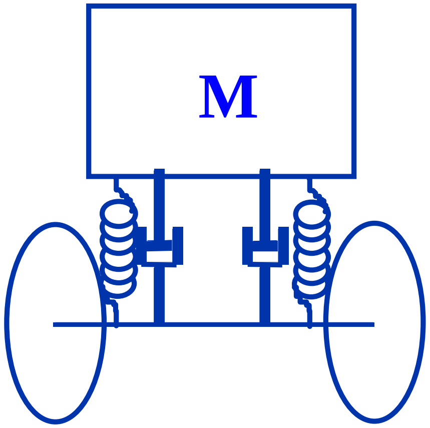
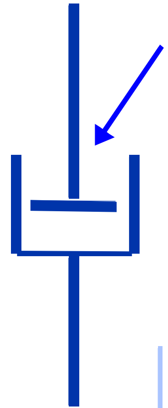
Experiment 3

Construct and test a critical damping system for a spring.





Shock absorber damps oscillations of springs. If overdamped, hard jolts transmitted to mass and recovery is very slow. If underdamped, many oscillations of spring. If damping is just right, we call it critically damped and the return to equilibrium is fastest.

spring constant → k; damping coefficient → b

$$F = -mg - k(y - y_0) - bv$$

equilibrium position = 0

$$ma = -k\left(y - \left[y_0 - \frac{mg}{k}\right]\right) - bv$$

$$\omega_0 = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$ ← damped oscillator frequency

underdamped solution

$$y = y_0\, e^{-\frac{b}{2m}t} \cos(\omega_0 t)$$

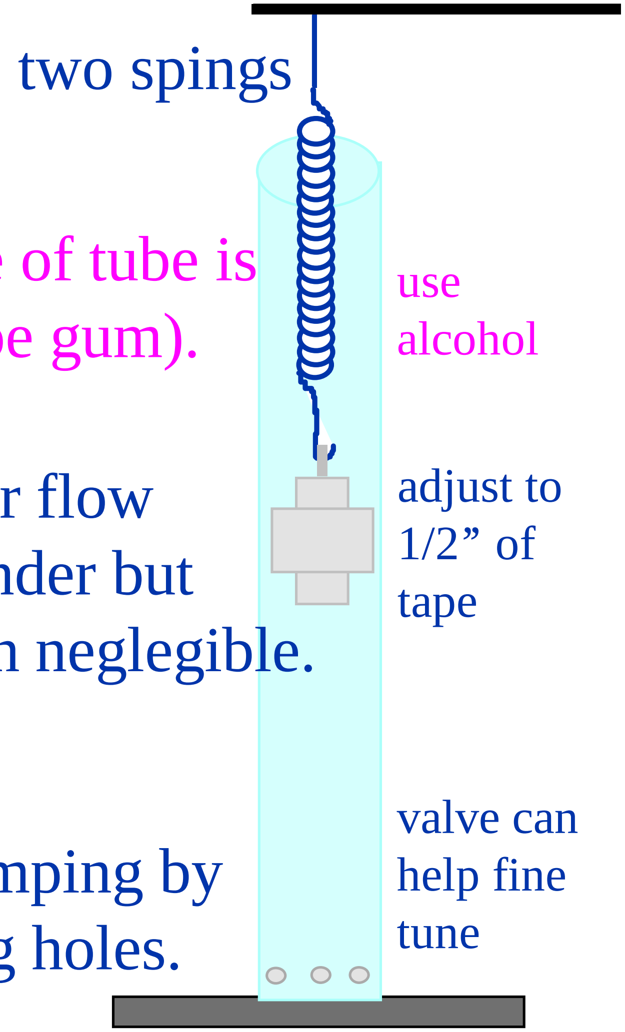
overdamped solution

$$y = y_0\, e^{-\left(\frac{b}{2m} \pm \sqrt{\frac{b^2}{4m^2} - \frac{k}{m}}\right)t}$$

