Vibrational Analysis of a Bicycle

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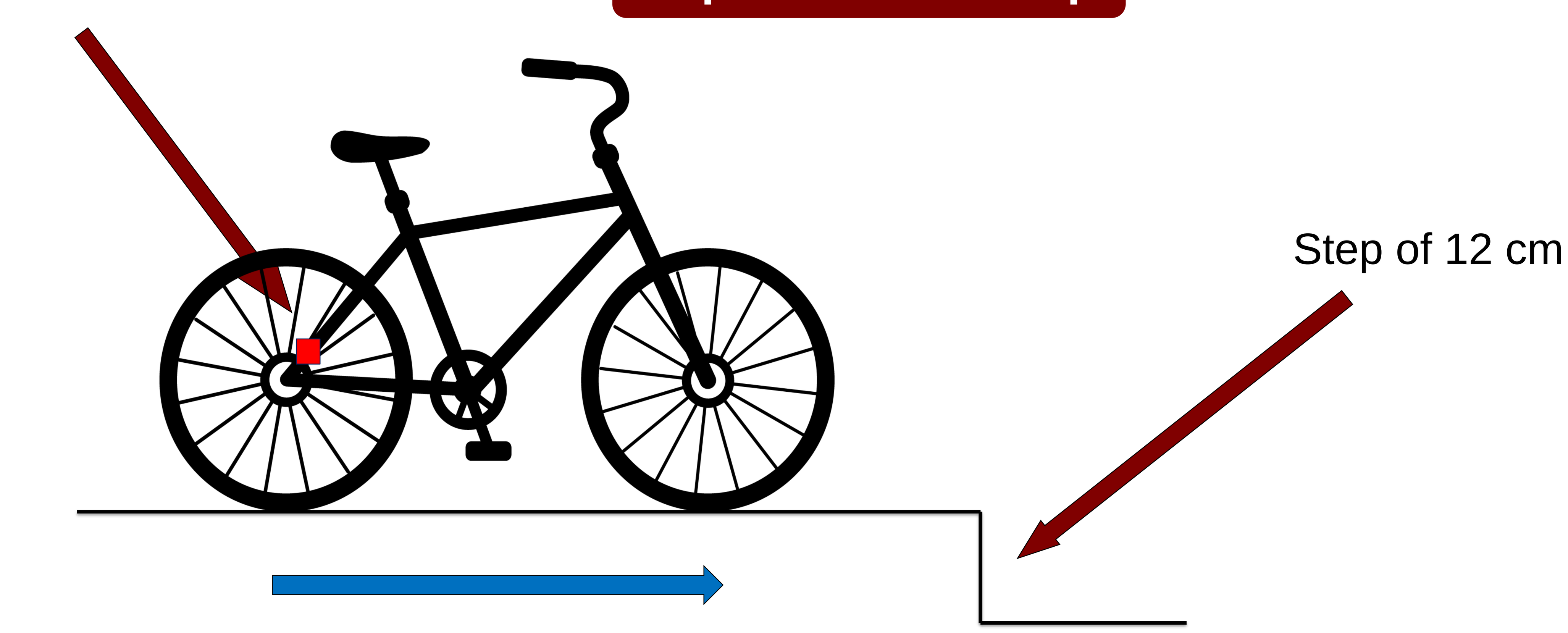
Abstract

