Ball Valve	Rotary Valve	Junctions in Tubing	Large to Small	Branching	Housing with Feet	Clamps	Weights	Truss-Like Support
Volumetric Flow Rate	0.3	5	5	4	2	4	5				
Stability	0.2			5				3	5	4	2
Compatibility with Given Dimensions	0.15	3	3	5	3	3	3	3	3	3	3
Amount of Material	0.1	4	3	5	3	4	2	4	3	1	2
Cost Efficiency	0.15	4	5	5	2	3	3	5	4	3	1
Ease of Production	0.1	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	1
Total	1	3.35	[illegible]	4.5	2	2.8	3	2.6	[illegible]	2.1	1.3

We had changed our decision matrix since we had not thought of our valve shaft for FDR

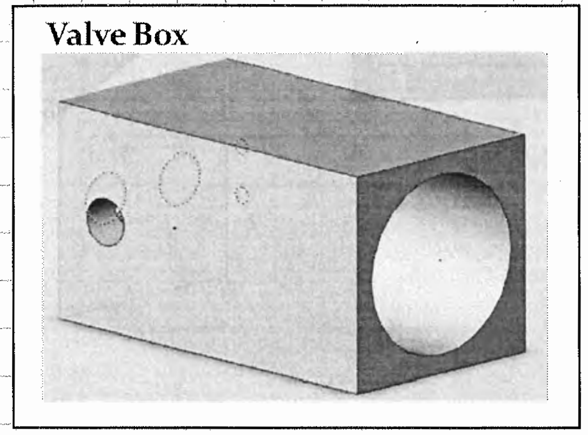




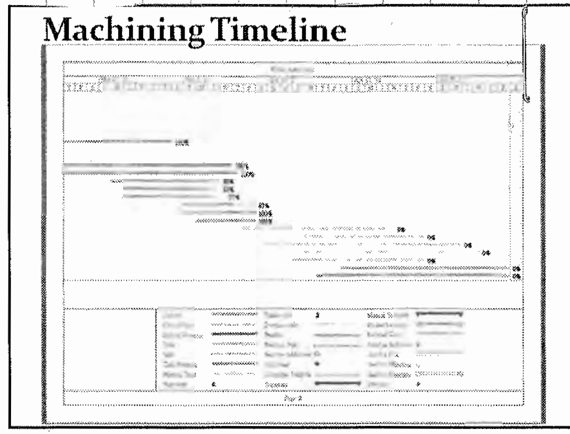
To Page No. 75

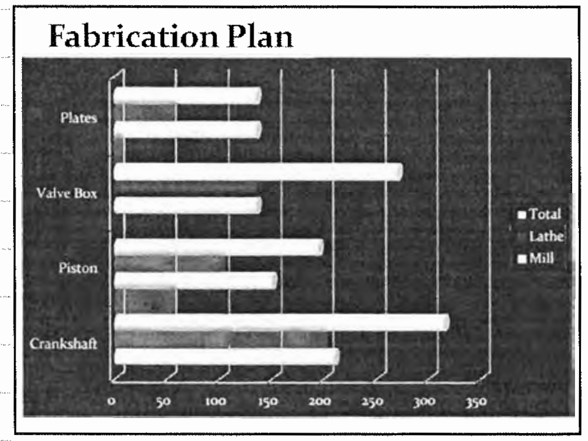
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	4/8/11	Recorded By: Rebecca Ventimiglia	4/8/11

Date: 4/8/11 (FDR continued)

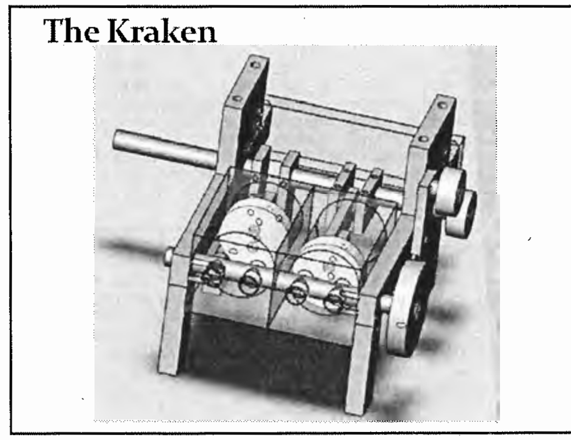


We figured we could save material & machining on curved surfaces by making our own cylinder



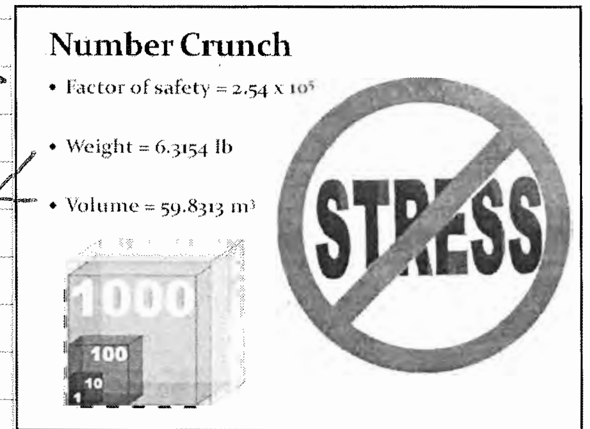


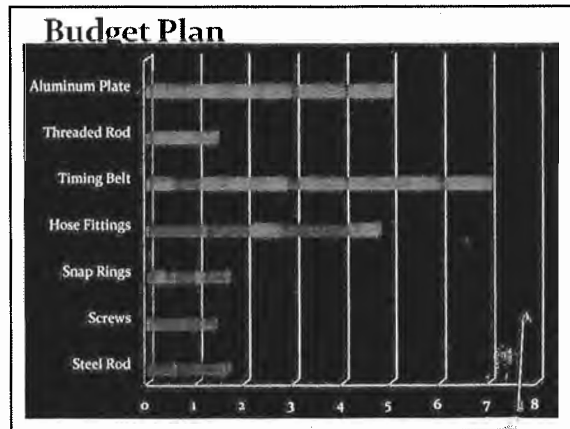
Shows how the mill is mostly needed and how the crankshaft is most time consuming



Factor of Safety from Ryan's analysis →

From Solidworks model & accurately assigning material to parts in solidworks





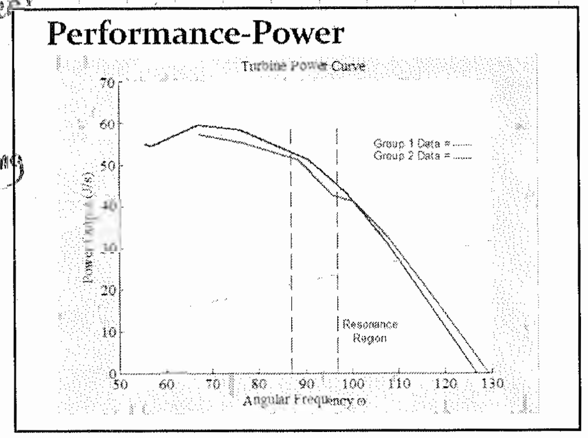
Timing Belt is biggest expense, as expected.

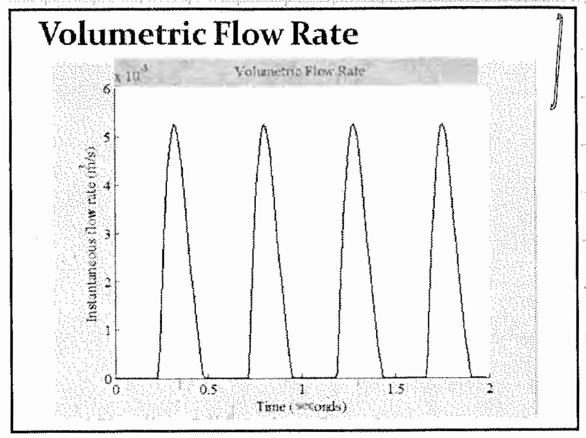
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	4/8/11	Recorded By: Rebecca Ventimiglia	4/8/11

From Page No. 75

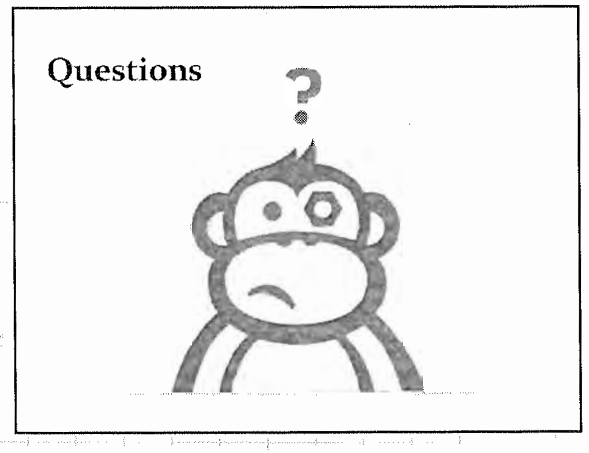
Date: 4/8/11 - FDR (continued)

Shows low power requirement to prevent stalling out/anything caused by frictional forces we cannot account for.





Volumetric Flow Rate Chart



- After FDR, we started to machine. We got our stock and realized that the number of stock faces was less than anticipated. Fortunately, there was enough stock to spare on each piece so that we could still get the stock down to size and have faced surfaces. Today's shop was mostly spent cutting stock and facing parts.

