Engineering Analysis

November 6, 2012

Matt Garcia, Randy Jackson, Jeremy Mountain, Qian Tong, Hui Yao

College of Engineering, Forestry, and Natural Sciences
Northern Arizona University

Overview

- Problem Statement
- Updated Design
- Material Analysis
- Compression Analysis
- Bearing Analysis
- Screw Analysis
- Cost Analysis
- Updated Timeline

Matt

Problem Statement

Need: *The eccentric loading of the test specimens causes fatigue failure.*

Goal: *Design an improved material testing fixture.*

Constraints:

1. Specimen size (3 x 3 x 20) mm
2. Exposed Length (6 mm)
3. Grips cannot bite into specimen
4. Push rods and grips must be non-magnetic
5. Distance between magnets (10mm)
6. Magnetic Field (0.5 - 1.0 T)
7. Axial Alignment (50 µm)

Objectives:

Objectives	Basis for Measurement	Units
Axially Aligned	Distance from Perfect Alginment	µm
Tension Compression Testing	Repeated Testing	# of Tests
Damage Specimen	Cost of Specimen Time to Replace	$$ / Month
Inexpensive	Machining Cost Material Cost	$$

Jeremy

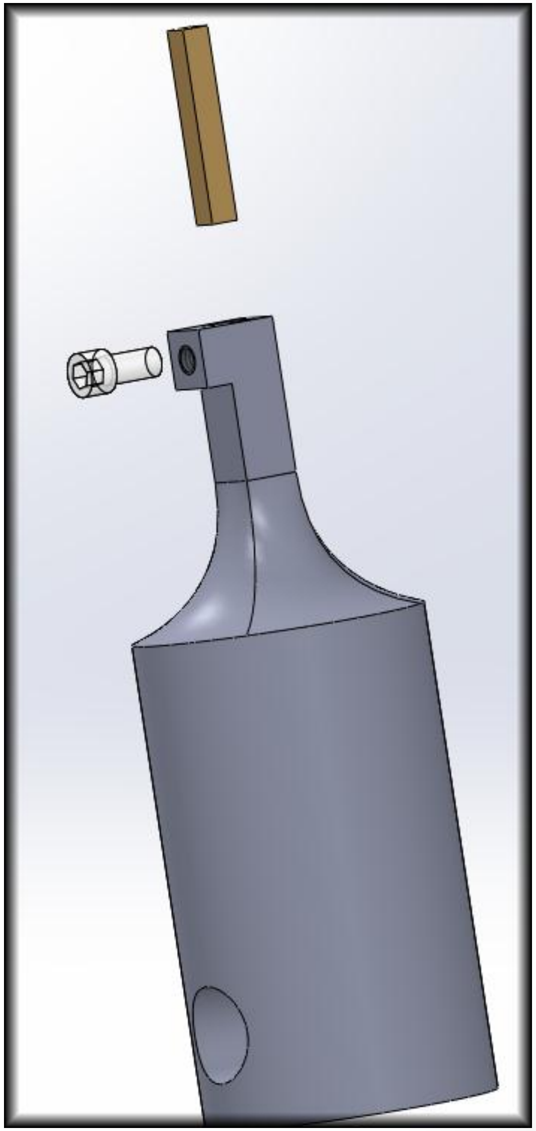
Updated Design

Previous Design

- Interference with magnets
- Spacing > 10 mm

New Design

- No Interference
- Spacing < 10 mm



Jeremy

Material Analysis

Requirement:

- All parts of the fixture need to be non-magnetic

Types of Non-magnetic materials:

- Copper (Yield Strength)
- Silver (Expensive)
- Lead (Toxic)
- Magnesium (Chemically Active)
- Platinum (Too Expensive)
- Aluminum Alloy (Cheap, easy to get)

