Detailed Tilt Resistance

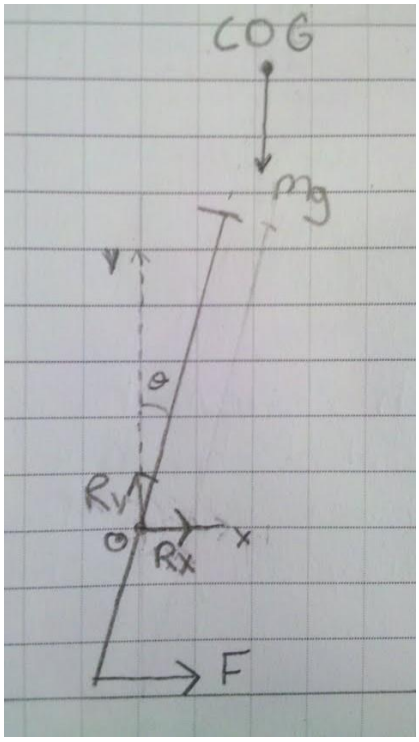
This concept utilizes a spring – damper system with each component in parallel. We will be using an off the shelf device to achieve this. We will be taking advantage of a bike shock which has adjustable qualities for both the spring and the damper.

How it works:

Spring-Damper systems are composed of what the name suggests. A spring works by displacement, meaning that the more the spring extends or compresses the more a force is applied. A damper on the other hand works with velocity. The faster an object is moving the more force a damper applies.

Governing Equations:

All the equations were achieved from the free body diagram of the bike. The mass of the bike was assumed negligible compared to the mass of the person on the bike. Therefore it isn't in any equation.



Spring Portion

$$F_s = \frac{mg(b+c)}{a}\frac{\sin\theta}{\cos\theta}$$

a = distance from pivot point to spring [m]

b = distance from pivot point to seat [m]

c = distance from seat to COG [m]

θ = angle of tilt [degree]

F = spring force [N]

m = mass of person [kg]

g = gravity [m/s^2]

Damping Portion

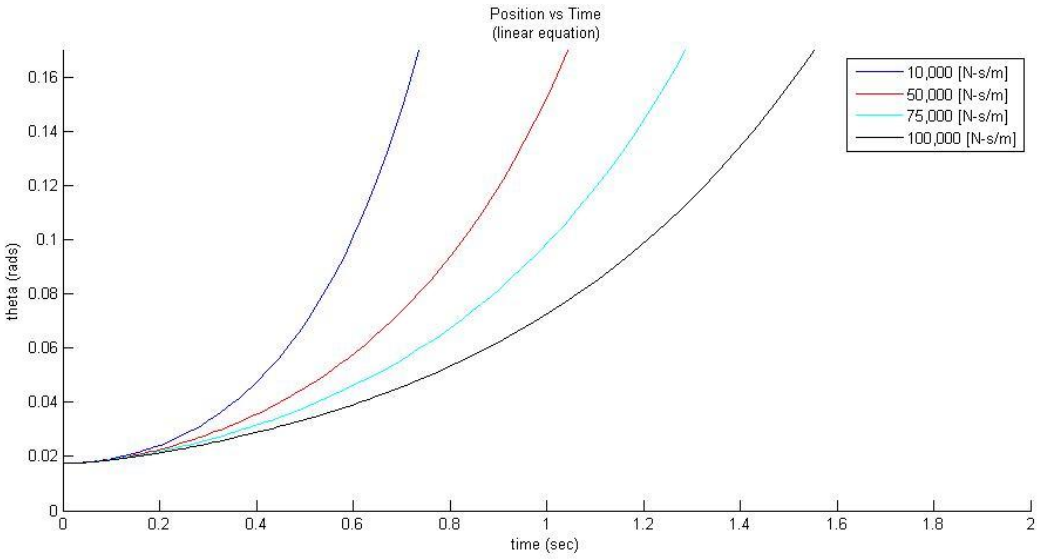
$$F_d = \frac{m(b+c)^2\ddot{\theta} - mg(b+c)\sin\theta}{a\cos\theta}$$

All the variables are the same as in the spring equation

Analysis of spring and damper:

	No Preload					With Preload (identical elsewise)				
Travel Distance (in)	0.654498	0.654498	0.654498	0.654498	0.654498	0.654498	0.654498	0.654498	0.654498	0.654498
seat to COG (in)	14	18	18	18	18	14	18	18	18	18
pivot to person (in)	16	20	20	20	20	16	20	20	20	20
pivot to spring (in)	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
angle (degree)	10	10	10	10	10	10	10	10	10	10
angle (radian)	0.174533	0.174533	0.174533	0.174533	0.174533	0.174533	0.174533	0.174533	0.174533	0.174533
weight (lb)	100	100	200	250	300	100	100	200	250	300
Preload (in)	0	0	0	0	0	0	0.1	0.9	1.3	1.6
Spring Constant	250	250	250	250	250	250	250	250	250	250
Total Force from person on Spring @ full tilt	139.6263	176.86	353.7201	442.1501	530.5801	139.6263	176.86	353.7201	442.1501	530.5801
Preload Force	0	0	0	0	0	0	25	225	325	400
Force Remaining after Preload	139.6263	176.86	353.7201	442.1501	530.5801	139.6263	151.86	128.7201	117.1501	130.5801
Force From Spring (based on preloading and deflection)	163.6246	163.6246	163.6246	163.6246	163.6246	163.6246	188.6246	388.6246	488.6246	563.6246
Net Force (+ means bottomed)	-23.9983	13.23541	190.0954	278.5255	366.9555	-23.9983	-11.7646	-34.9046	-46.4745	-33.0445
Weight(force) needed to shift back to center	-2.99978	1.306126	18.75942	27.48607	36.21271	-2.99978	-1.16098	-3.44453	-4.5863	-3.26097
% Bodyweigh to Shift	-2.99978	1.306126	9.379709	10.99443	12.0709	-2.99978	-1.16098	-1.72226	-1.83452	-1.08699

This is a picture of the calculations for just the spring portion using a 250 lb/in spring rate.



This is a graph of position vs. time for various damping coefficients

The Device:

Manitou Metel R Bike Shock

Dimensions:

Length	222mm (~8.75in)
Weight	350 g
Spring	Coil
Spring Rate	350 [lb/in]
Shaft Diameter	12.7mm (damper)

Features

- Adjustable knob to vary the damping power
- Adjustable spring preload

Advantages:

- Simple to operate
- All one piece that can be bought off the shelf
- Adjustable spring length to vary compression force
- Adjustable damping
- Fairly cheap
- Simple to operate. Very little training required.
- Requires no additional modifications to make this device function as needed.
- Short lead-time: 3-5 days.

Disadvantages:

- Requires mounting apparatus
- Only works in compression. Need to make an extender so it won't break in tension
- Time needed to weld new mounting apparatus and machine extender.
- No damping coefficient given
- Testing required to see if shock will work

Customer Needs Comparison:

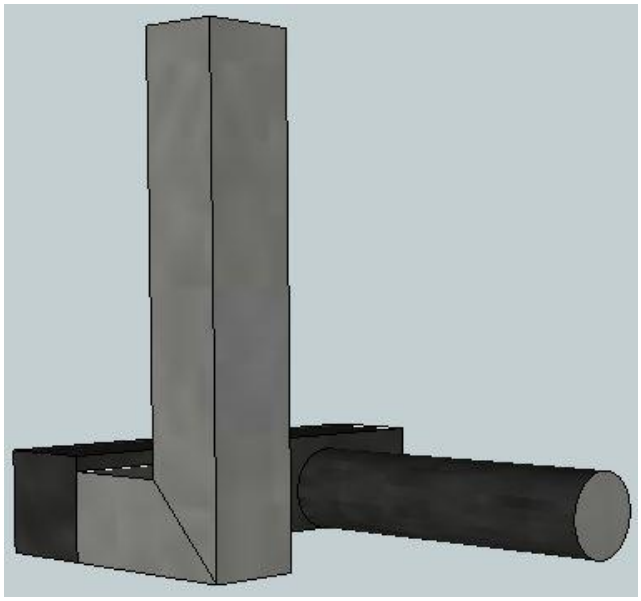
Needs Summary			
Need	**The Product**	**Needs to**	**Importance**
Need 1.1	Tilt Mechanism	Have consistent resistance across a range of motion	9
Need 1.2	Tilt Mechanism	Be adjustable for patient needs	3
Need 3.1	Instruction Sheet	Clear instructions about operation	3
Need 6.1	Bike Frame	Maintain stability	1
Need 7.1	Entire Bike	Keep mechanical noise to a minimum	1