for **critical damping** both of the above reduce to a simple exponential when

$$\frac{b^2}{4m^2} - \frac{k}{m} = 0$$

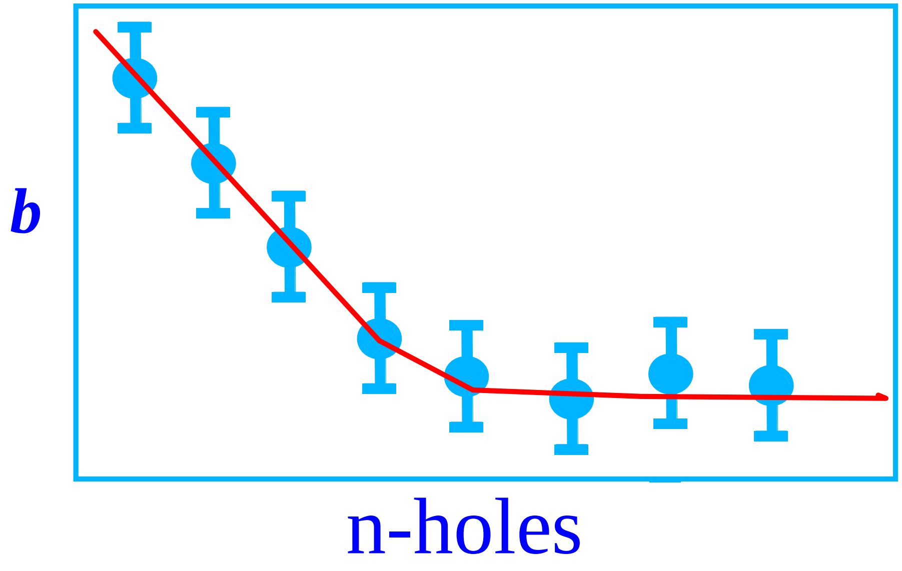
<u>Apparatus</u>



assure inside of tube is clean (no tape gum).

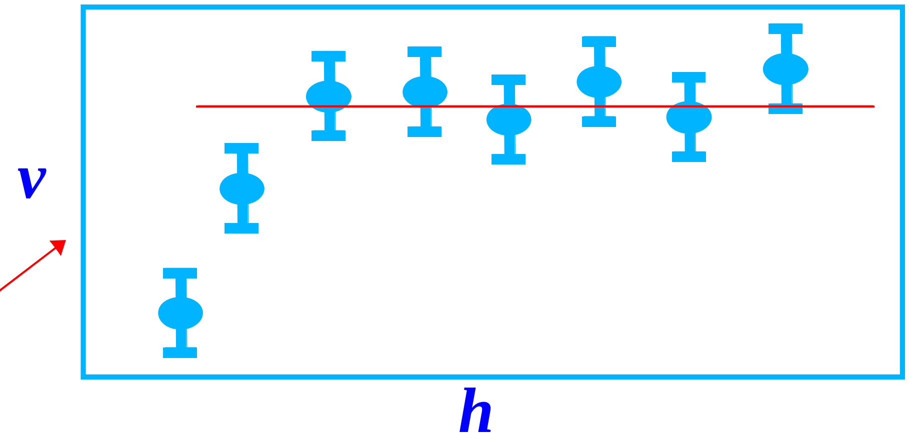
minimize air flow around cylinder but keep friction neglegible.

vary damping by covering holes.

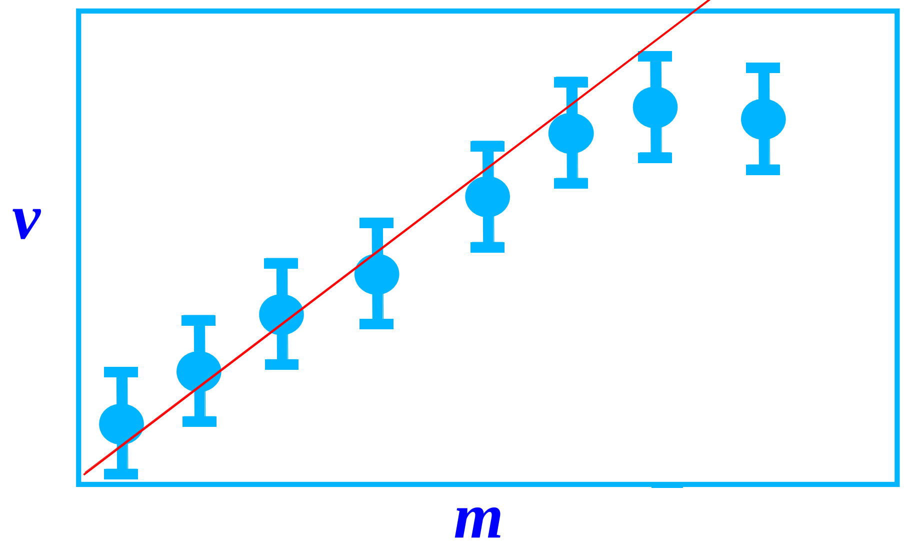


Construct and Test a Critical Damping System for a Spring

- Measure the spring constant *k*.
- Compute the damping coefficient *b* needed for critical damping.
- Adjust the air holes in the shock absorber to get the approximate *b*.
- Confirm *F=-bv* assumption.
- Test spring plus shock absorber combination and optimize for critical damping.
- Present your data well.



Terminal velocity is reached when *bv=mg*.



is damping linear in *v*?