4. Shooting Rubber Band

A Rubber Band may fly a longer distance if it is non-uniformly stretched when shot, giving it spin. Optimise the distance that a rubber band with spin can reach.

Rep: *Nikoloz Burduli*

Plan

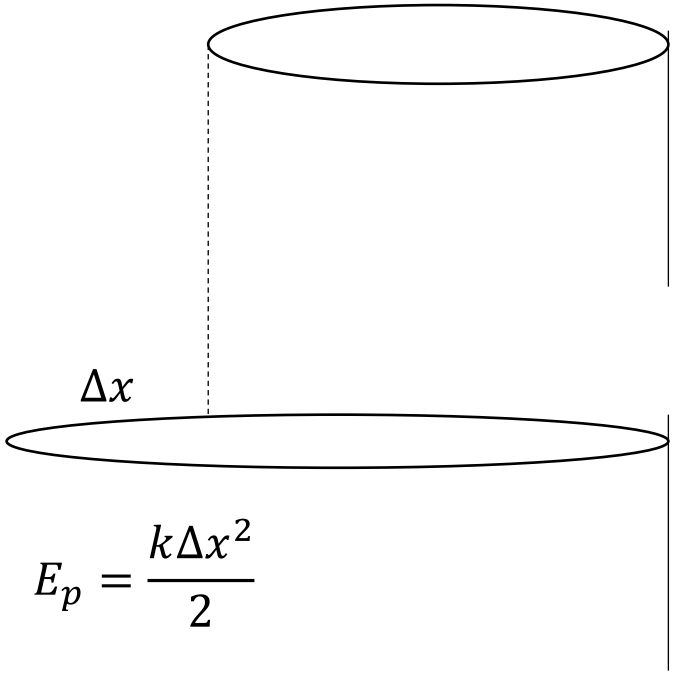
- Explanation of the phenomenon
  - *What is the cause of the rubber shot;*
  - *Why does a spinning rubber go farther;*

- Experimental Part
  - *Experimental setup;*
  - *What problems did we have during the experiments and how did we fix them;*
  - *Tension of the rubber band;*
  - *Distance from the head to the point of tension;*
  - *Determination of rubber stiffness;*
  - *Different rubber bands;*