To Page No. 77

Witnessed & Understood by me, Rebecca Ventimiglia | Date 4/8/11 | Invented by | Recorded By Rebecca Ventimiglia | Date 4/8/11

From Page No. 76

Date: 4/9/11 – Group Meeting in Duffield from 5:45–7 PM

- We decided to increase our L value and decrease our R value in order to reduce our power and because we saw that our stock could allow for such a slight change. We changed our R value from 1.5" to 1" and increased L from 2.5" to 3". This allowed for a greater L/R, which typically provides for smoother motion.

- We also discussed what we needed for the machine shop. Entering the machine shop, we had no idea what was necessary. We decided that we needed:
  - Drawings of each part w/ dimensions
  - A form of communication between machine slot times
    - └ wrapped in blue paper = all done
    - └ tape to identify cut stock
    - └ chart to track progress
  - Organize signing up for more time slots
    - └ Monday + Wednesday mornings, Thursday afternoons – good!
    - └ More mill time than lathe time needed.

To Page No. 78

Witnessed & Understood by me, Rebecca Ventimiglia | Date 4/9/11 | Invented by | Recorded By Rebecca Ventimiglia | Date 4/9/11

From Page No. 77

Date: 4/14/11

This Chart was used to keep track ~~of~~ completed processes in the shop. Dates by the process represent when it was completed.

Machining Processes Per Part

Component	Part	Lathe:	Mill:	Processes:					Status:
FRAME	Bottom Mounts		☒	Cut from Stock	Trim down	Screw holes	Face Plate Holes 5/5		
	Top Mount		☒	Cut from Stock	Trim down	Screw holes 4/2	Face Plate Holes 5/4		
	Side Plates		☒	Cut from Stock	Trim down	Screw holes	Side Holes for Shafts 5/4	Side Hole for Tensor	
	Cylinder Housing	☒	☒	Cut from Stock	Trim down	Screw holes	Slot for Valve	Bore for Cylinders 4/23	
	Back Housing		☒	Cut from Stock	Trim down	Screw holes 5/5			
	Connecting Rods		☒	Cut from Stock	5/5				
	Feet		☒	Cut from Stock	Trim down 4/29	Screw holes 5/5			
BELT	Small Pulleys	☒	☒	Cut from Stock	Trim down	Screw holes	Lathe to Circle 4/27	Groove for Belt	
	Large Pulley	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Belt 4/26		
VALVE SHAFT	Valve Shaft	☒	☒	Cut from Stock	Trim down	Screw holes 4/19	Cut Semi-Circles 4/18		
CRANKSHAFT	Timing Belt Rod	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings	Groove for Belt	
	Connections (R)	x	☒	Cut from Stock 4/14	Trim down	Screw holes 4/19			Crankshaft: 4/23
	Middle Rod	☒	☒	Cut from Stock	Trim down	Screw holes 4/19			
	Face Plate Rod	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings 4/18		
	Intermediate Rod	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings 4/18		
PISTON	Piston Head	☒	☒	Cut from Stock	Trim down	Screw holes	slot for attachment		
	Piston Linkages (L)		☒	Cut from Stock	Trim down	Screw holes			
	Piston Head Attachment		☒	Cut from Stock	Trim down	Screw holes 4/28			
	Piston Head Joint		☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings		
TENSOR	Tensor Roller	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings		
	Tensor Plate		☒	Cut from Stock	Trim down	Screw holes			

KEY:	
M	Measured
C	Cut from Stock
D	Done
WIP	Work in Progress

To Page No. 79

Witnessed & Understood by me, Rebecca Ventimiglia — Date 4/14/11

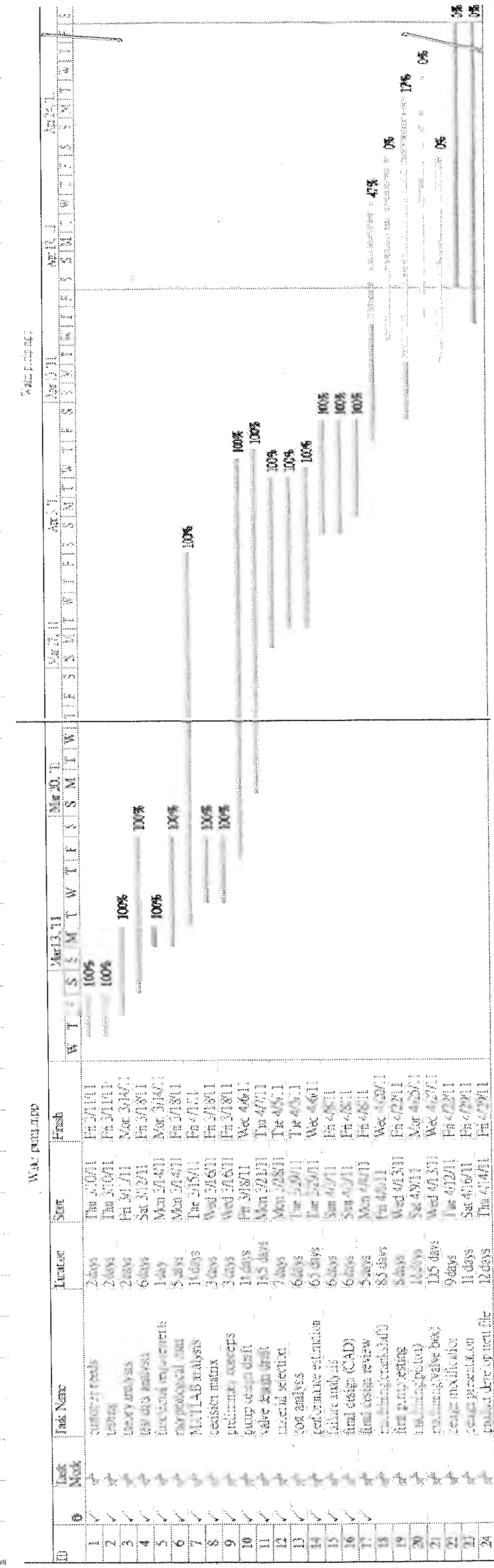
Invented by

Recorded By Rebecca Ventimiglia — Date 4/14/11

TITLE MAE 2250: Windpump Project : Gantt Chart

From Page No. 78

Date: 4/15/11
Gantt Chart



To Page No. 80

Witnessed & Understood by me, Rebecca Ventimiglia

Date 4/15/11

Invented by

Recorded By Rebecca Ventimiglia

Date 4/15/11

From Page No. 79

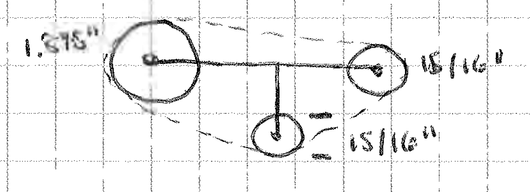
Date: 4/15/11

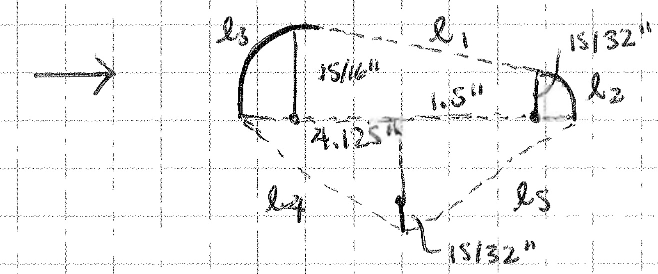
Today was the last day to order parts → we ordered

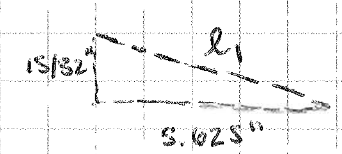
1 Timing Belt sized at .0151" (~~1/8~~) x 3/16" x 16" outer diameter → $17.04
(2 weeks to come in)

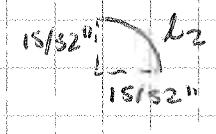
1 Box of #8-32 Screws (50 ct) → $9.90

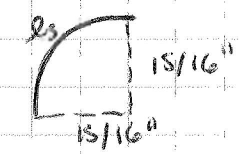
Figuring Out Dimensions for Belt:







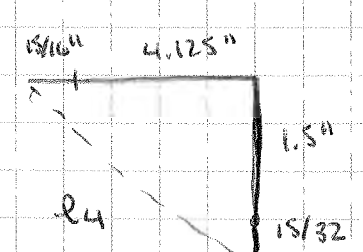


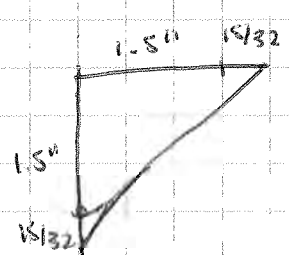


$a^2+b^2=c^2$
$5.625''^2+(15/32)^2=c^2$
$31.641+.2197=c^2$
$31.86\ in^2=c^2$
$5.645''=c=l_1$

$l_2=\frac{\pi(r)}{2}$
$l_2=\pi\frac{(15/32)}{2}$
$l_2=.7363''$

$l_3=\frac{\pi r}{2}$
$l_3=\frac{\pi(15/16)}{2}$
$l_3=1.4726''$





Length of Belt = $l_1+l_2+l_3+l_4+l_5$ = 16.0699"

$a^2+b^2=c^2$
$(15/16+4.125)^2+(1.5+15/32)^2=c^2$
$(5.0625)^2+(3.876)^2=c^2$
$5.43''=c$

$a^2+b^2=c^2$
$(1.5+(15/32))^2+(1.5+15/32)^2=c^2$
$7.75''^2=c^2$
$2.7842''=c$

To Page No. 81

Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	4/15/11	Recorded By: Rebecca Ventimiglia	4/15/11

From Page No. 80

Date: 5/3/11

Below is a rough estimate of when we completed parts in our machining process & troubles we experienced while machining