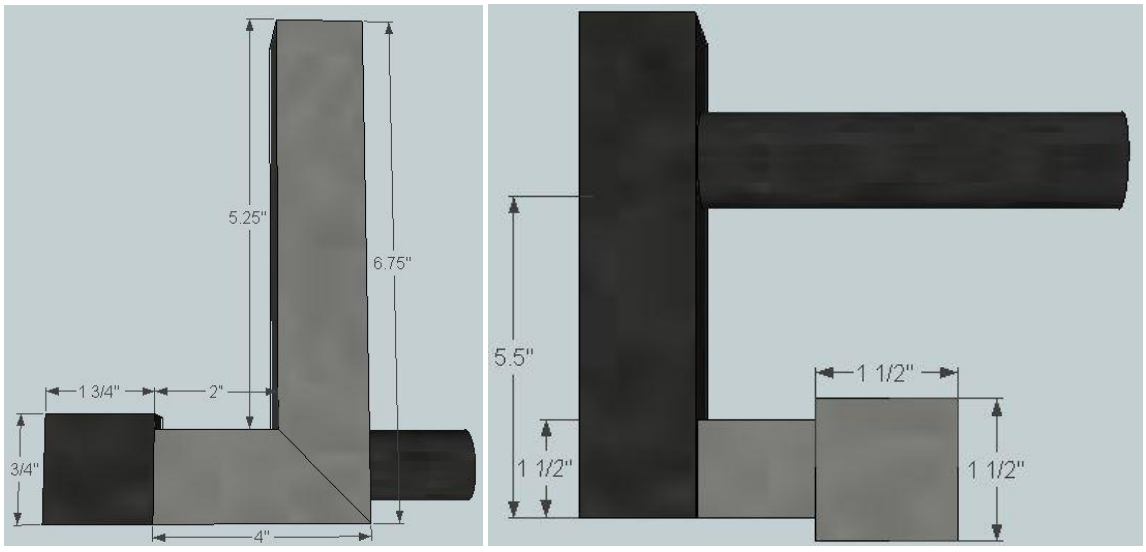
Truncated Customer Needs from Edge

- Because we are using this bike shock we meet the customer needs of a consistent resistance range of motion because of the damper portion.
- It is adjustable as well because both the spring and damper can be adjusted for different preferences.
- Because of the adjustability this is easy to create the instructions without and major explanation.
- This concept is adding to the frame so maintaining bike stability is something we will definitely take into account when adding/modifying the frame.
- This device is also fairly quiet.

Parts Being Made:

Base Addition

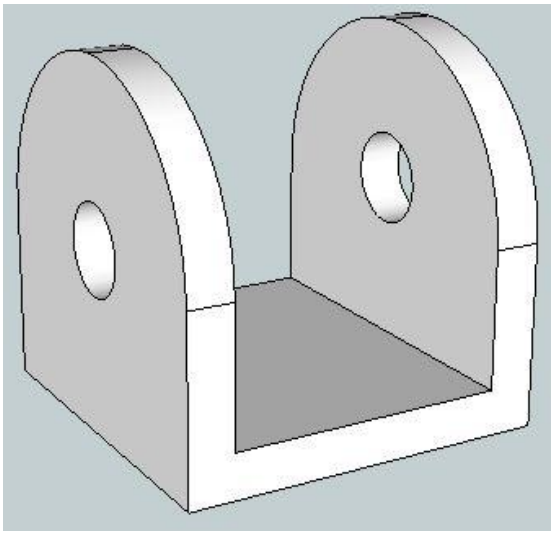


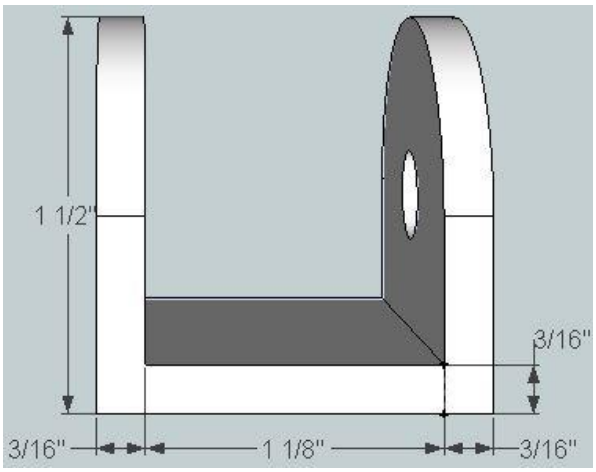


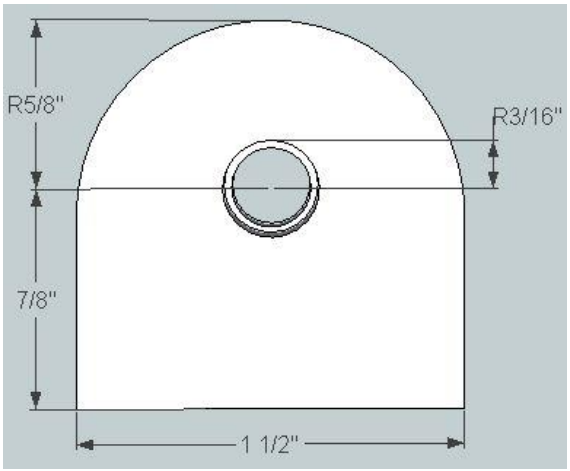
Left is side view, right is top view

This is the mounting apparatus that will be attached to the existing base of the bike. The lighter colored parts are the parts to be added.