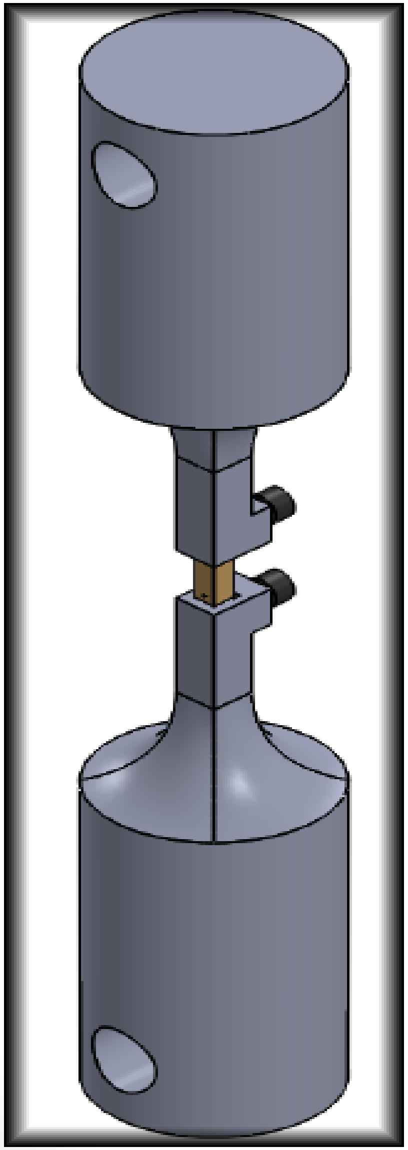
Hui

Material Analysis – Cont.

1000 series	**Pure aluminum.** Basic aluminum without any other addition.
2000 series	**Alloyed with *copper.*** Formerly used in aerospace applications.
3000 series	**Alloyed with *manganese*.** Rust-proof material.
4000 series	**Alloyed with *silicon*.** Wear resistant material.
5000 series	**Alloyed with *magnesium*.** Prevents the oxidation.
6000 series	**Alloyed with *magnesium* and *silicon*.** Easy to machine and inexpensive.
7000 series	**Alloyed with *zinc.*** Now used for aerospace applications.

Hui

Material Analysis – Cont.



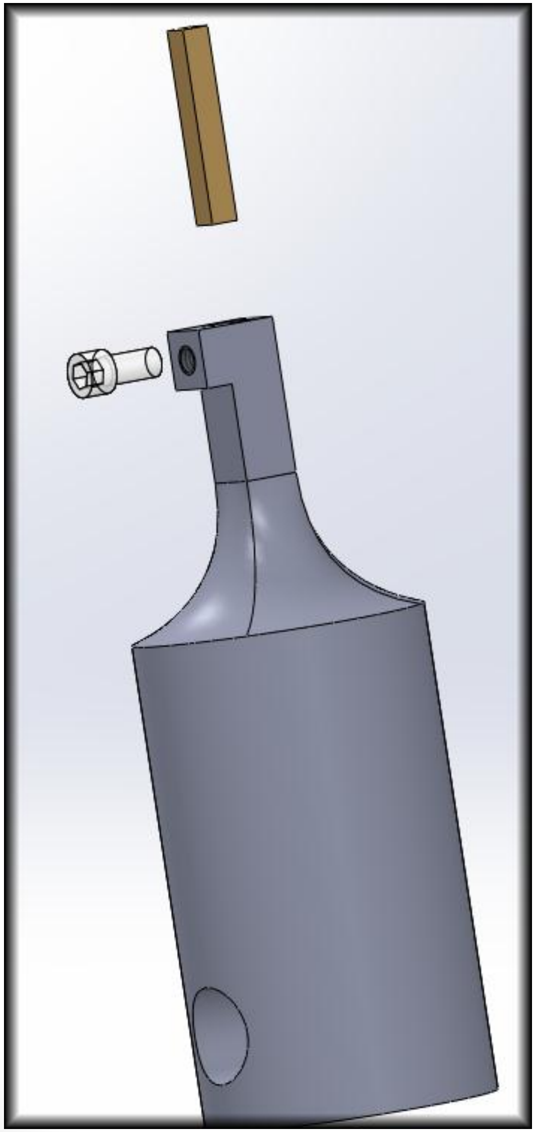
Aluminum 6061 – T6

- A precipitation hardening aluminum alloy.
- It has good mechanical properties.
- It is one of the most common alloys of aluminum for general purpose use

- **6061 - T1**
- **6061 - T3**
- **6061 - T4**
- **6061 - T5**

Hui

Material Analysis – Cont.