Date	Processes Accomplished/Worked On	Problems	Improvements
4/8	Stock Cutting	–	–
4/14	Stock Cutting, facing of crankshaft connections	–	–
4/18	Grooves for Snap Rings on crankshaft pieces, facing on lathe, facing connections	–	–
4/19	Holes in crankshaft rods	– Lost Face-Plate Side to Crankshaft	– More Organized in Shop/Track Parts Better
4/20	Crankshaft Pieces Back Plate	– Alignment of Holes in Crankshaft Rods	– Better Machining techniques, redo parts all at once
4/21	Holes in Crankshaft connections		
4/22	Redo holes in rods w/ new technique → make holes all at once	– Crushed 1 Crankshaft Connection in Vice	– Drill Largest holes last because they weaken part
4/23	Bore out enclosure, remark Crankshaft made!	– Unsure how to center on the lathe	– Must mill out hole, not bore
4/26	Bore cylinder (mill), pulley, side plate holes	– Solidworks gives large fitting for screw holes – Difficult machining takes more time (large drill bit)	– Set to smaller fitting in drawings – Reconsider design earlier due to machining difficulties
4/27	Small Pulleys		
4/28	Piston head, long arm bar, adapter –		
4/29	Press fit adapter, reamed crankshaft holes, turned down steel for piston pin	– Realizing design flaws └ mounting needed new holes & dimensioning	– More organized CAD – think ahead!
5/2	Drilled holes in 1 mount		
5/4	Ream crankshaft holes, bottom mounts		
5/5	Finished up mounts, new holes in side plates, cut threaded rod, bought hosing/valves, holes in cylinder box for fittings & feet		

To Page No. 82

Witnessed & Understood by me, Rebecca Ventimiglia Date 5/3/11

Invented by

Recorded By Rebecca Ventimiglia Date 5/3/11

From Page No. 81

Date : 5/3/11 – Meeting at Duffield – 8 pm – 9:15 pm

– we met to organize for the marketing & sales pitch

– Brainstorm Pros about Pump → quality machining, easily adjustable for 2 cylinders, intuitive how parts go together, convienent carrying handle! :)

→ Divide up work

CAD Changes → we decided to reduce our pump from ~~one~~ two cylinders to one since the timing belt did not come in and because of machining difficulties (see previous page). We eliminated the valve shaft & second cylinder from the design, & Ryan changed CAD to reflect this

Costing Analysis → Catherine

Animation → Rebecca

Analysis → Andre

Presentation Formating / Coordination → Chris

To Page No. 83

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	5/3/11	Recorded By Rebecca Ventimiglia	5/3/11

TITLE MAE 2250: Windpump Project: Meeting

From Page No. 82

Date: 5/4/11 – Group Meeting in Duffield from 8–10 pm

– Costing Analysis, CAD, animation, & analysis all put together for presentation

– Re-evaluated machining hours, costs for parts, and surfaces. Data for calculations is to follow...

PURCHASED MATERIAL:

Material Given:

Material	Quantity	Parts Manufactured	Stock Used	Stock to Spare	Cost per Unit	Total Cost
16" of ½" Diameter Steel Rod	1.333	Valve Shaft, Crankshaft- Face Plate Side, Middle Rod	13.0075"	2.9925"	1.65	2.19945
2 ¼" X 2 ¼" X 10" Aluminum Plate	1	2 Valve/ Cylinder Housings	8.25"	1.75"	11.79	11.79
1"x2"x10" Aluminum Plate	1	4 Crankshaft Connectors, Tensor Plate	1.75'	8.25"	5.58	5.58
¼"x1"x10" Aluminum Plate	1	2 Piston Head Attachment Plates, 2 Linkages	10"	0"	1.83	1.83
½"x4"x10" Aluminum Plate	1	Back Housing, 2 Side Housings, 2 Small Pulleys	9.125"	0.875"	5.03	5.03
9" of 1.875" PVC Round Stock	1	2 Pistons	1"	8"	6.8	6.8
12" of 2" O.D. Aluminum Tubing	0	-	-	-	-	0
						26.42945

Material to Purchase:

Material	Quantity	Parts Manufactured	Stock Used	Stock to Spare	Cost per Unit	Total Cost
16" of ½" Diameter Steel Rod	1.5	Crankshaft- Timing Belt Side, Intermediate Joints, 2 Piston	9.44"	6.56"	1.65	2.475
1" 8-32 Screws	32	-	-	-	0.0423	1.3536
Snap Rings	18	-	-	-	0.0916	1.6488
Hose Fittings	2	-	-	-	1.19	2.38
Timing Belt (6082K111)	1	-	-	-	7.04	7.04
1/4-20 Threaded Rod	1	Connections for Mounts	-	-	1.41	1.41
Check Valves	2				0.78	1.56
Hex Nuts	2				0.07	0.14
Hosing	7				0.26	1.82
½"x4"x10" Aluminum Plate	1	Top Mount, 2 Bottom Mounts, 4 Feet, 1 Large Pulley	8.825"	1.175"	5.03	5.03
						24.8574

Total ≈ $50

To Page No.

Witnessed & Understood by me, Rebecca Ventimiglia — Date 5/4/11

Invented by — Date 5/4/11

Recorded By Rebecca Ventimiglia

Project No. 2

Book No. 1

TITLE MAE 2250: Windpump Project: Final Cost Analysis

From Page No. 84

Date 5/4/11 – Cost Analysis (Continued)

← Machining Hours

		Total				Chris				Ryan		
Date		Time Start	Time End	Duration	Work	Time Start	Time End	Duration	Work	Time Start	Time End	Duration
4/8/11	fri	03:30:00 PM	04:30:00 PM	1	lathe/stock cutting	03:30:00 PM	04:30:00 PM	1	mill	03:30:00 PM	04:30:00 PM	1
4/8/11	fri	03:30:00 PM	04:30:00 PM	1	mill	--	--	--	--	--	--	--
4/14/11	thu	01:00:00 PM	02:30:00 PM	1.5	lathe	--	--	--	--	--	--	--
4/15/11	fri	02:30:00 PM	04:30:00 PM	2	mill	02:30:00 PM	3:30:00 PM	1	mill	03:30:00 PM	4:30:00 PM	1
4/15/11	fri	02:30:00 PM	04:30:00 PM	2	mill	--	--	--	--	--	--	--
4/18/11	mon	09:00:00 AM	11:00:00 AM	2	lathe	--	--	--	--	--	--	--
4/18/11	mon	09:00:00 AM	11:00:00 PM	2	mill	--	--	--	--	9:00:00 AM	10:00:00 AM	1
4/18/11	mon	12:30:00 PM	02:30:00 PM	2	lathe	--	--	--	--	--	--	--
4/19/11	tue	02:30:00 PM	03:30:00 PM	1	mill	02:30:00 PM	04:30:00 PM	1	stock cutting	02:30:00 PM	03:30:00 PM	1
4/20/11	wed	09:00:00 AM	11:00:00 AM	2	mill	--	--	--	--	09:00:00 AM	10:00:00 AM	1
4/20/11	wed	09:00:00 AM	11:00:00 AM	2	mill	--	--	--	--	--	--	--
4/21/11	thu	10:30:00 AM	01:00:00 PM	2.50	lathe	10:30:00 AM	11:45:00 AM	1.25		--	--	--
4/22/11	fri	02:30:00 PM	04:30:00 PM	2	mill	02:30:00 PM	3:30:00 PM	1	mill	03:30:00 PM	4:30:00 PM	1
4/22/11	fri	02:30:00 PM	04:30:00 PM	2	mill	--	--	--	--	--	--	--
4/23/11	sat	09:00:00 AM	11:00:00 AM	2	mill	9:00:00 AM	10:00:00 AM	1	mill	10:00:00 AM	11:00:00 AM	0:00
4/23/11	sat	09:00:00 AM	11:00:00 AM	2	mill	--	--	--	--	--	--	--
4/26/11	mon	04:45:00 PM	08:30:00 PM	3.75	lathe	04:45:00 PM	06:00:00 PM	1.25	lathe	6:00:00 PM	08:30:00 PM	1.5
4/26/11	mon	04:45:00 PM	08:30:00 PM	3.75	mill	--	--	--	--	--	--	--
4/26/11	tue	09:00:00 AM	11:00:00 AM	2	mill	--	--	--	--			
4/27/11	wed	09:00:00 AM	11:00:00 AM	2	mill	--	--	--	--	10:00:00 AM	11:00:00 AM	1
4/28/11	thu	09:00:00 AM	05:00:00 PM	8	mill	2:00:00 PM	3:30:00 PM	1.5	mill	9:00:00 AM	10:00:00 AM	1
4/29/11	fri	09:00:00 AM	03:00:00 PM	5	mill	12:00:00 PM	1:00:00 AM	1	mill	1:00:00 AM	2:00:00 AM	1
5/2/11	tue	02:30:00 PM	04:30:00 PM	2	mill	2:30:00 PM	3:30:00 PM	1	mill	--	--	--
5/4/2011	thu	02:30:00 PM	04:30:00 PM	2	mill	2:30:00 PM	3:30:00 PM	1	mill	2:30:00 PM	3:30:00 PM	1

TOTAL:	57.5	TOTAL PER PERSON:	12	12.5

Total	66.4
Average	13.28
Rounded Ave.	13.25
Overtime	3.75 (Andre)
Total	

To Page No. 86

Witnessed & Understood by me, Rebecca Ventimiglia

Date 5/4/11

Invented by

Recorded By Rebecca Ventimiglia

Date 5/4/11

TITLE MAE 2250: Windpump Project: Final Cost Analysis

From Page No. 85

Date: 5/4/11 – Final Cost Analysis

← Machining Hours Continued.

