INVESTIGATION AND OPTIMIZATION OF A MECHANICAL REGENERATIVE BRAKING LAUNCH ASSIST DEVICE

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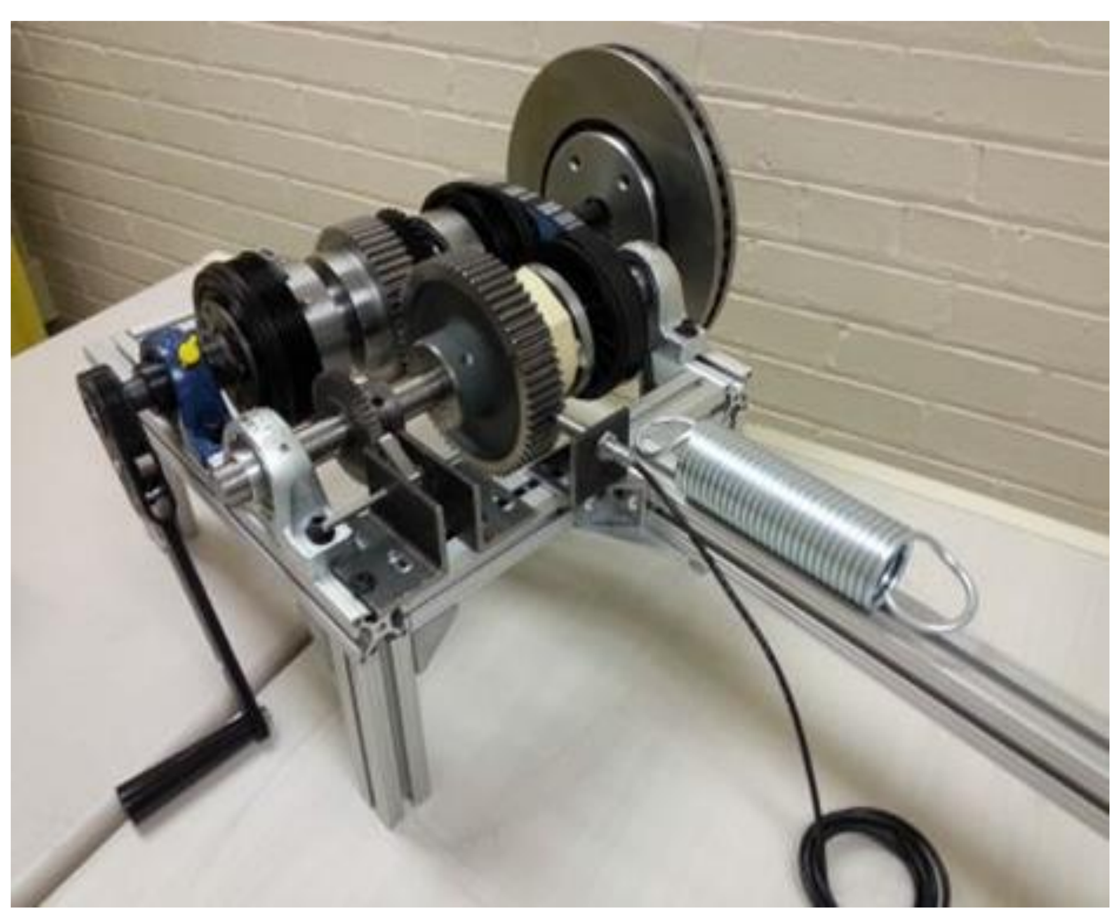
Objective: The goal of this project is to identify ideal spring characteristics for a strain-based, regenerative braking launch assist that is capable of propelling a 2000 pound car at 5 miles per hour.

Motivation

- A regenerative brake and launch assist (RBLA) mechanism has been formulated that uses springs to store energy.
- This project will identify an ideal spring configuration to be used with the mechanism.



Spring-based, RBLA mechanism prototype.