Nylon Type 66

- One of the most commonly used polymers.
- Easy and cheap to get.
- Less Yield Strength than aluminum alloy

- **Brass**
- **Aluminum**

Hui

Compression Analysis

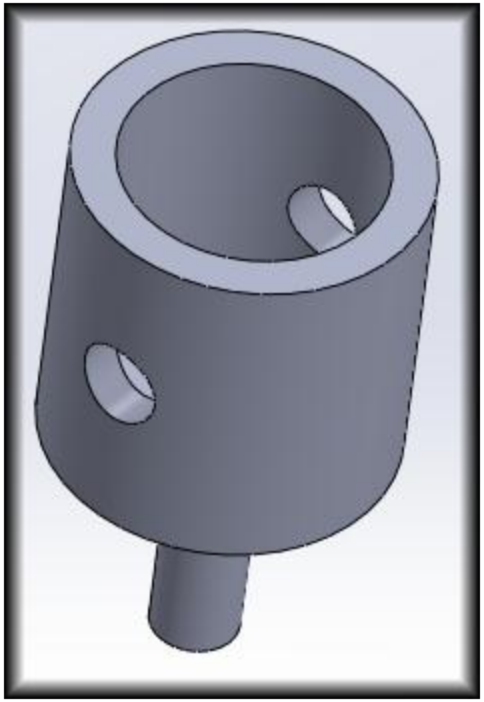
Results:

Length	3	mm
Width	3	mm
Area	9	mm^2
	0.000009	m^2

Force (N)	Stress (N/m^2)
10	1.111E+06
20	2.222E+06
30	3.333E+06
40	4.444E+06
50	5.556E+06
60	6.667E+06
70	7.778E+06
80	8.889E+06
90	1.000E+07
100	1.111E+07

Matt

Bearing Analysis



	Pin 10mm	Pin 15mm	Pin 20mm	Pin 25mm
Outer Diameter (mm)	**Stress (MPa)**	**Stress (MPa)**	**Stress (MPa)**	**Stress (MPa)**
31.0	16.00	10.67	8.00	6.40
32.0	8.00	5.33	4.00	3.20
33.0	5.33	3.56	2.67	2.13
34.0	4.00	2.67	2.00	1.60
35.0	3.20	2.13	1.60	1.28
36.0	2.67	1.78	1.33	1.07
37.0	2.29	1.52	1.14	0.91
38.0	2.00	1.33	1.00	0.80
39.0	1.78	1.19	0.89	0.71
40.0	1.60	1.07	0.80	0.64

Jeremy

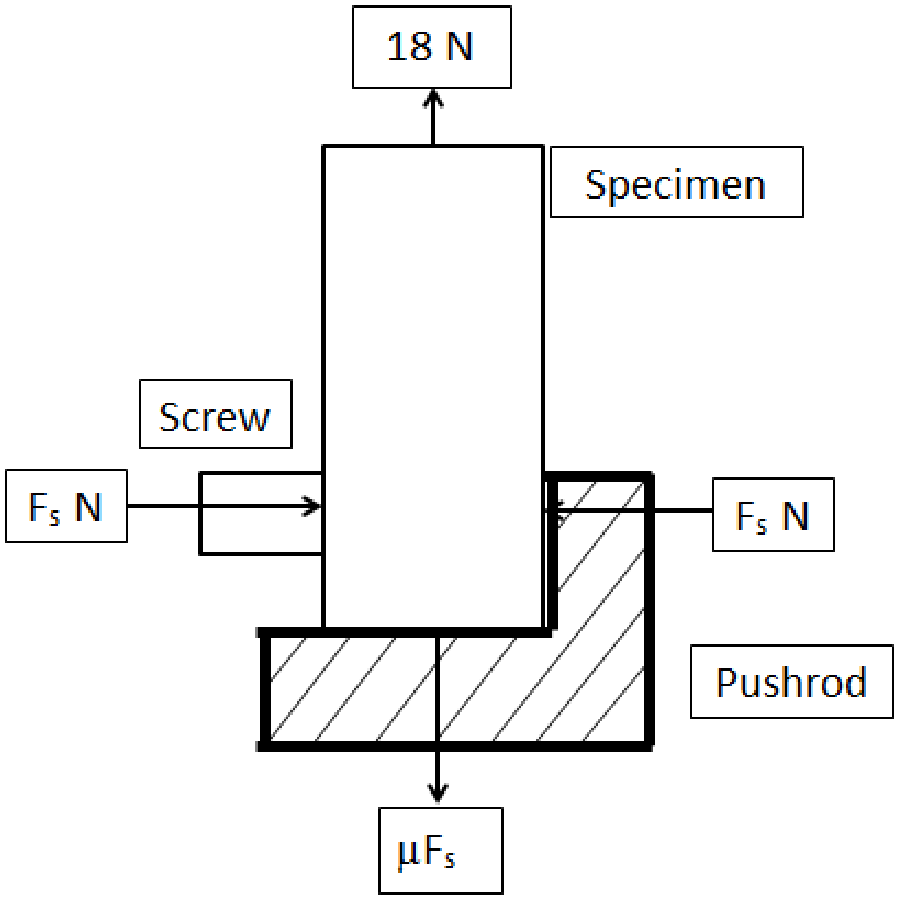
Screw Analysis

Sum of the forces:

$$\sum F_y = 18N - \mu F_s = 0$$

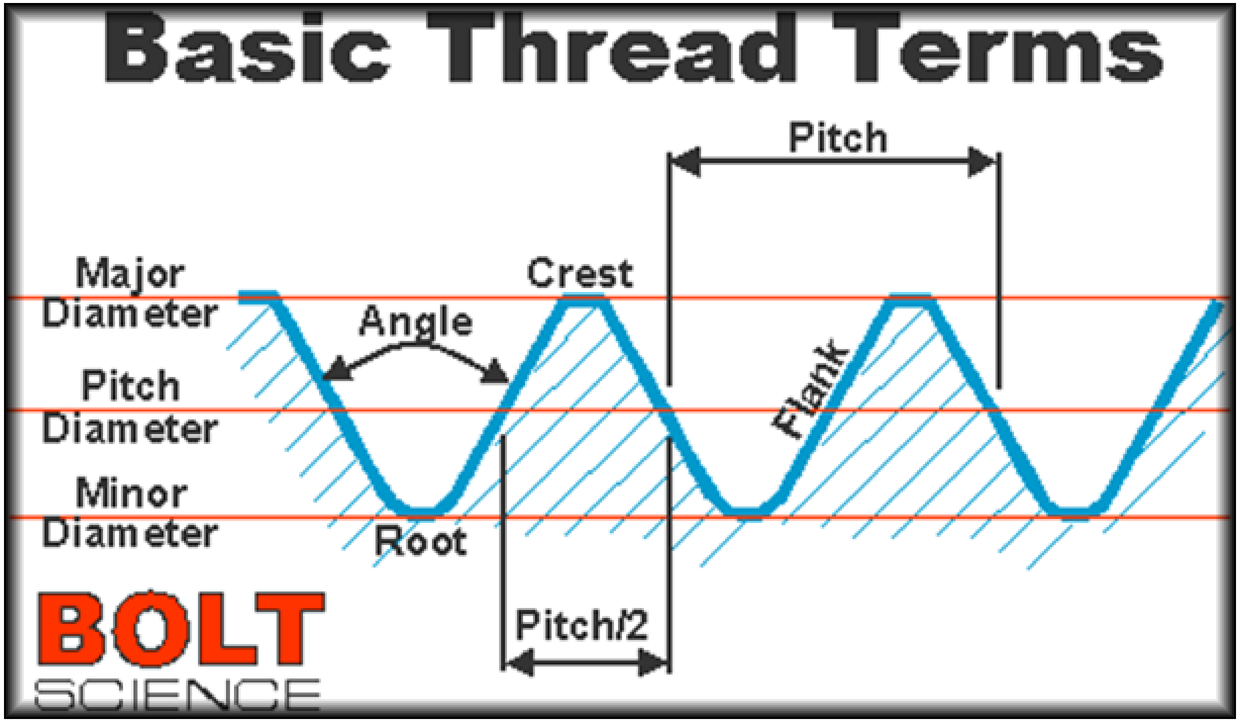
$$F_s = \frac{18}{\mu} N$$

F_s [N]	Friction
120.0	0.2
36.0	0.5
21.2	0.9
15.0	1.2



Randy

Screw Analysis – Cont.



Source: www.boltscience.com

Randy

Screw Analysis – Cont.