	Andre				Catherine				Rebecca			
Work	Time Start	Time End	Duration	Work	Time Start	Time End	Duration	Work	Time Start	Time End	Duration	Work
lathe	--	--	--	--	--	--	--	--	--	--	--	--
--	03:30:00 PM	04:30:00 PM	1	lathe	03:30:00 PM	4:30:00 PM	1	mill	03:30:00 PM	4:30:00 PM	1	mill
--	01:00:00 PM	02:30:00 PM	1.5	mill	--	--	--	--	--	--	--	--
mill	--	--	--	--	03:30:00 PM	4:30:00 PM	1	mill	03:30:00 PM	4:30:00 PM	1	mill
--	02:30:00 PM	3:30:00 PM	1	mill	--	--	--	--	--	--	--	--
--	09:00:00 AM	11:00:00 AM	2	mill	--	--	--	--	--	--	--	--
lathe	--	--	--	--	10:00:00 AM	11:00:00 AM	1	lathe	--	--	--	--
--	12:30:00 PM	1:30:00 AM	1	lathe	--	--	--	--	1:30:00 AM	2:30:00 AM	1	lathe
mill	03:30:00 PM	04:30:00 PM	1	mill	03:30:00 PM	04:30:00 PM	1	mill	--	--	--	--
mill	--	--	--	--	10:00:00 AM	11:00:00 AM	1	mill	--	--	--	--
--	09:00:00 AM	10:00:00 AM	1	mill	--	--	--	--	10:00:00 AM	11:00:00 AM	1	mill
--	11:45:00 AM	01:00:00 PM	1.25		--	--	--	--	--	--	--	--
mill	--	--	--	--	03:30:00 PM	4:30:00 PM	1	mill	03:30:00 PM	4:30:00 PM	1	mill
--	02:30:00 PM	3:30:00 PM	1	mill	--	--	--	--	--	--	--	--
mill	--	--	--	--	--	--	--	--	--	--	--	--
--	9:00:00 AM	10:00:00 AM	1	mill	--	--	--	--	10:00:00 AM	11:00:00 AM	1	mill
lathe	--	--	--	--	--	--	--	--	--	--	--	--
--	04:45:00 PM	06:00:00 PM	1.25	mill	6:00:00 PM	08:30:00 PM	1.5	mill	6:00:00 PM	07:30:00 PM	1.5	mill
	--	--	--	--	9:00:00 AM	10:00:00 AM	1	mill	10:15:00 AM	11:00:00 AM	0.45	mill
mill	--	--	--	--	9:00:00 AM	10:00:00 AM	1	mill	10:15:00 AM	11:00:00 AM	0.45	mill
mill	10:00:00 AM	12:00:00 PM	1	mill	--	--	--	--	12:00:00 PM	2:00:00 AM	2	mill
mill	1:00:00 AM	2:00:00 AM	1	mill	2:00:00 PM	3:00:00 PM	1	mill	9:00:00 AM	11:00:00 AM	2	mill
--	3:30:00 PM	4:30:00 PM	1	mill	--	--	--	--	--	--	--	--
mill	3:30:00 PM	4:30:00 PM	1	mill	3:30:00 PM	4:30:00 PM	1	mill	3:30:00 PM	4:30:00 PM	1	mill
			17				11.5				13.4	

To Page No. 87

Witnessed & Understood by me, Rebecca Ventimiglia
Date 5/4/11
Invented by
Recorded By Rebecca Ventimiglia
Date 5/4/11

From Page No. 86

Date: 5/4/11

- This chart shows our team's engineering hours →

Meeting Date	Place	Time Starts	Time Ends	Duration	No of Group Members
3/10/2011	Duffield Atrium	21:00:00	22:00:00	1	4
3/11/2011	Taylor studio	14:00:00	16:25:00	2:25:00	5
3/12/2011	Upson basement	16:30:00	18:30:00	2:00:00	5
3/14/2011	Upson basement	07:00:00 PM	21:00:00	2:00:00	5
3/17/2011	Duffield cubby	06:30:00 PM	21:15:00	2:45:00	3 to 5
3/18/2011	Taylor studio	14:00:00	16:25:00	2:25:00	4
3/29/2011	Duffield	10:30:00 PM	0:30:00	2	5
3/30/2011	Duffield	02:30:00 PM	04:30:00 PM	2:00:00	3
3/31/2011	Upson basement	09:30:00 PM	11:30:00 PM	2:00:00	5
4/1/2011	Taylor studio	14:00:00	04:25:00 PM	2:25:00	5
4/2/2011	Upson lounge	06:00:00 PM	08:00:00 PM	2:00:00	4
4/4/2011	Upson basement	08:00:00 PM	10:00:00 PM	2:00:00	4
4/7/2011	Duffield	07:00:00 PM	09:00:00 PM	2:00:00	5
4/8/2011	Taylor	02:00:00 PM	04:30:00 PM	2:30:00	5
4/9/11	Duffield	05:45:00 PM	07:00:00 PM	1:15:00	4
5/3/11	Duffield	08:00:00 PM	09:15:00 PM	1:15:00	4
5/4/2011	Duffield	08:00:00 PM	10:00:00 PM	2:00:00	5

Cost Analysis Calculation –

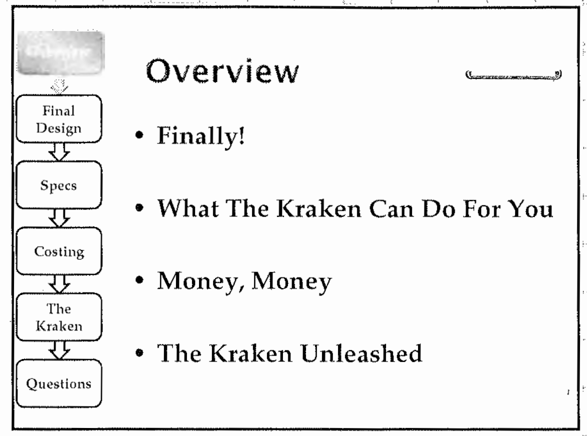
	Hours	Cost
Total Eng Hours –	145 hrs. +	19,452.92
Machining Hours –	66.4 + 3.75 overtime	2,656 + 300
Material –		250
Manufacturing –		+ 302.4
		$ 23,461.32

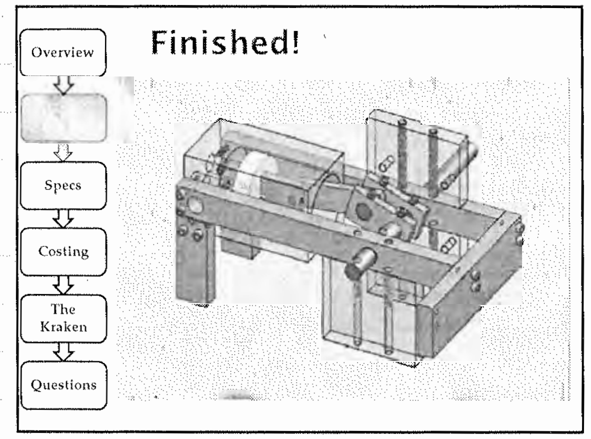
To Page No. 88

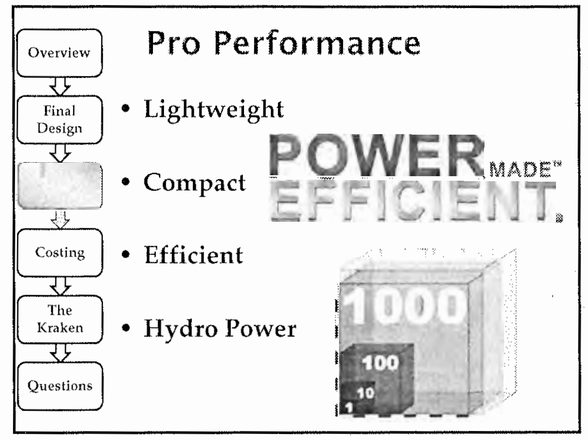
Witnessed & Understood by me, Rebecca Ventimiglia Date 5/4/11
Invented by
Recorded By Rebecca Ventimiglia Date 5/4/11