- Conclusion
  - *Important parameters;*

Explanation of the phenomenon

What is the cause of the rubber shot



$$E_p = \frac{k\Delta x^2}{2}$$

$$E_p = \frac{k\Delta x^2}{2} \longrightarrow E_k = \frac{mv^2}{2}$$

Why does the spinning rubber go farther

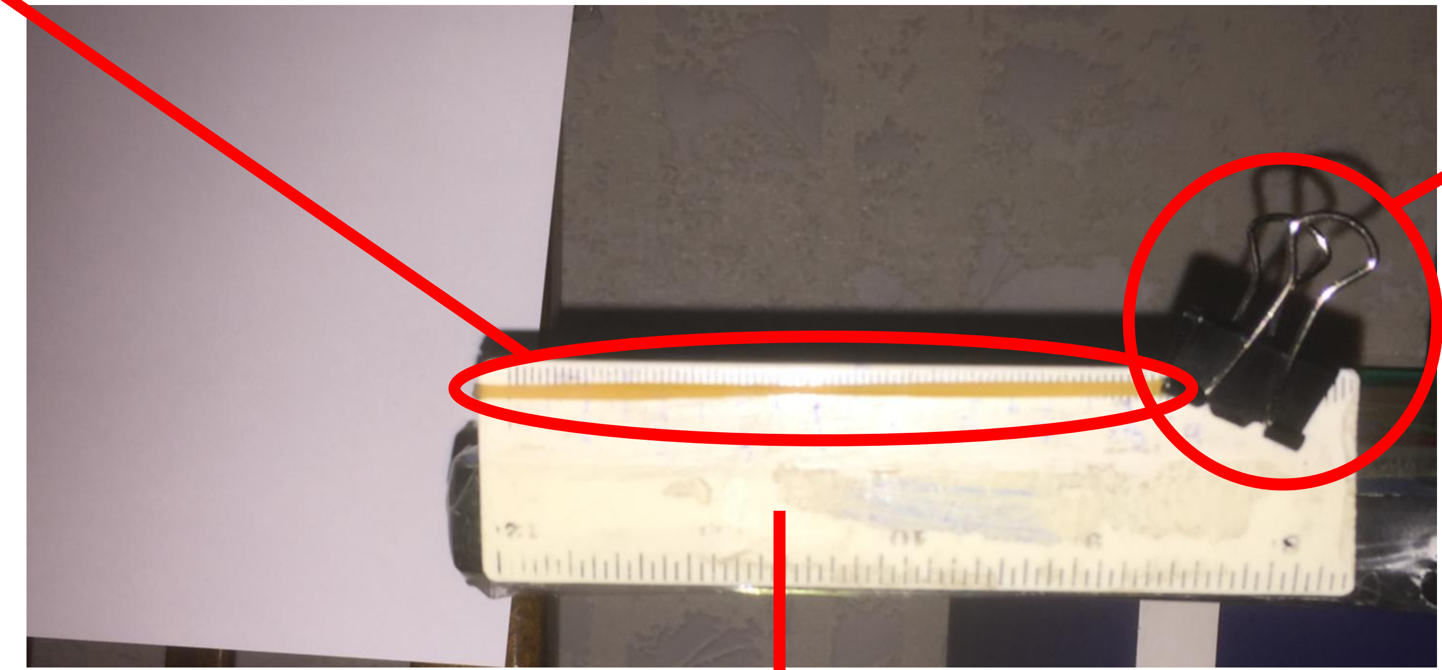