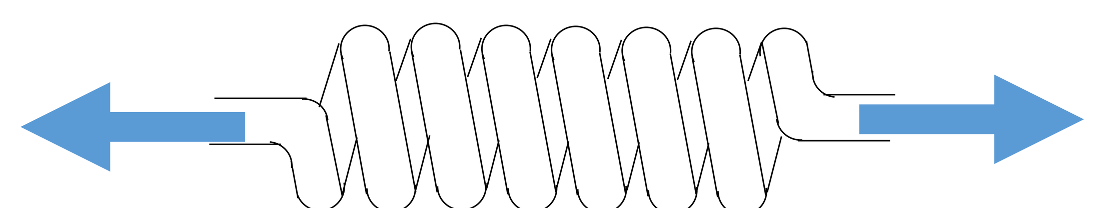
Mechanical properties used

Vehicle mass (m)	2000 lbs
Launch speed (v)	5 mph
Spring index limit	4 - 20
Allowable shear stress (τ)	87 ksi
Allowable normal stress (σ)	130 ksi

Initial Results

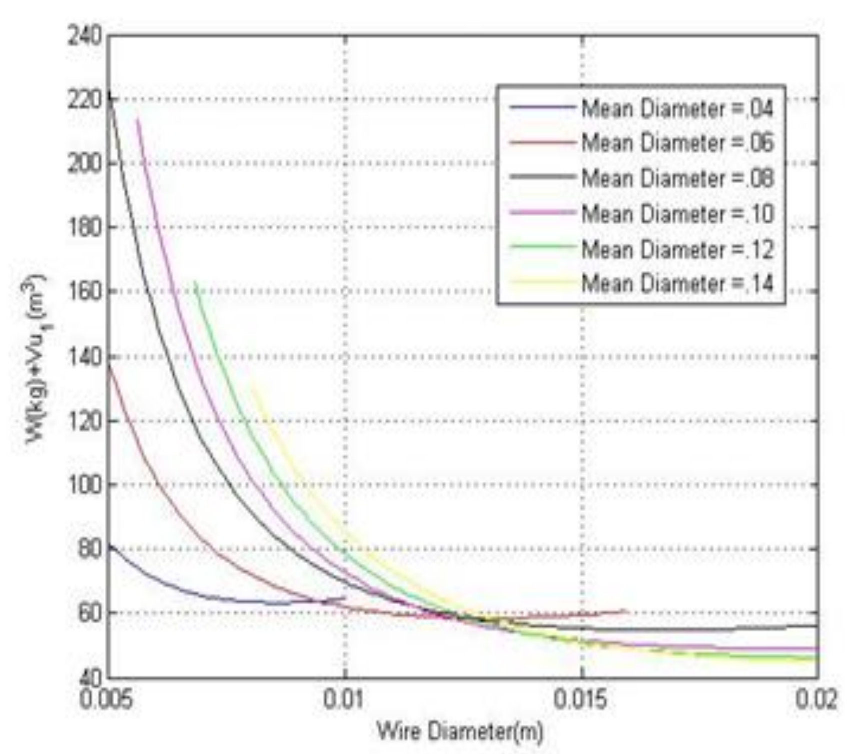
The following plots display the weight, W, and storage volume, Vu, for a spring that stores the necessary RBLA energy using different wire and coil diameter combinations.

For an extension spring:

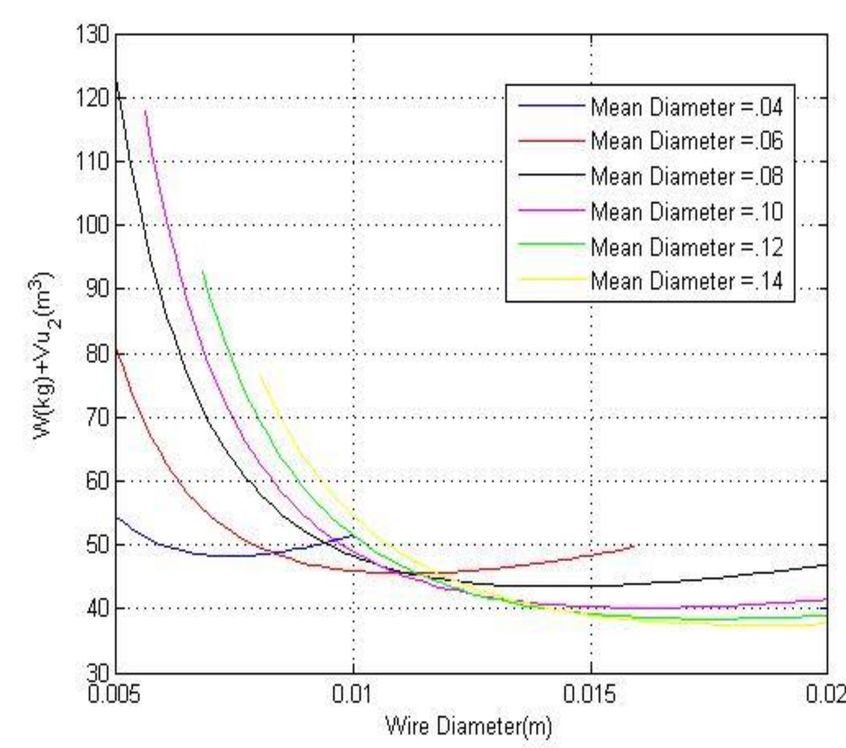


$$Stress, \tau = \frac{8wDF}{\pi d^3}$$

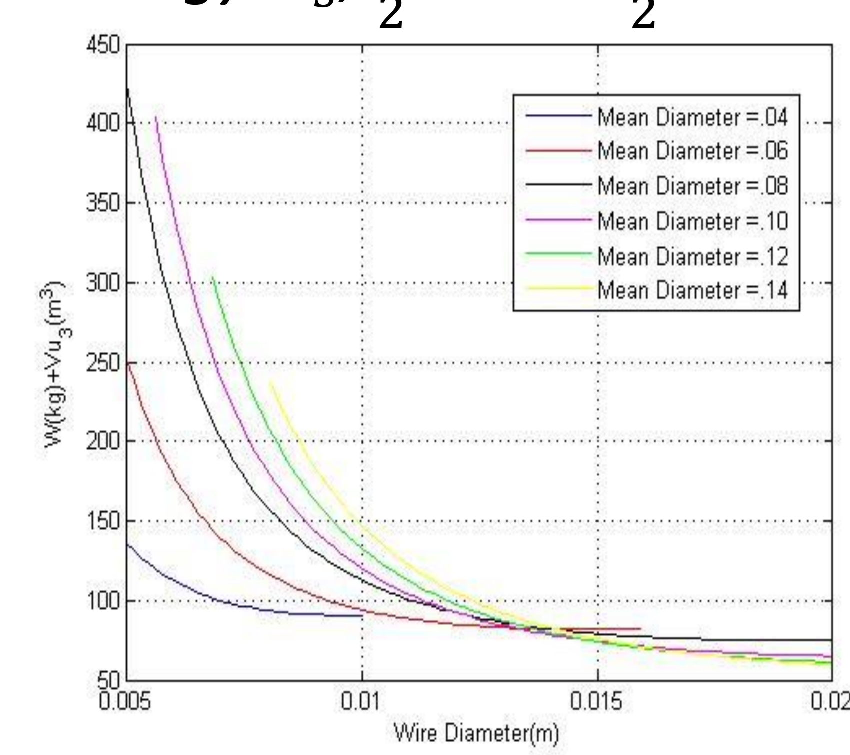
$$Energy\ U_s,\ \frac{1}{2}kx^2 = \frac{1}{2}mv^2$$