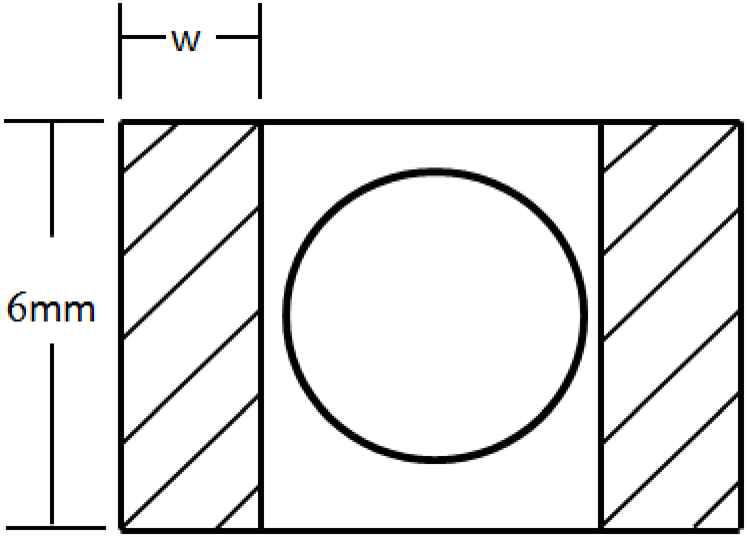
Screw: M3 x 0.5 x 6 mm

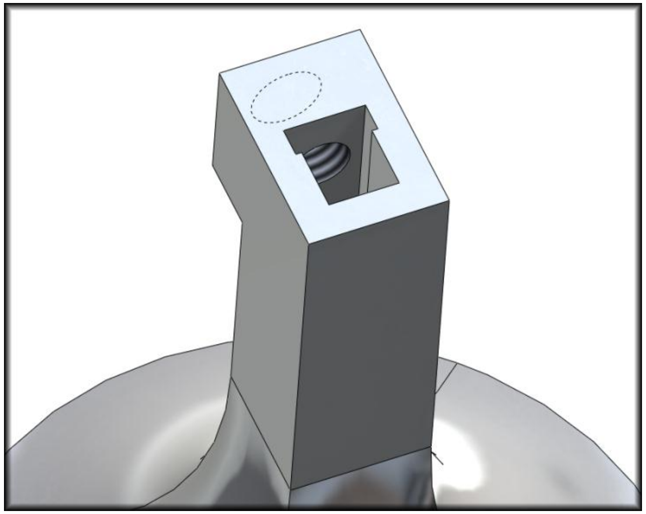
Major Diam. D [mm]	Minor Diam. dr [mm]	Thread Engagement Length Le [mm]	Pitch Diam. dp [mm]	Pitch p [mm]	External Shear Area [mm^2]	Internal Shear Area [mm^2]
3.000	2.385	3.500	2.567	0.500	**18.623**	**32.986**

	Nylon Type 66			Brass		
	Yield Str. [MPa]	Force [N]	Coeff. Friction	Yield Str. [MPa]	Force [N]	Coeff. Friction
	45	120	0.15	130	51.43	0.35
External Thread Force to Fail [N]	838.1			2421.0		
Internal Thread Shear to Fail [N]	8081.6			8081.6		

Randy

Screw Analysis – Cont.





M3 x 0.5 x 6mm	Break Fixture	
Wall 'w'	**Stress MPa**	**FS**
0.50	20.00	12.1
0.55	18.18	13.3
0.60	16.67	14.5
0.65	15.38	15.7
0.70	14.29	16.9
0.75	13.33	18.1
0.80	12.50	19.3
0.85	11.76	20.5
0.90	11.11	21.7
0.95	10.53	22.9
1.00	10.00	24.1
1.05	9.52	25.3
1.10	9.09	26.5
1.15	8.70	27.7
1.20	8.33	28.9
1.25	8.00	30.1

Randy

Cost Analysis

- Cost of Metals

Material	$/lb	Description	Scale
Copper	3-3.5	A little Expensive	4
Silver	30-32	Too expensive	2
Lead	2.3-3.0	A little Expensive	5
Magnesium	2-2.6	A little Expensive	6
Aluminum Alloy	**0.6-0.9**	**Inexpensive**	9
Platinum	50-60	Too Expensive	1

Cost Analysis – Cont.

- Cost of Aluminum Alloys

Aluminum Alloy	Alloyed Component	Price: $/kg
1000 Series	Pure 99%	2.6-4
2000 Series	Copper	2.5-4.2
3000 Series	Manganese	3.5-3.6
4000 Series	Silicon	3.0-5
5000 Series	Magnesium	2.5-3.5
6000 Series	Magnesium Zinc	2.5-3.5
7000 Series	Zinc	2.5-5.5

Cost Analysis – Cont.