From Page No. 87

Date: 5/5/11 - Lab Section: Sales Pitch - (8-10:30PM) - Taylor Design Studio

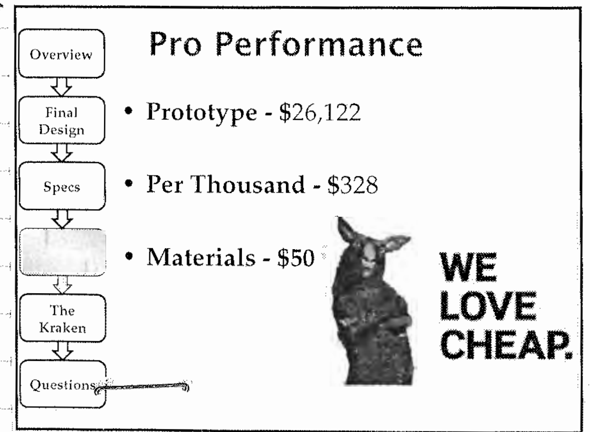


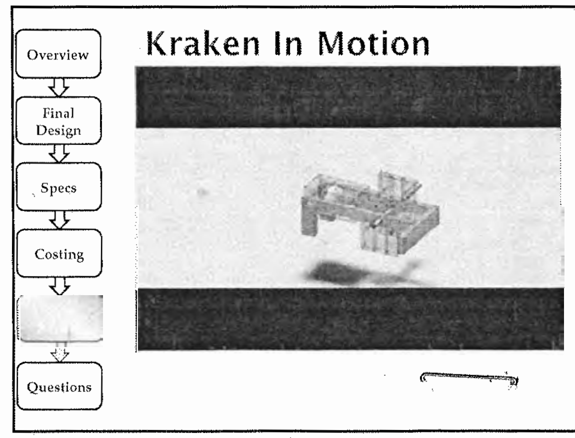




Final Specs

Final Costing Info





To Page No. 89

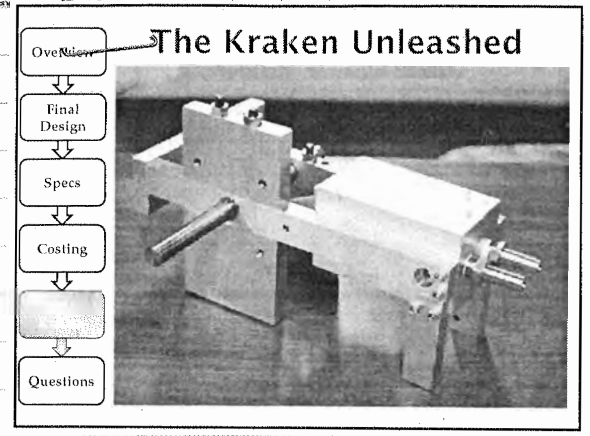
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	5/5/11	Recorded By Rebecca Ventimiglia	5/5/11

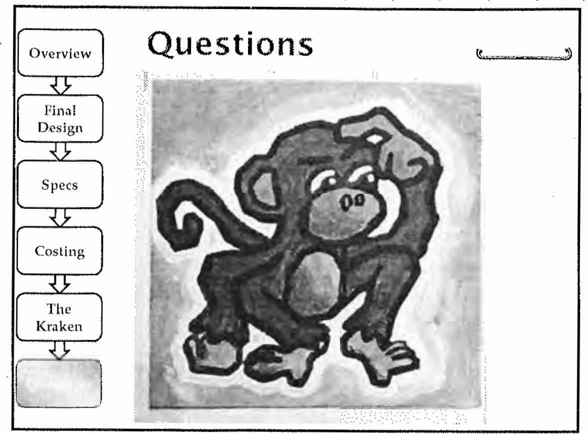
TITLE MAE 2250: Windpump Project: Sales Pitch

From Page No. 83

Date: 5/5/11 - Sales Pitch

Final Photo →





- Final Specs presented in presentation:
  - Power Required - 15 Watts (from Matlab code w/adjustment for 1 cylinder)
  - Weight - 4.545 lbs
  - Height: 5.475"
  - Length: 9"
  - Width: 5.5"
  - Volume: .1 ft^3

To Page No. 90

Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	5/5/11	Recorded By: Rebecca Ventimiglia	5/5/11

TITLE MAE 2250: Windpump Project: Notes on Assembly

Project No. 2

Book No. 1

From Page No. 89

Date: 5/5/11

- When putting the Kracken together, we noticed some tips for the user manual →

  - Assemble the piston head in the cylinder first, then the side bars, then the back plate
  - Put screws in one at a time, tighten evenly
  - When attaching the enclosure to the side plates, there is some give in the y-direction so line up the bottom of the back plate w/ the bottom of the enclosure to ensure a smooth motion of piston head.
  - Do not remove the connecting 1/4"-20 rods from bottom mounts. It's a very tight fit so have these pieces come attached.
  - Have crankshaft also come mostly assembled → snap ring tool is not available to everyone, so account for ways to work around it.

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Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	5/5/11	Recorded By: Rebecca Ventimiglia	5/5/11

From Page No. 90

Date: 5/5/11

Manufacturing Processes →
This chart is of our finalized processes. It shows the processes we completed and the ones eliminated due to design changes and the belt not arriving until 5/5/11

Component	Part	Lathe:	Mill:	Processes:					Status:
FRAME	Bottom Mounts		☒	Cut from Stock	Trim down	Screw holes	Face Plate Holes			D
	Top Mount		☒	Cut from Stock	Trim down	Screw holes	Face Plate Holes			D
	Side Plates		☒	Cut from Stock	Trim down	Screw holes	Side Holes for Shafts	~~Side Hole for Tensor~~		D
	Cylinder Housing	☒	☒	Cut from Stock	Trim down	Screw holes	Slot for Valve	Bore for Cylinders		D
	Back Housing		☒	Cut from Stock	Trim down	Screw holes				D
	Connecting Rods		☒	Cut from Stock	Grind					D
	8-32 Screws			Saw to Size	Grind					D
	Feet		☒	Cut from Stock	Trim down	Screw holes				D
BELT	Small Pulleys	☒	☒	~~Cut from Stock~~	~~Trim down~~	~~Screw holes~~	~~Lathe to Circle~~	~~Groove for Belt~~		D
	Large Pulley	☒	☒	~~Cut from Stock~~	~~Trim down~~	~~Screw holes~~	~~Groove for Belt~~			D
VALVE SHAFT	Valve Shaft	☒	☒	~~Cut from Stock~~	~~Trim down~~	~~Screw holes~~	~~Cut Semi-Circles~~			-
CRANKSHAFT	Timing Belt Rod	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings	Groove for Belt		D
	Connections (R)	☒		Cut from Stock	Trim down	Screw holes				D
	Middle Rod	☒	☒	Cut from Stock	Trim down	Screw holes				D
	Face Plate Rod	☒	☒	Cut from Stock	Trim down	Screw holes	Groove for Snap Rings			D
	Intermediate Rod	☒	☒	~~Cut from Stock~~	~~Trim down~~	~~Screw holes~~	~~Groove for Snap Rings~~			D
PISTON	Piston Head	☒	☒	Cut from Stock	Trim down	Screw holes	~~Mill slot for attachment~~			D
	Piston Linkages (L)		☒	Cut from Stock	Trim down	Screw holes				D
	Piston Head Attachment		☒	Cut from Stock	Trim down	Screw holes				D
	Piston Head Joint		☒	Cut from Stock	Trim down	Screw holes	~~Groove for Snap Rings~~			D
TENSOR	Tensor Roller	☒	☒	~~Cut from Stock~~	~~Trim down~~	Screw holes	~~Groove for Snap Rings~~			-
	Tensor Plate		☒	~~Cut from Stock~~	~~Trim down~~	~~Screw holes~~				-

KEY:	
M	Measured
C	Cut from Stock
D	Done
WIP	Work in Progress

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Witnessed & Understood by me, Rebecca Ventimiglia | Date 5/5/11
Invented by | Date 5/5/11
Recorded By Rebecca Ventimiglia

From Page No.

Date: 5/5/2011 → Testing during Lab Section (ELL)

Group 1: Team Blastoise
- 1.5 L/min
- ~~Weight~~:
- Cost: $ 201.65

Group 2: No Pump
- 0 L/min
- Cost: $205.35

Group 3: Pump It!
- 0L/min
- ~~Weight~~:
- ~~Cost~~: Cost: $312.04

Group 4: Mach 5
- Pump, no results → 0 L/min
- Weight: 45 lbs
- Cost: $328

~~Parts Chart~~:

Cost Chart

Group	1	2	3	4
Prototype Cost	$ 21645.81	$37345	$18129.21	$25819.06
Single Pump Cost	$21825.81	$37513	$18333.21	$26122.47
1000 Pump Cost	$201.65	$205.35	$312.04	$325.22

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Witnessed & Understood by me, Rebecca Ventimiglia — Date 5/5/11