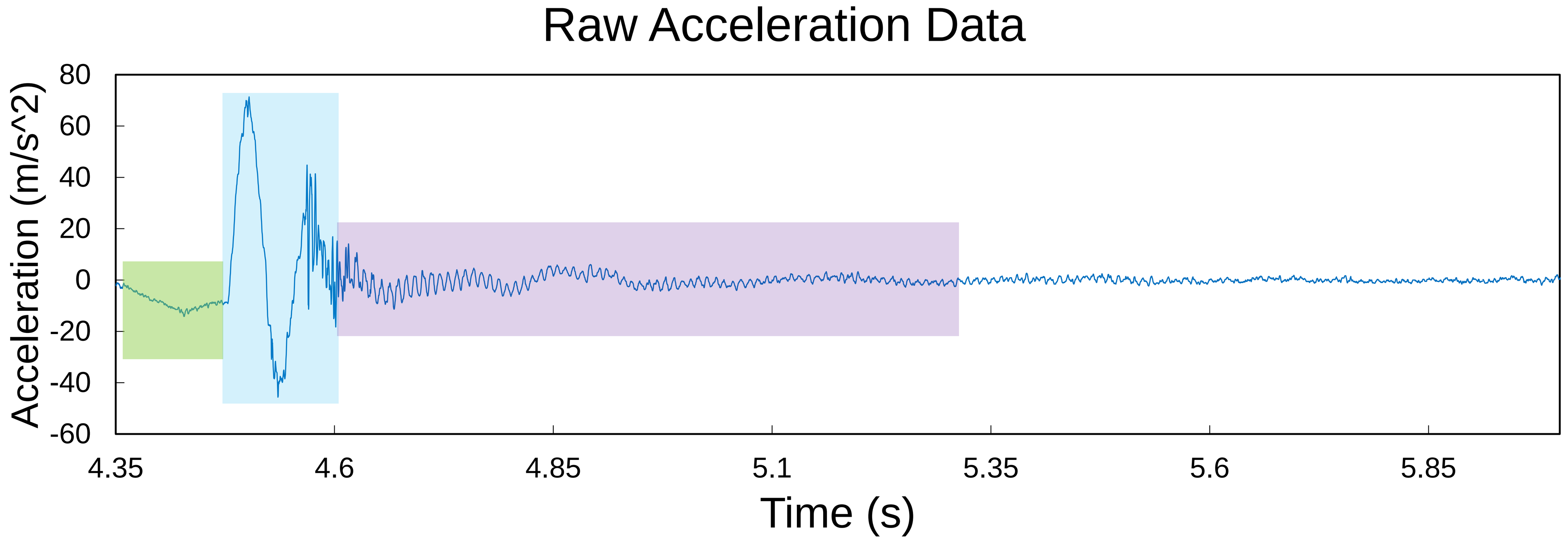
Bicycles don't have a currently known optimal tire pressure which minimizes the settling time of vibrations to give the rider a more comfortable ride. To find this optimal pressure, an accelerometer was attached to the rear of the frame and accelerations were recorded as the bicycle was ridden over a step with different tire pressures. The data was then fitted to obtain the bicycles' response time and damping. These results showed that the damping of the tire decreased linearly with pressure and the bicycle frame flexes and damps the vibrations the same as pressure was increased. This information gave rise to a quadratic response time which was then data fitted to find the minimum response time of 0.98 ± 0.4s at 88kPa.

Introduction/Background

- Excessive vibration in bicycles cause issues such as back pain and carpal tunnel syndrome [1]
- Optimal tire pressure will minimize time of vibration from road imperfections
- Important mechanical characteristics: System response, damping coefficient, response time
- Experiment focuses on rear wheel since most of the mass is loaded on it
- Values in experiment is true for my bike only

