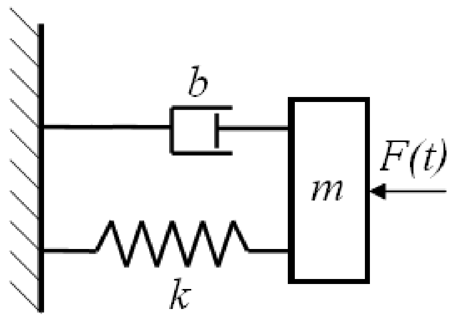
Tilt Resistance Concept

Description: This concept uses a spring and damper system to control the tilt speed and help the patient back upright again.

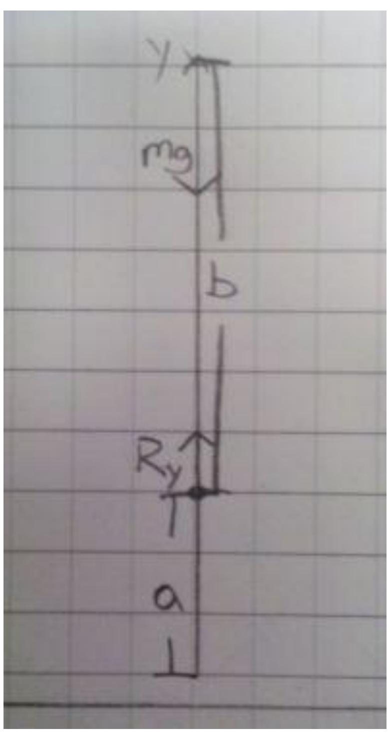


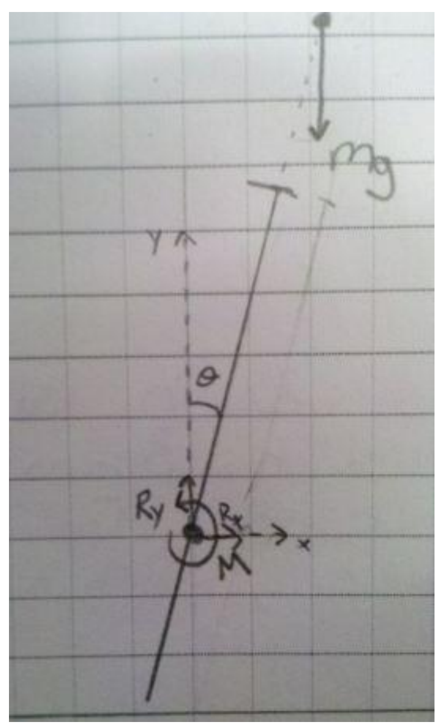
Picture of a spring damper system (found at www.maplesoft.com)

How it works:

- The damper portion is used to slow the momentum of the rider to give a gradual feeling to the tilt.
- The spring portion helps return the bike back to the upright position by using the stored energy to assist the rider.

Free Body Diagram:





The left picture is when the bike is upright and the right picture is when it is tilted at angle θ

Where:

a = length of bike from spring-damper location to pivot point

b = length of bike from pivot point to seat

c = length of bike from seat to persons center of gravity

θ = tilt angle

m = mass of the person

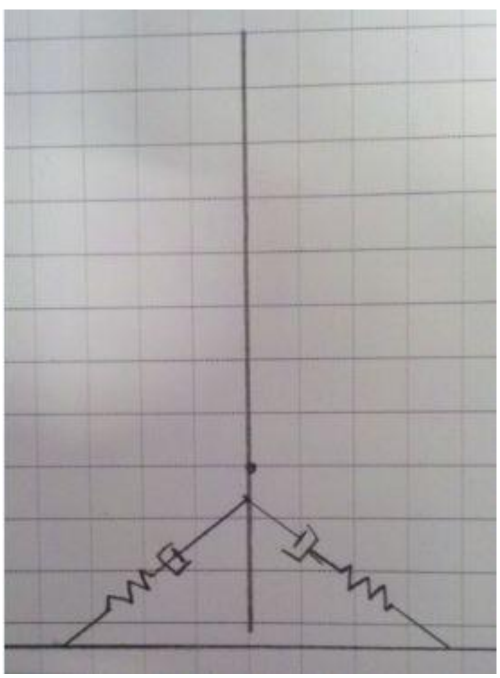
Summing the moments the equation for the moment around the pivot point is:

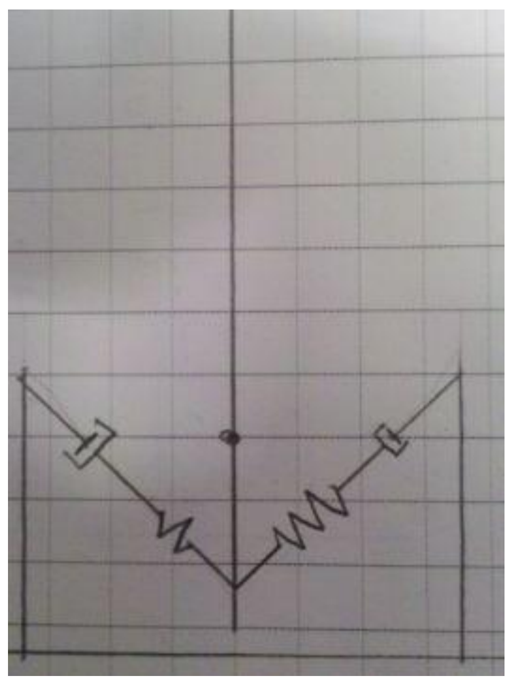
$$M = (b + c)mg\cos(90 - \theta)$$

Since the spring-damper system is needed to keep the moment around the pivot point zero for a maximum condition then the force (F) associated is:

$$F = \frac{(b + c)}{a}mg\cos(90 - \theta)$$

<u>Set up variations</u>:





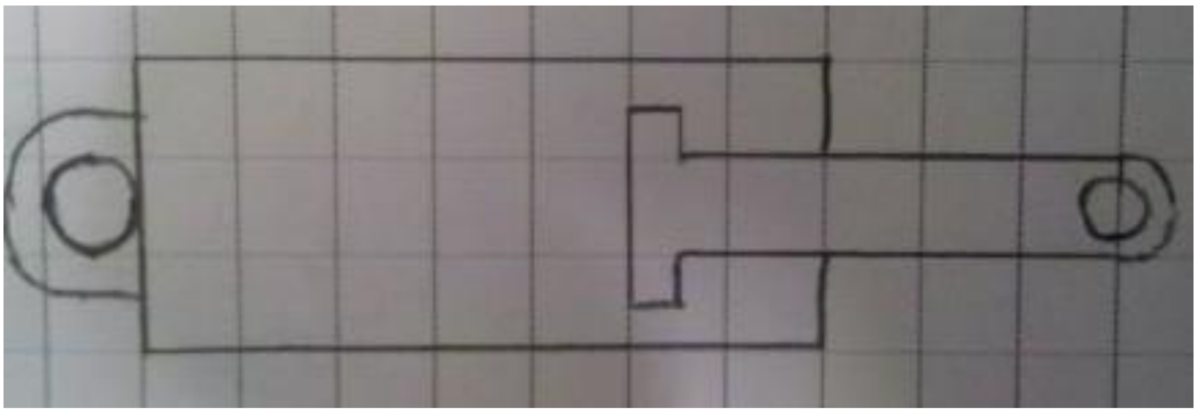
The picture on the left is the way we can set it up now by just replacing the rubber cords with the spring damper system. The set up on the right is a way to maximize the force exerted by the spring-damper system at a maximum deflection of 15 degrees.

Choice of spring-damper system:

We are choosing a bike shock to give us the desired force needed. The bike shock will be adjustable so the resistance could be adjustable.

Modifying the bike shock:

Since a bike shock only works in compression to prevent the shock from breaking in tension we plan on using a sliding tube to be able to extend when needed.



Advantages:

- Does what we need in a simple but efficient way
- The damper gets rid of the slack in resistance at the top that was a problem for the customer.
- Off the shelf parts not much needs to be fabricated
- Simple adjustability built in

Disadvantages:

- Cost is expensive
- There are exposed pinch points that can harm the patient or physical therapist

Mathematical Analysis:

Metrics	No Preload					With Preload (identical elsewise)				
Travel Distance (in)	0.61087	0.61087	0.61087	0.61087	0.61087	0.61087	0.61087	0.61087	0.61087	0.61087
seat to COG (in)	14	18	18	18	18	14	18	18	18	18
pivot to person (in)	30	36	36	36	36	30	36	36	36	36
pivot to spring (in)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
angle (degree)	10	10	10	10	10	10	10	10	10	10
angle (radian)	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453
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	350	350	350	350	350	350	350	350	350	350
Total Force from person on Spring @ full tilt	218.301	267.914	535.829	669.786	803.743	218.301	267.914	535.829	669.786	803.743
Preload Force	0	0	0	0	0	0	35	315	455	560
Force Remaining after Preload	218.301	267.914	535.829	669.786	803.743	218.301	232.914	220.829	214.786	243.743
Force From Spring (based on preloading and deflection)	213.803	213.803	213.803	213.803	213.803	213.803	248.803	528.803	668.803	773.803
Net Force (+ means bottomed)	4.49773	54.1115	322.026	455.983	589.94	4.49773	19.1115	7.02583	0.98299	29.9402
Weight(force) needed to shift back to center	0.35777	3.50723	20.872	29.5545	38.2369	0.35777	1.23871	0.45538	0.06371	1.94057
% Bodyweigh to Shift	0.35777	3.50723	10.436	11.8218	12.7456	0.35777	1.23871	0.22769	0.02549	0.64686

According to the above analysis, a spring with the following specifications should work:

Spring rate: 350 lb/in

Preloadability: 2+ inches