Spring Calculations Summary: Slowing/Braking and Locking Design

Spring calculations are necessary to determine which properties are needed for the spring in our braking/slowing mechanism in order to slow the user to an appropriate speed before the pin locks the user in place. The spring is needed to apply a vertical, downward force onto the stationary wood surface (which may be coated to increase friction if necessary) in order to allow the rubber piece to slow the user, as well as to push the entire mechanism into the hole to auto-lock the user in place at port and starboard positions, 180^0 away from each other.

The calculations were performed starting with an assumed circular diameter of 22", or a radius of 11". Using the equation

$$S = \theta r$$

and using the known value of π for the angle θ, the arc length, S, was found to be 2.880 ft.

Next, the force of friction, F_f, was calculated using the formula

$$F_f d = mgh$$

where
$d = S$
mg = combined weight = 300lb$_f$
h = height = diameter*sin θ, and assuming $\theta = 22.5^0$ (an extreme heel angle)

Once F_f is known, it can be used in conjunction with the formula

$$F_f = \mu F_N$$

where
μ = coefficient of friction (lookup value for materials)

to solve for the normal force, F_N. Lastly, this value can be used, given the formula

$$F_s = kx = F_N$$

to solve for the necessary spring constant, k, to completely stop the person using the friction force. If this occurred, the person would be at zero velocity just as the locking pin locked itself in place, meaning the pin would not actually provide any of the stopping force.

However, in actuality, it is okay for the pin itself to do some of the stopping force, as long as the jolt it provides in stopping is not significant. This was taken into account when analyzing the numbers in the spring calculations, as the selected spring will not completely stop the person. However, especially by increasing the friction force by increasing the coefficient of friction by coating the wood in rubber ($\mu = 1.16$ for rubber on rubber versus .7 for rubber on wood) we are confident that the chosen spring will provide enough of a slowing effect in order for the pin stop to be at a reasonable force.

Summary of Spring Values

θ **deg**	**θ** **rad**	**$F_f d=mgh=mgd\sin\theta$** **F_f [lb$_f$]**	**μ** **[]**	**$F_f=\mu F_N$** **F_N [lb$_f$]**	**x** **[in]**	**$F_s=kx=F_N$** **k [lb/in]**
45	0.785	134.797	0.7	192.567	0.25	770.269
22.5	0.393	72.952	0.7	104.217	0.25	416.866
15	0.262	49.339	0.7	70.484	0.25	281.938
45	0.785	134.797	1.16	116.204	0.25	464.817
22.5	0.393	72.952	1.16	62.889	0.25	251.557
15	0.262	49.339	1.16	42.534	0.25	170.135

The selected spring to use has a k-value of 157 lbs/in. Although this is below even the best calculated value for spring constant, k, we are confident that this spring will provide enough slowing force to allow the pin to lock into place relatively gently.

According to previous calculations, the max speed the user will travel when at a heel angle of 45^0 (a virtually unrealistic and unobtainable worst-case scenario heel angle) is 5.875 ft/s or 4.00 mph. This would take .49 seconds for a full, 180^0 travel. With our proposed slowing, this speed and force would be considerably lower (even 4.00 mph is only the speed of a quick step.) This further enhances our confidence in this spring selection for this slowing/braking and locking mechanism.