At Y_i

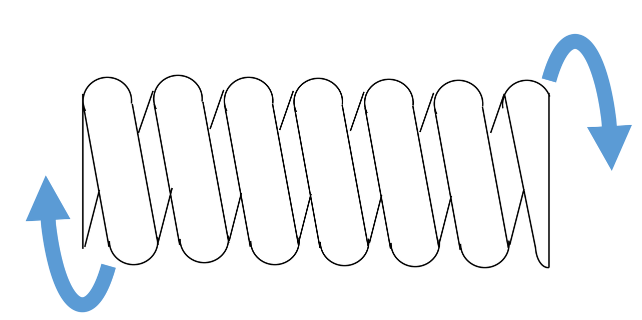


At $0.5Y_i$



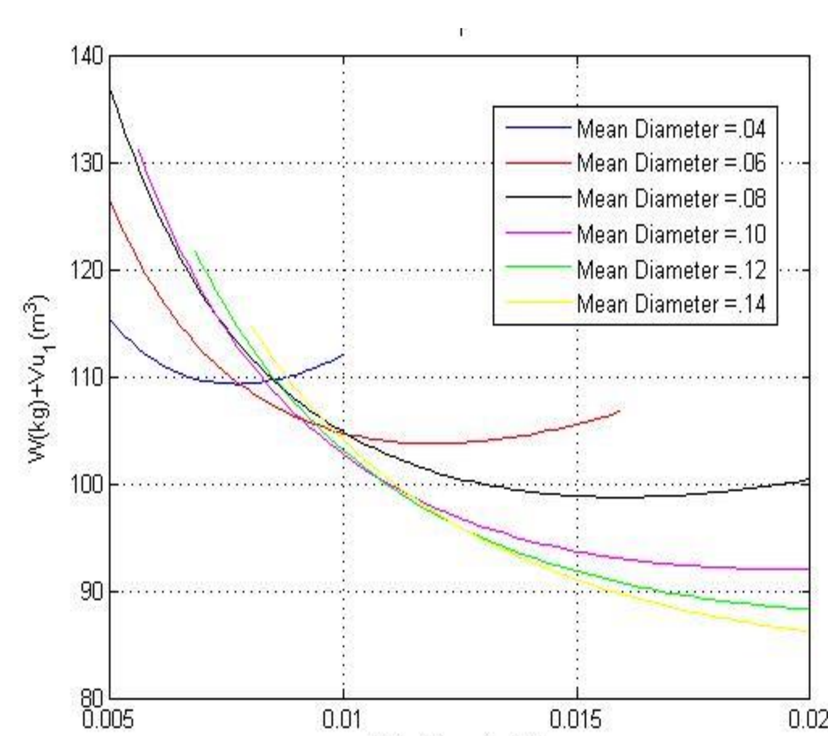
At $2Y_i$

For a torsional spring:

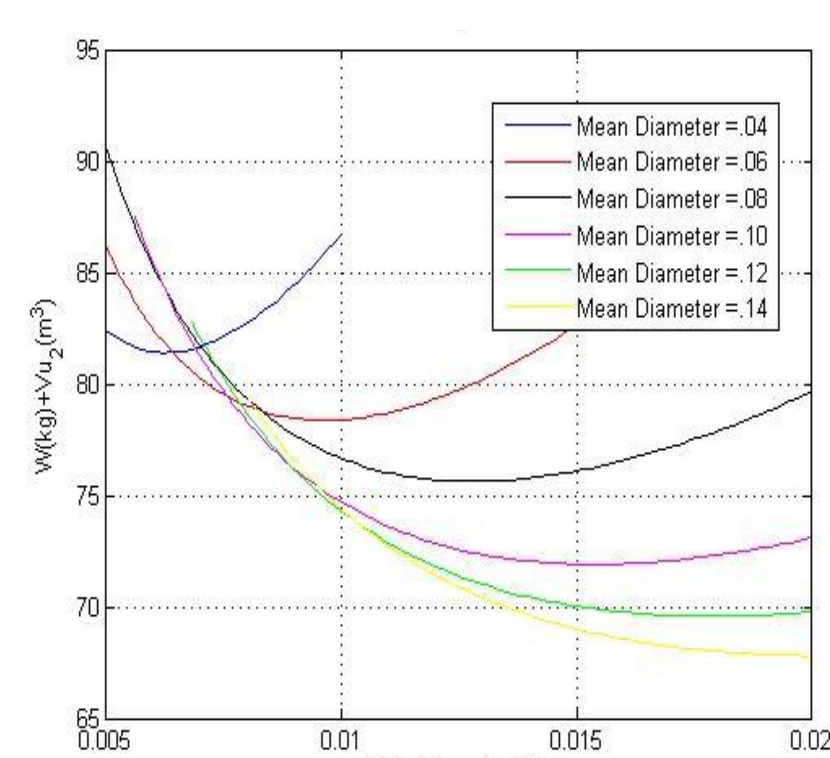


$$Stress, \sigma = k_b \frac{32T}{\pi d^3}$$

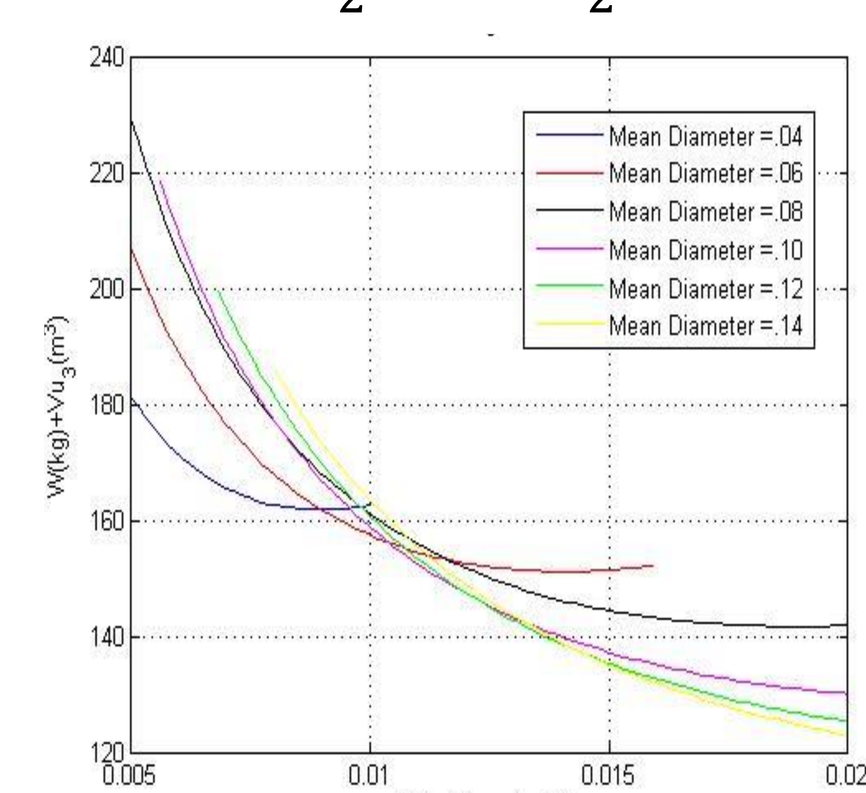
$$Energy\ U_s,\ \frac{1}{2}k\theta^2 = \frac{1}{2}mv^2$$



At Y_i



At $0.5Y_i$



At $2Y_i$

Technique Utilized

- Machine design equations were generated that relate the stiffness(k), stress and energy(U_s) for each spring configuration.
- Optimization involves minimizing both weight and volume of spring while storing energy.
- Pareto front $W + Y(Vu)$ optimization technique used for various Y values to locate minimum.
- Initial values Y_i were selected such that on average, $W = Vu$.
- Extension springs are better than torsion springs.
- Larger wire and coil diameters leads to optimum design.

Future Direction

- To derive equations and create similar plots for spiral and other spring configurations.
- Test the prototype with different springs to assess frictional and hysteresis losses.