Experimental Setup



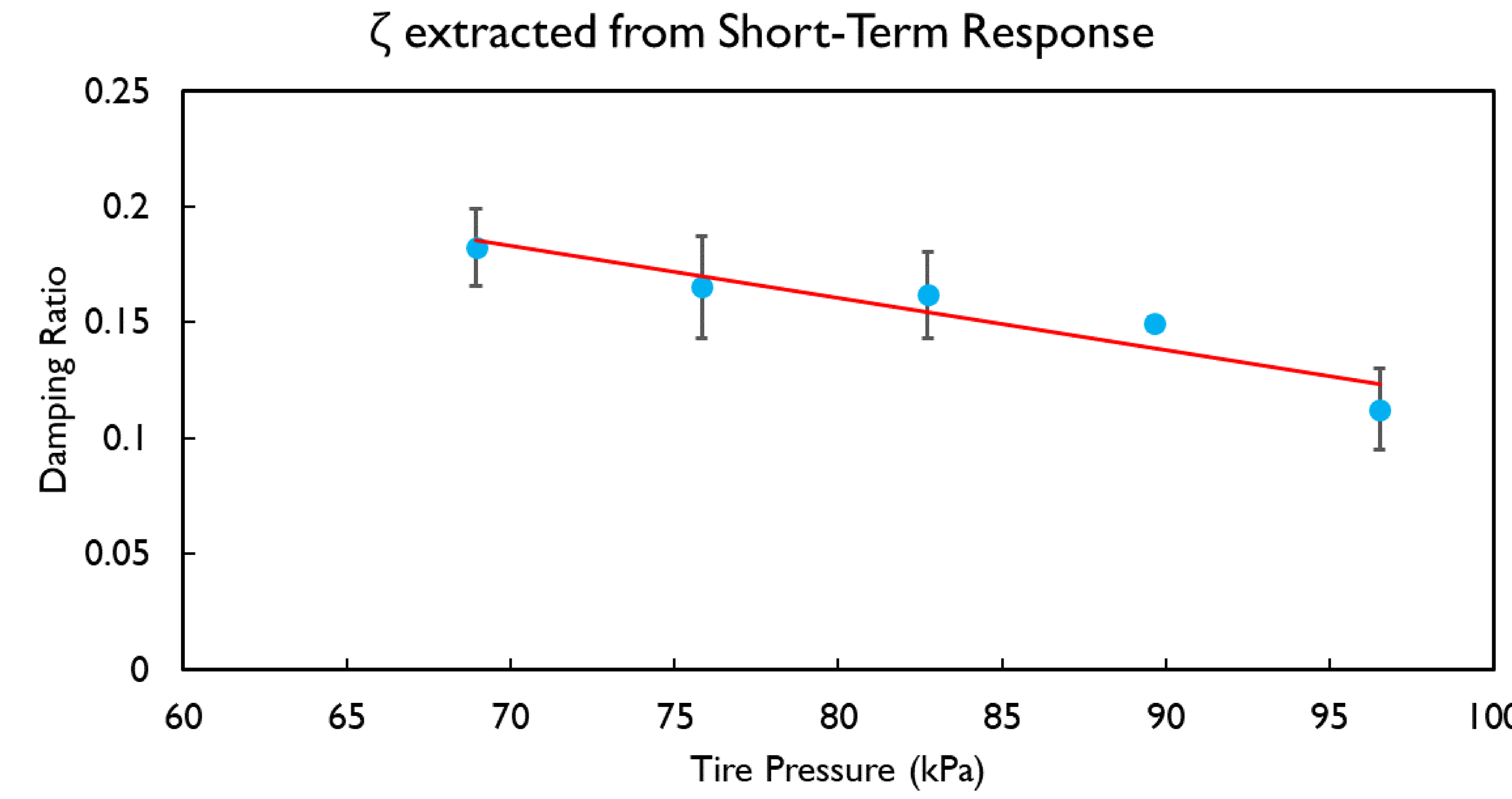


Acceleration: $\ddot{x} = Ae^{-Bt}[(B^2 - C^2)\sin(Ct + D) - 2BC\cos(Ct + D)]$

- $B = \zeta\,\omega_n$
- $C = \omega_d = \omega_n\sqrt{1-\zeta^2}$

- Bicycle falling from step
- Short-Term response
- Long-Term response

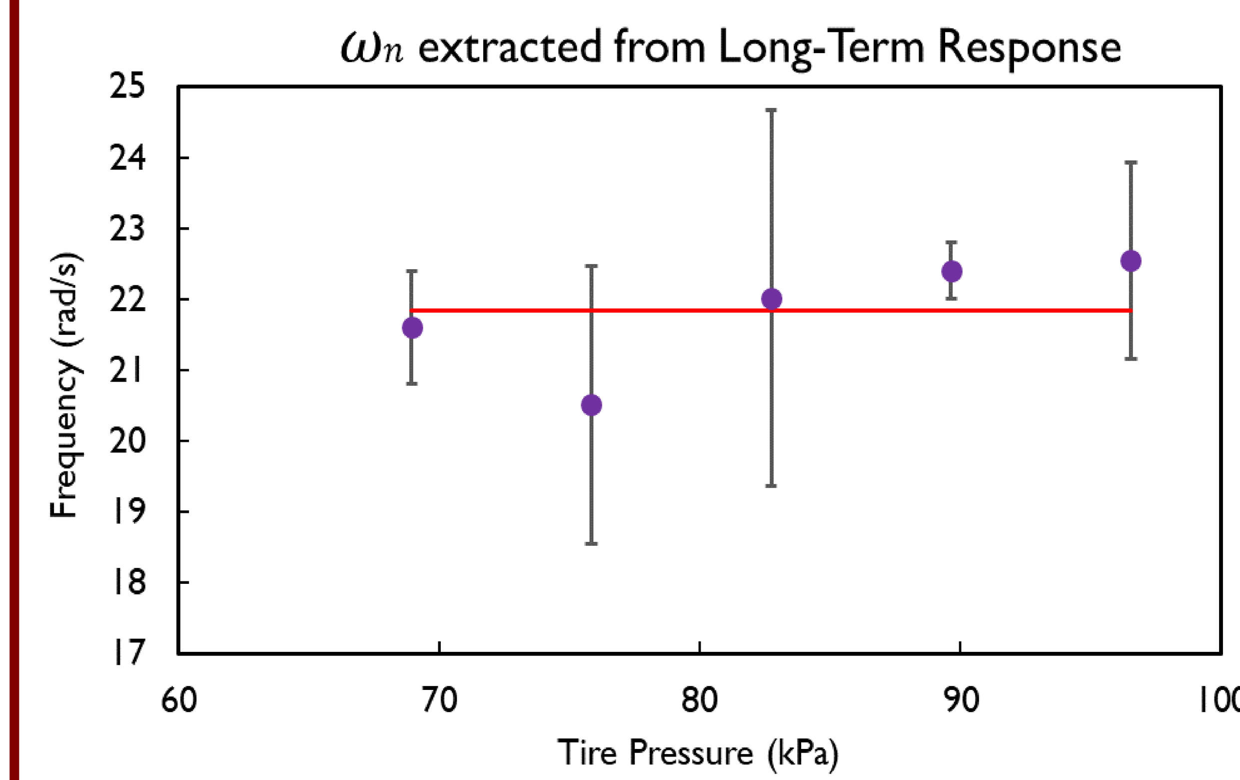
Results

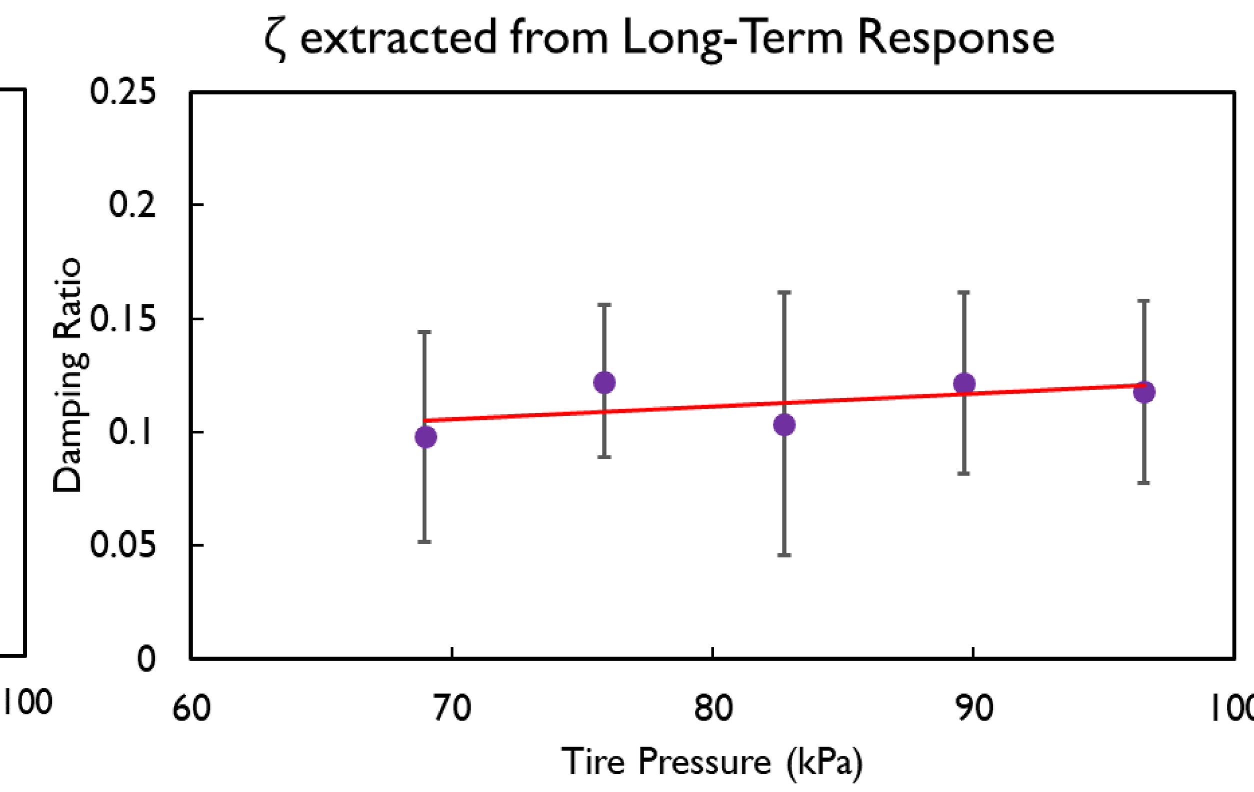


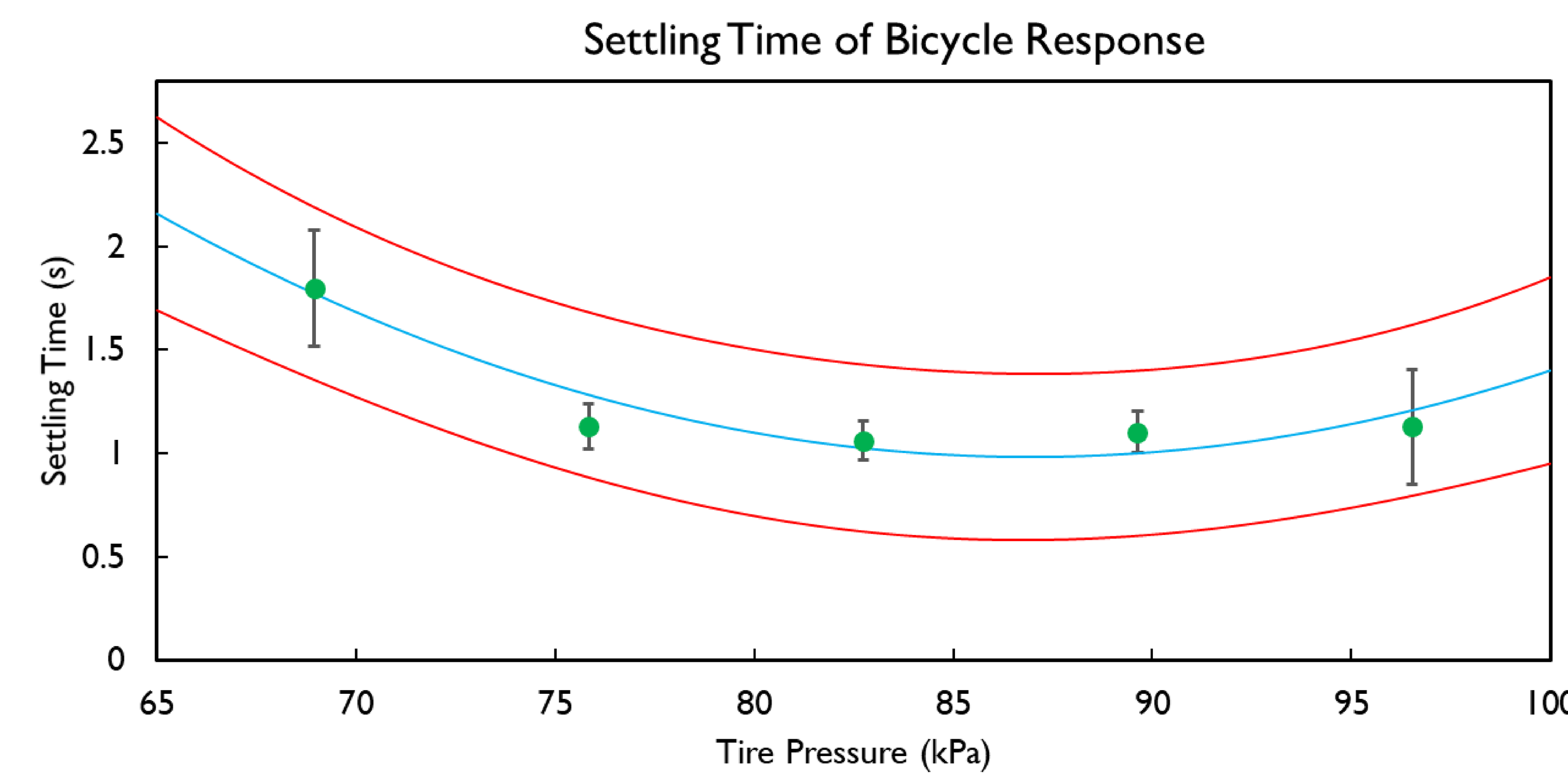
$y = Ax + B$

$A = -0.00226 \pm 0.00064$

$B = 0.341 \pm 0.054$







$Ax^2 + Bx + C$

$A = 0.00245 \pm 0.00092$

$B = -0.43 \pm 0.15$

$C = 19.5 \pm 6.3$

Conclusions

- Short-term response is due to tire oscillation since there is dependence on tire pressure
- Long-term response is due to frame oscillation since there is lack of dependence on tire pressure
- Minimum response time is when the tire and frame responds minimally which is found to be at **88kPa** with a response time of **0.98 ± 0.4s**

Acknowledgements

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References

[1] Arthurs-Brennan, M., 2017, "Common Cycling Injuries: Treatment and Prevention," Cycling Weekly [Online]. Available: https://www.cyclingweekly.com/fitness/common-cycling-injuries-349671. [Accessed: 24-Sep-2019]

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