- Cost of Screws

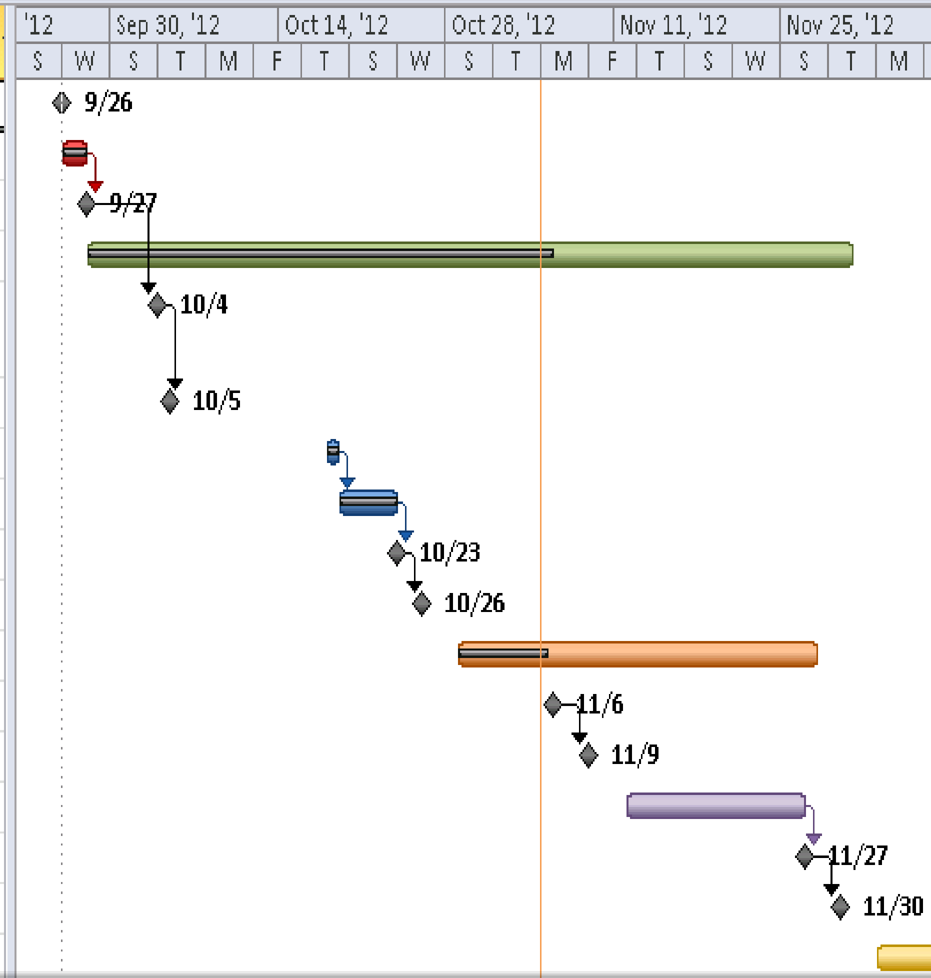
Screw	Price / piece [$/piece]
Bronze (high Strength)	0.029-0.032
Brass	0.1-1
Nylon	**0.005-0.006**

Conclusion

- Pushrod: Aluminum 6061 – T6
- Sleeve: Aluminum 6061 – T6
- Pin: Aluminum 6061 – T6
- Screw: Nylon 66

Updated Timeline

	Task Name
1	Groups Assigned
2	Contact Client, set up meeting
3	Meet with Client
4	Work on and update Website
5	Presentation 1 - Needs Identification, Product Specification, and Project Plan
6	Report 1
7	Meet with Client regarding design ideas
8	Modify designs, select best design
9	Presentation 2 - Concept Generation and Selection
10	Report 2 - Concept Generation and Selection
11	Engineering Analysis
12	Presentation 3 - Engineering Analysis
13	Report 3 - Engineering Analysis
14	Final Design Review and Project Proposal
15	Presentation - Final Design Review and Project Proposal
16	Final Design Review and Project Proposal
17	Meet with Client



Matt

References

1. http://www.engineershandbook.com/Tables/frictioncoefficients.htm
2. http://www.engineersedge.com
3. http://www.alibaba.com
4. Shigley's Mechanical Engineering Design, 9th Edition.
5. http://www.tcdcinc.com
6. http://www.engineeringtoolbox.com/friction-coefficients-d_778.html

Matt