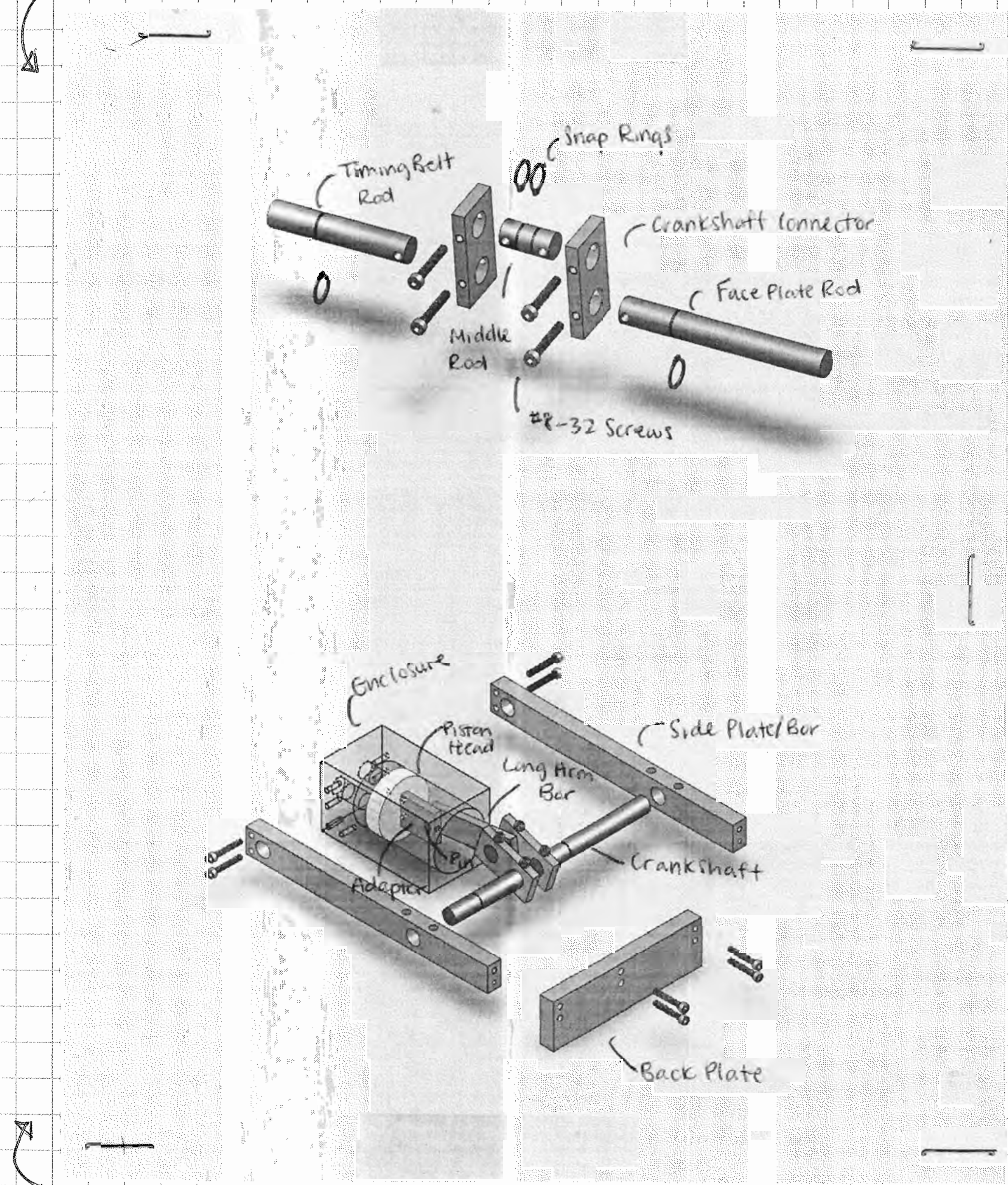
Invented by — Date 5/5/11

Recorded By Rebecca Ventimiglia

TITLE MAG 2250: Windpump Project: Final CAD + Pump Pics

From Page No. 92

Date: 5/6/11
Crankshaft Explosion



Side Plate Explosion

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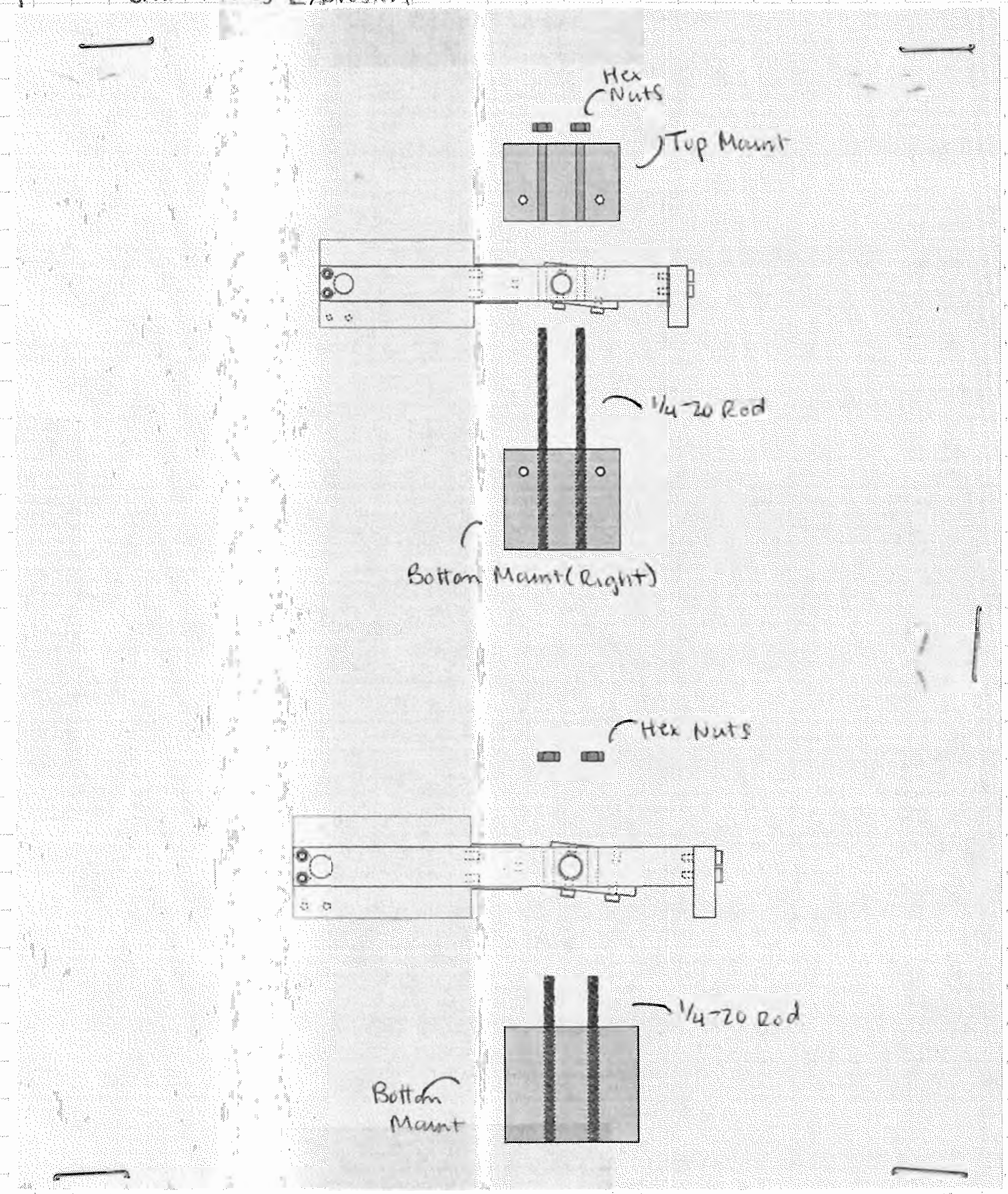
Witnessed & Understood by me,	Date	Invented by	Date
Rebecca Ventimiglia	5/6/11	Recorded By Rebecca Ventimiglia	5/6/11

From Page No. 93

Date: 5/6/11

Right Side (Face Plate) Explosion



Left Side Explosion

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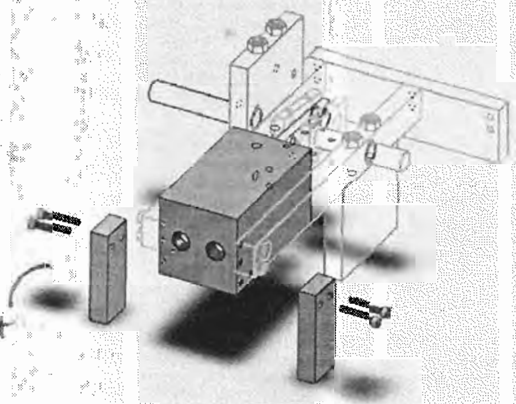
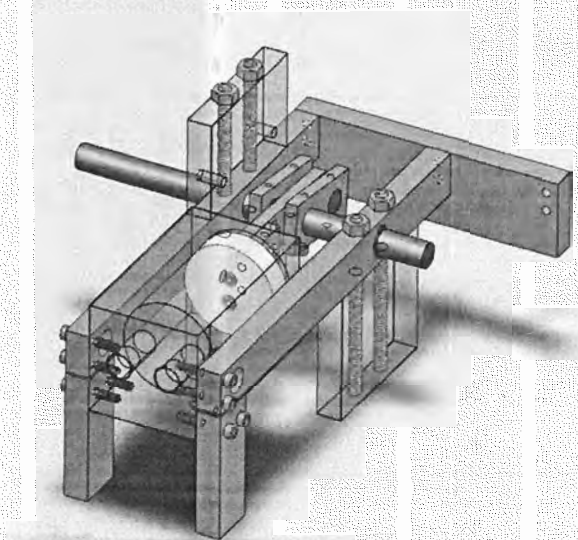
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	5/6/11	Recorded By: Rebecca Ventimiglia	5/6/11

From Page No. 94

Date: 5/6/11

Back Enclosure Explosion





Final Assembly (The KRACKEN!)