Bracket



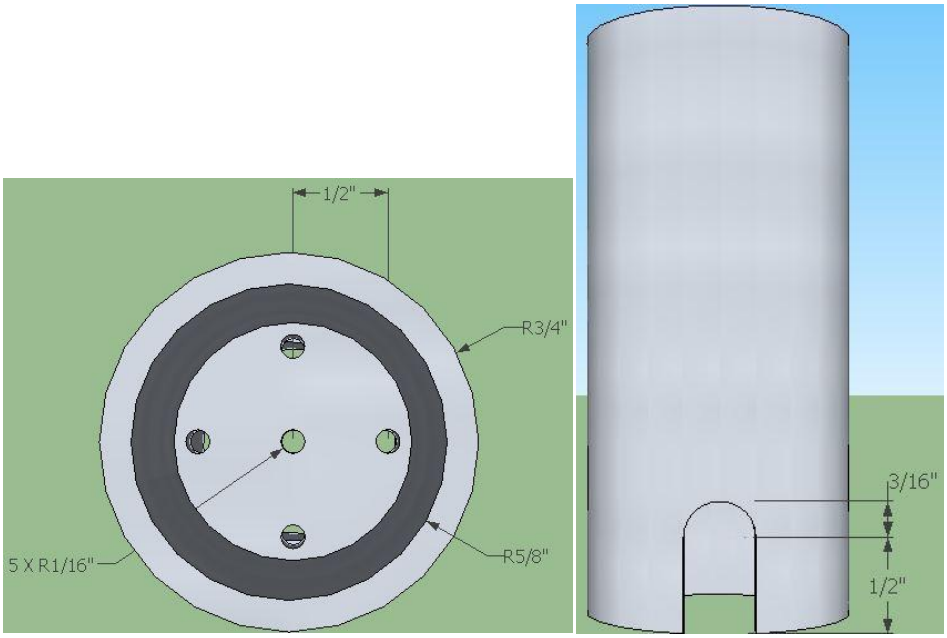




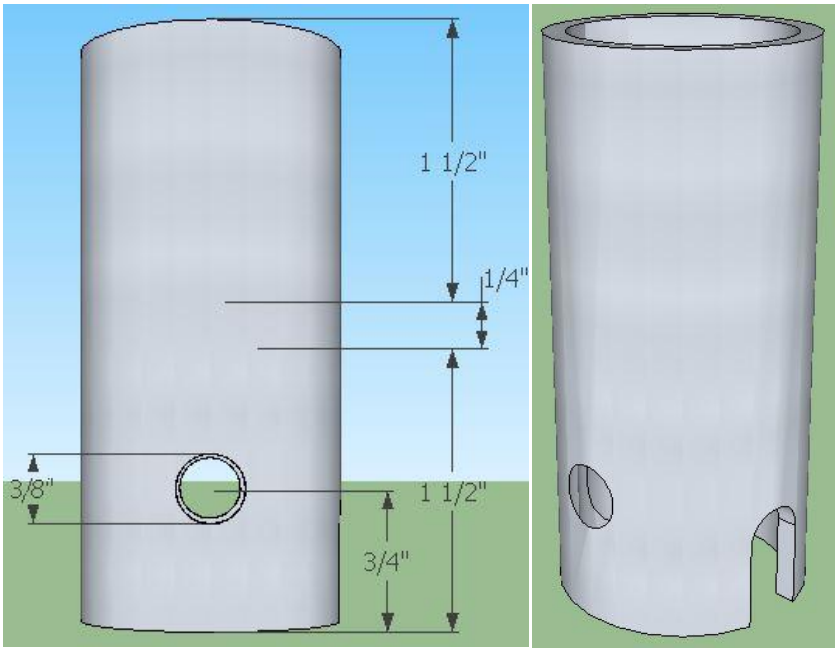
Left is front view and right is side view.

This is the bracket holding the shock part plus extender in place. One of these will be used on each end therefore four of these will be needed. We plan on using extra metal we have from the base addition to create these parts.

Extender



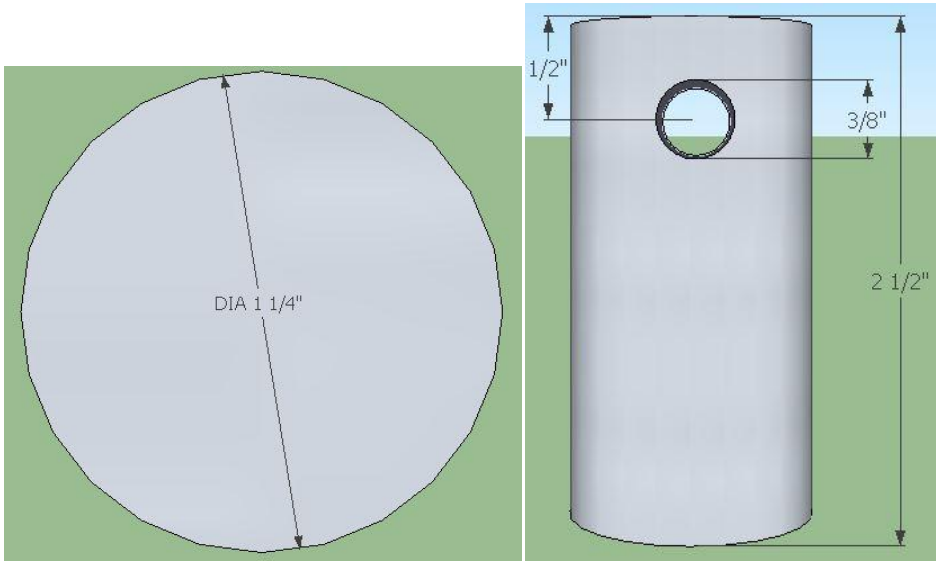
Left is the top view, right is the side view.



Left is the front view, right is the isometric view.

We are planning on machining this out of an aluminum rod with a 1.5” diameter. The bottom end goes around the top of the shock so it can be axially constrained to prevent buckling. There is going to be an aluminum rod inserted into the top that can move in and out allowing the shock not to break while in tension.

Piston



Left is the top view, right is the side view.

This is the part being inserted into the top of the extender. The hole here will be attached to the bracket via a pin. Since the bike is only going to move about 0.35” this is more than enough distance such that the piston will not fallout of the extender.

Bill of Materials:

Amount of Material	Price	Object	Where
4 feet	$82.23	1-1/2” 304 Steel Square Piping	Speedymetals.com
1 foot	$14.68	1-1/2” Rd 2024-T3 Aluminum	Speedymetals.com
2 shocks	$206.60	Shocks (w/shipping)	Chainreationcycles.com
Total	$253.51		