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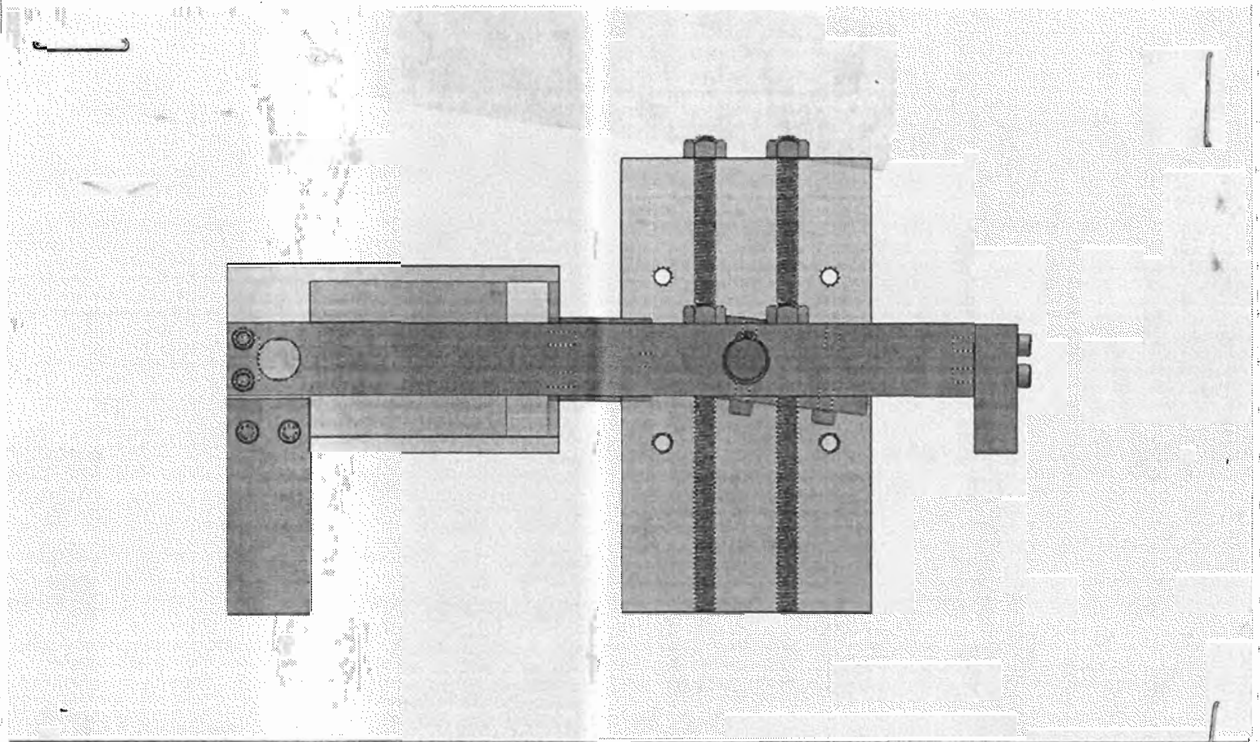
Witnessed & Understood by me.	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	5/6/11	Recorded By: Rebecca Ventimiglia	5/6/11

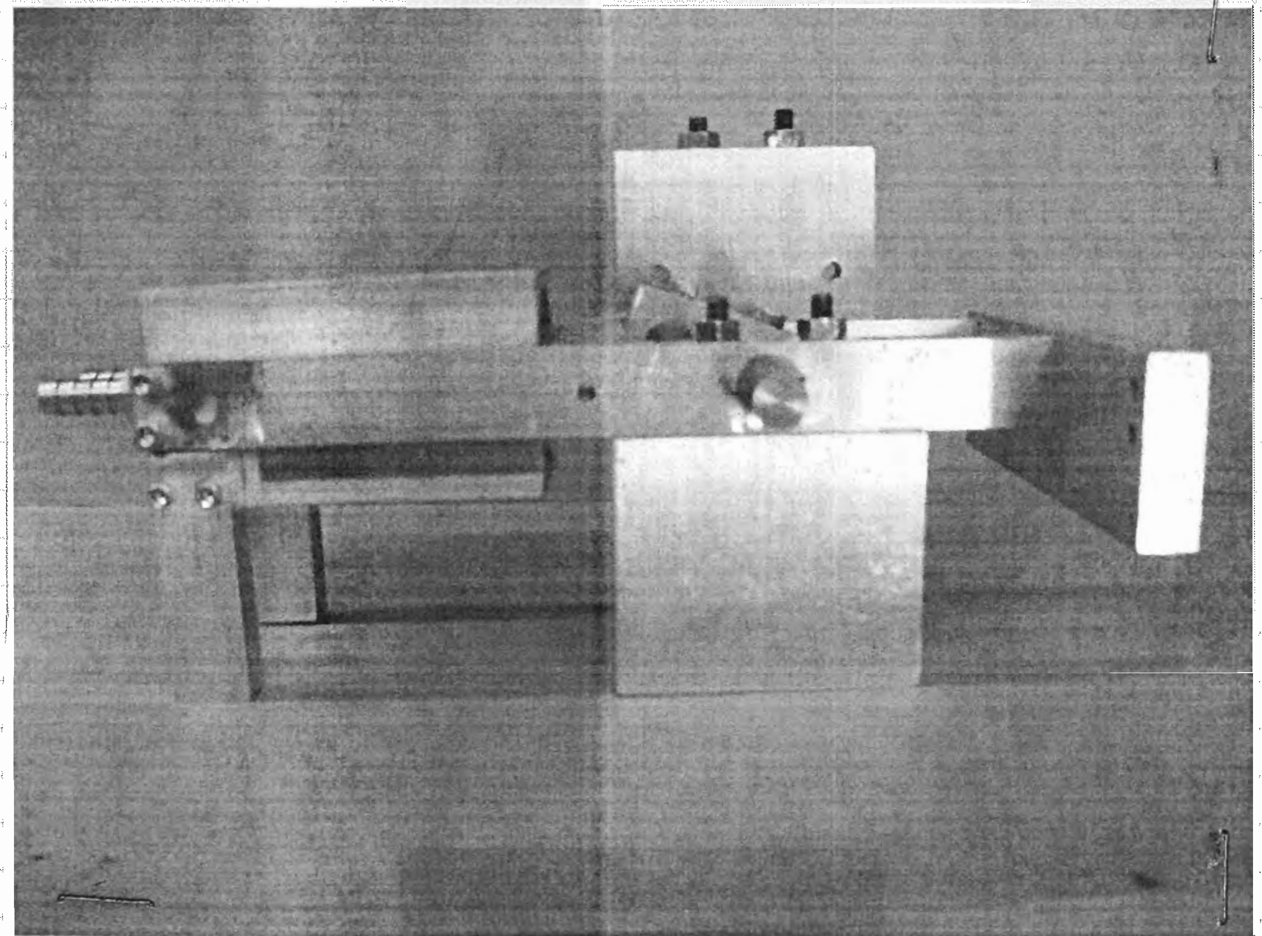
TITLE MAE 2250: Windpump ~~___~~ Project: Final CAD + Pics

From Page No. 95 Date: 5/6/11

Side View of Assembly



Side View of Kraken



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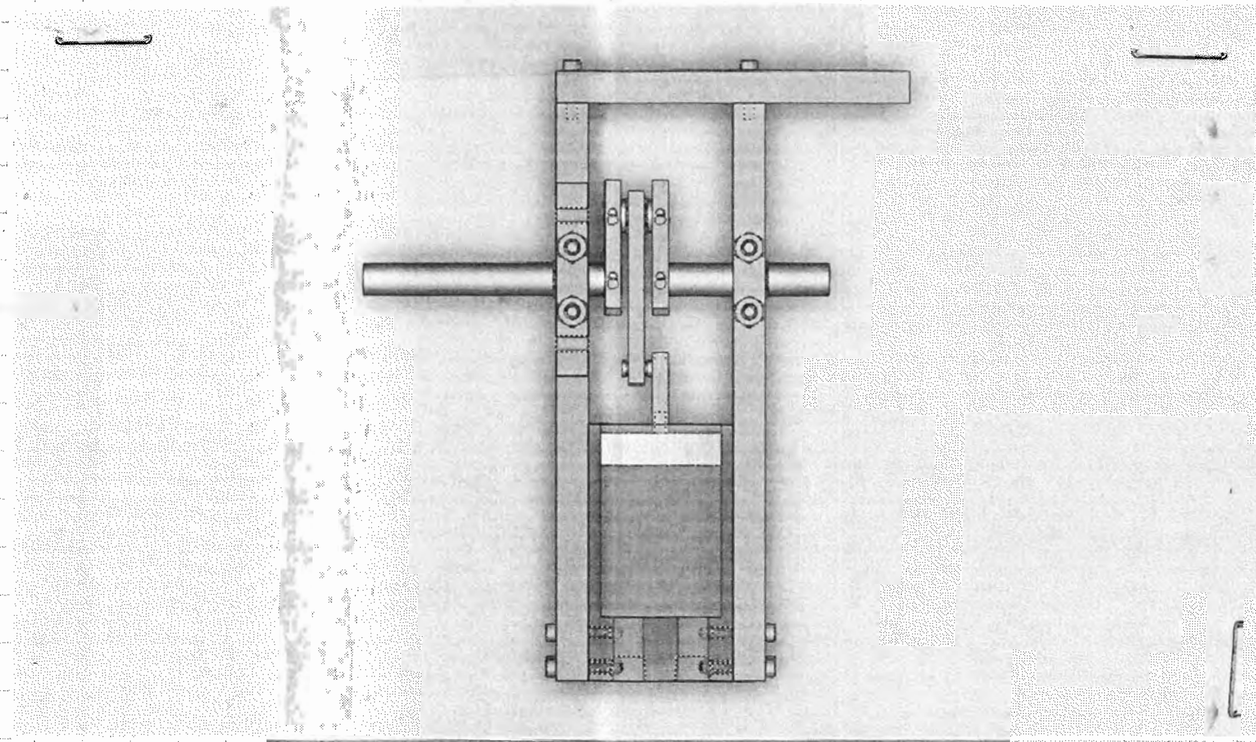
Witnessed & Understood by me,	Date	Invented by / Recorded By	Date
Rebecca Ventimiglia	5/6/11	Recorded By Rebecca Ventimiglia	5/6/11

TITLE MAE 2250: Windpump Project : Final CAD + Pics

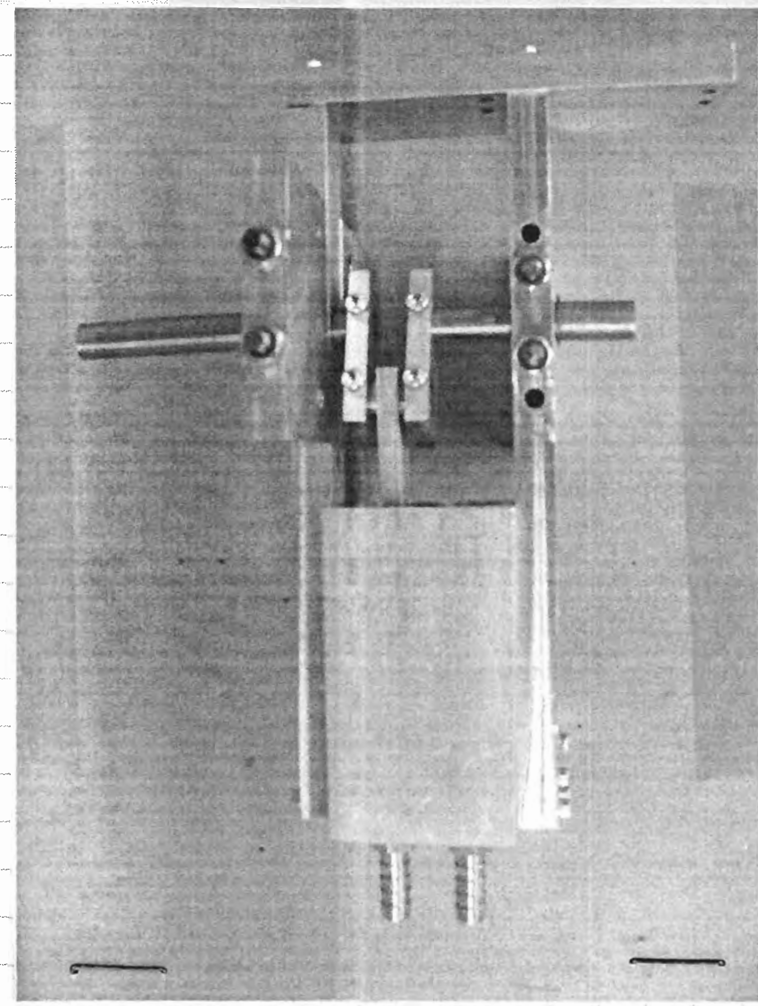
From Page No. 96

Date: 5/6/11

Top View of Assembly



Top View of the Kraken



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Witnessed & Understood by me, Rebecca Ventimiglia

Date 5/6/11

Invented by

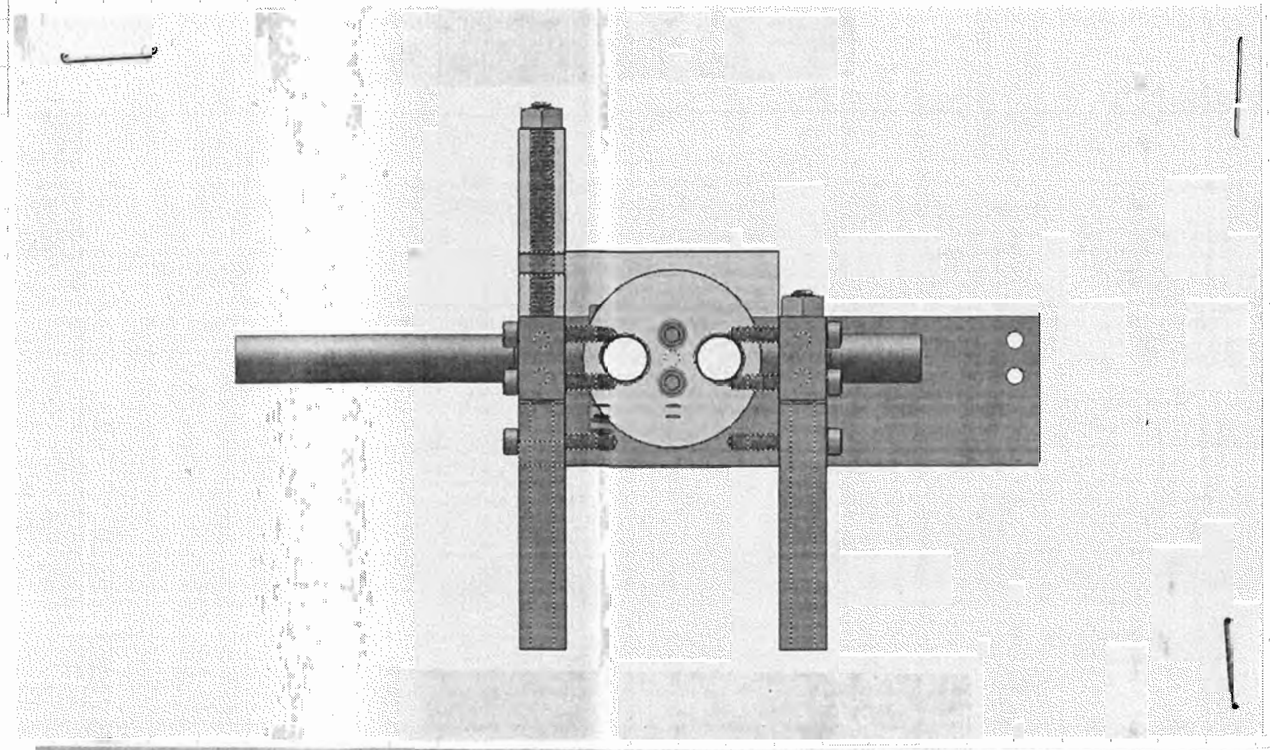
Recorded By Rebecca Ventimiglia

Date 5/6/11

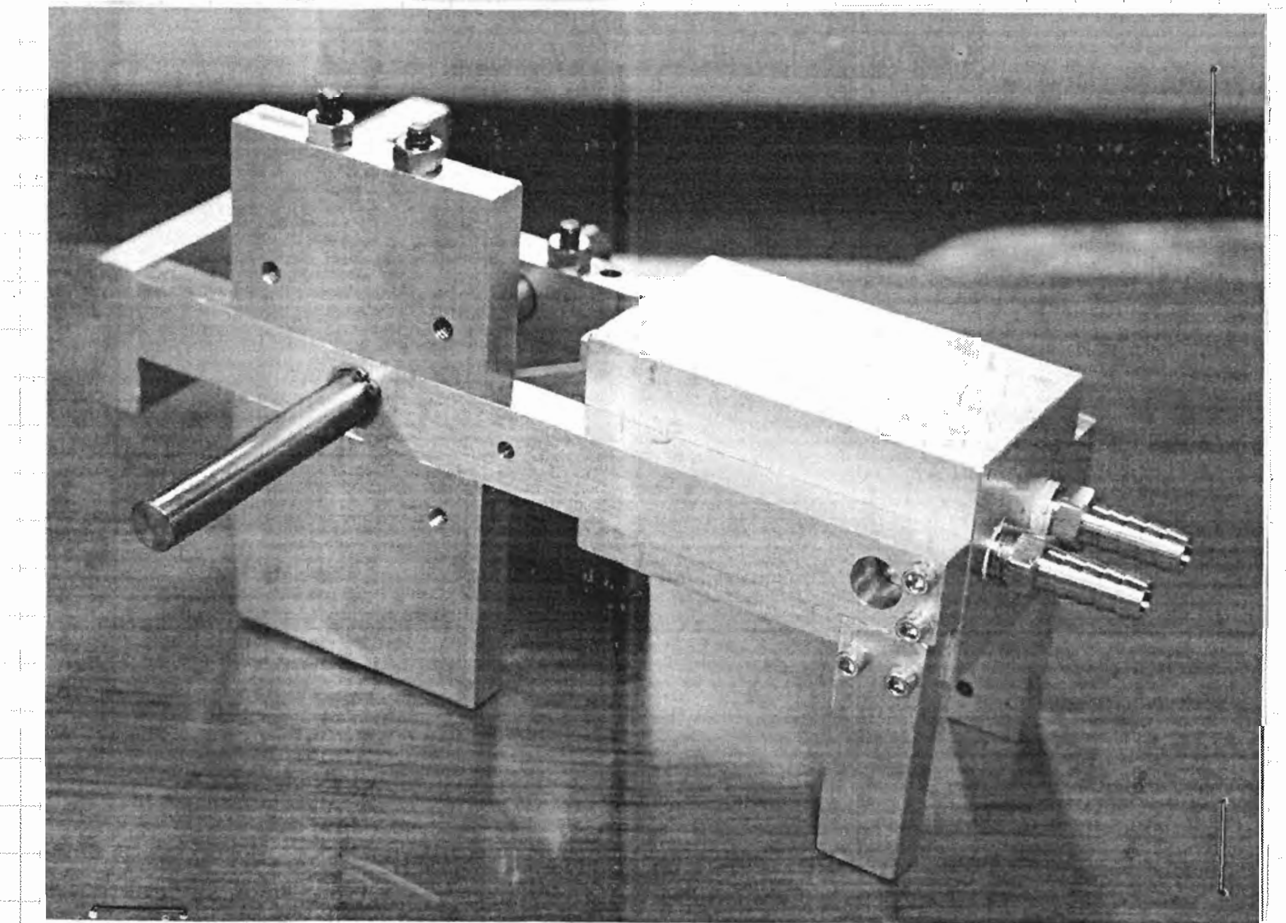
From Page No. 97

Date: 5/6/11

Front View of Assembly



The Kraken Assembled!



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TITLE Final Group Meeting of 2250 "

From Page No. 98

5/7/11: Last Group Meeting Duffield – 11 AM – 5:00 PM

- We came together to collaborate and finish our project development file
- Honestly, I had a great time working with my group and the TAs and I wish Cornell would offer more courses like this one. Thanks for an awesome class – it truly was the best one I've taken at Cornell thus far.

- Appended ~~are~~ the drawings for all parts, old and revised that were ever a part of our Kraken design.

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Witnessed & Understood by me.	Date	Invented by	Date
Rebecca Ventimiglia	5/7/11	Recorded By: Rebecca Ventimiglia	5/7/11