Uniformly

Non-Uniformly

Experimental Part

Experimental Setup 1

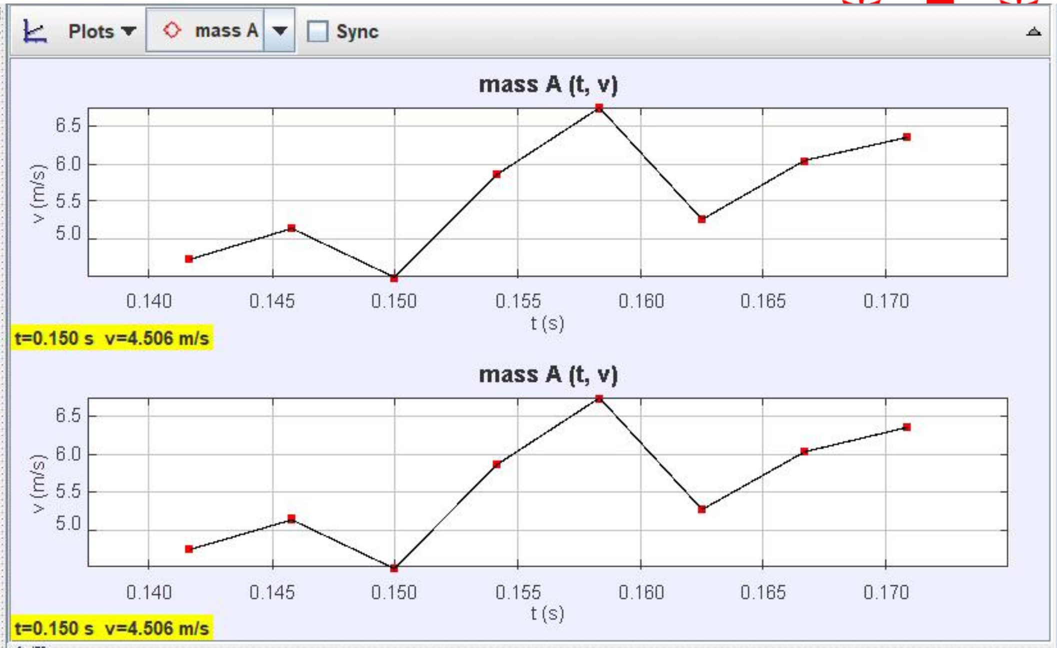
Rubber Band



Shooting Mechanism

Ruler

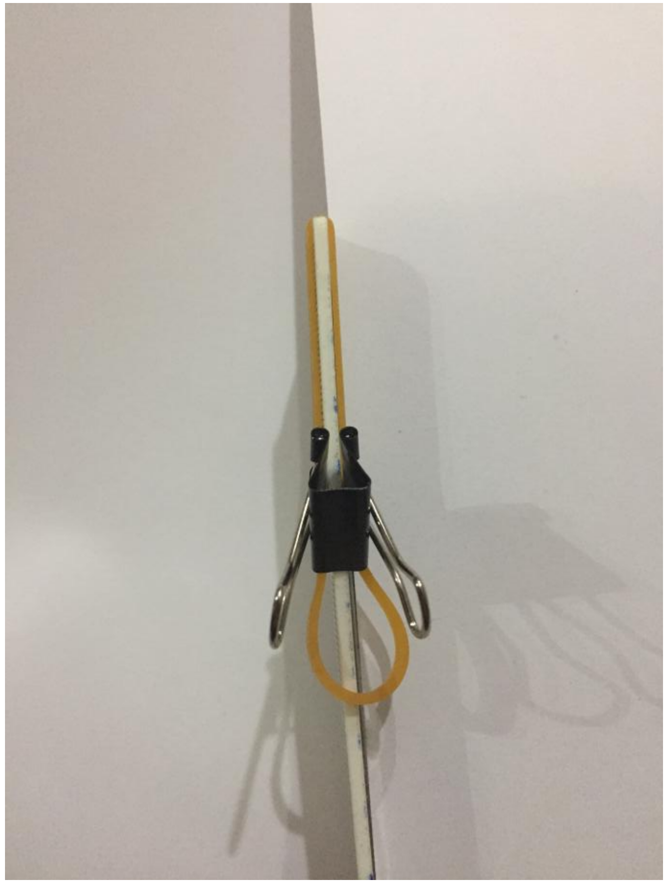
Observation of Experiments

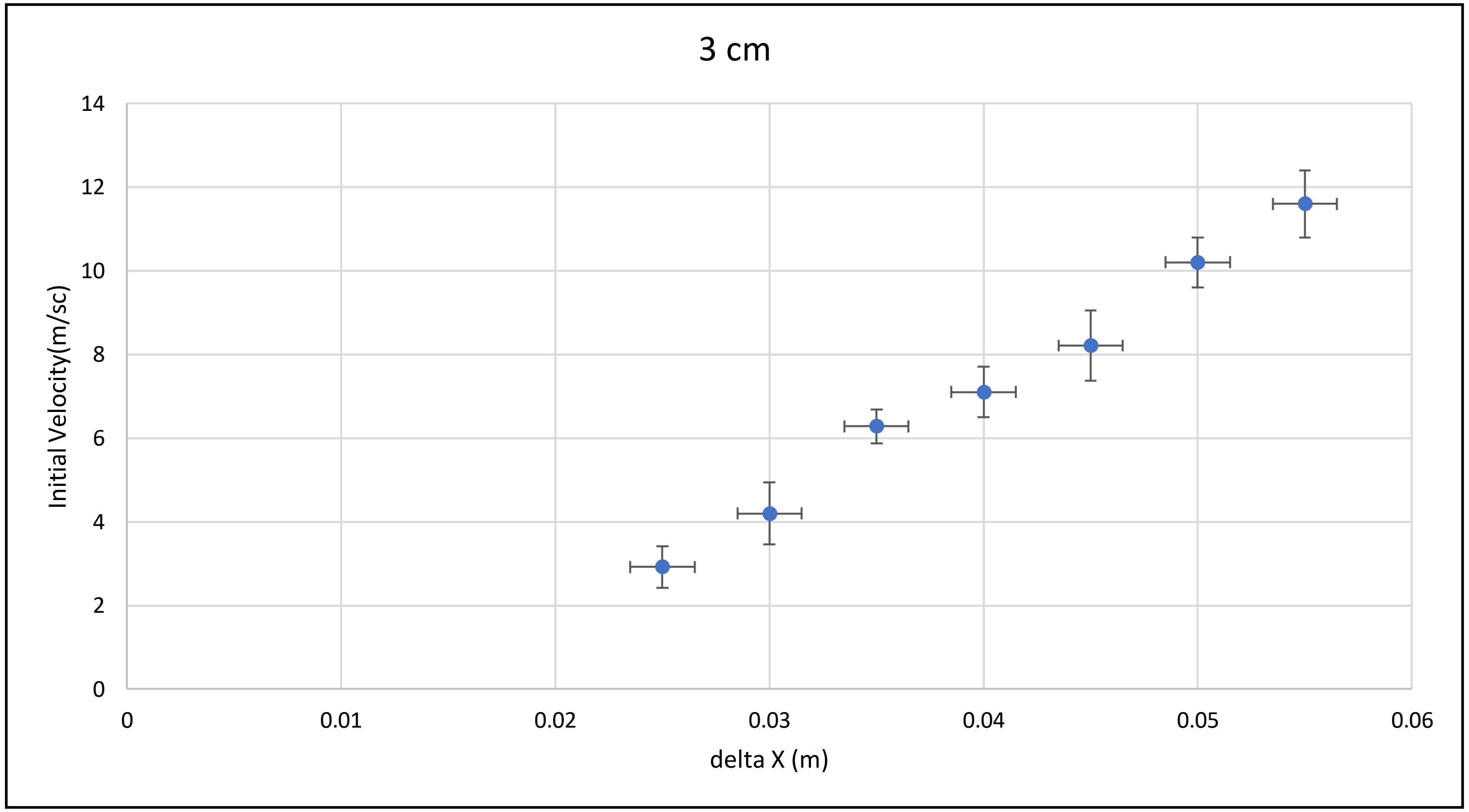


Columns mass A

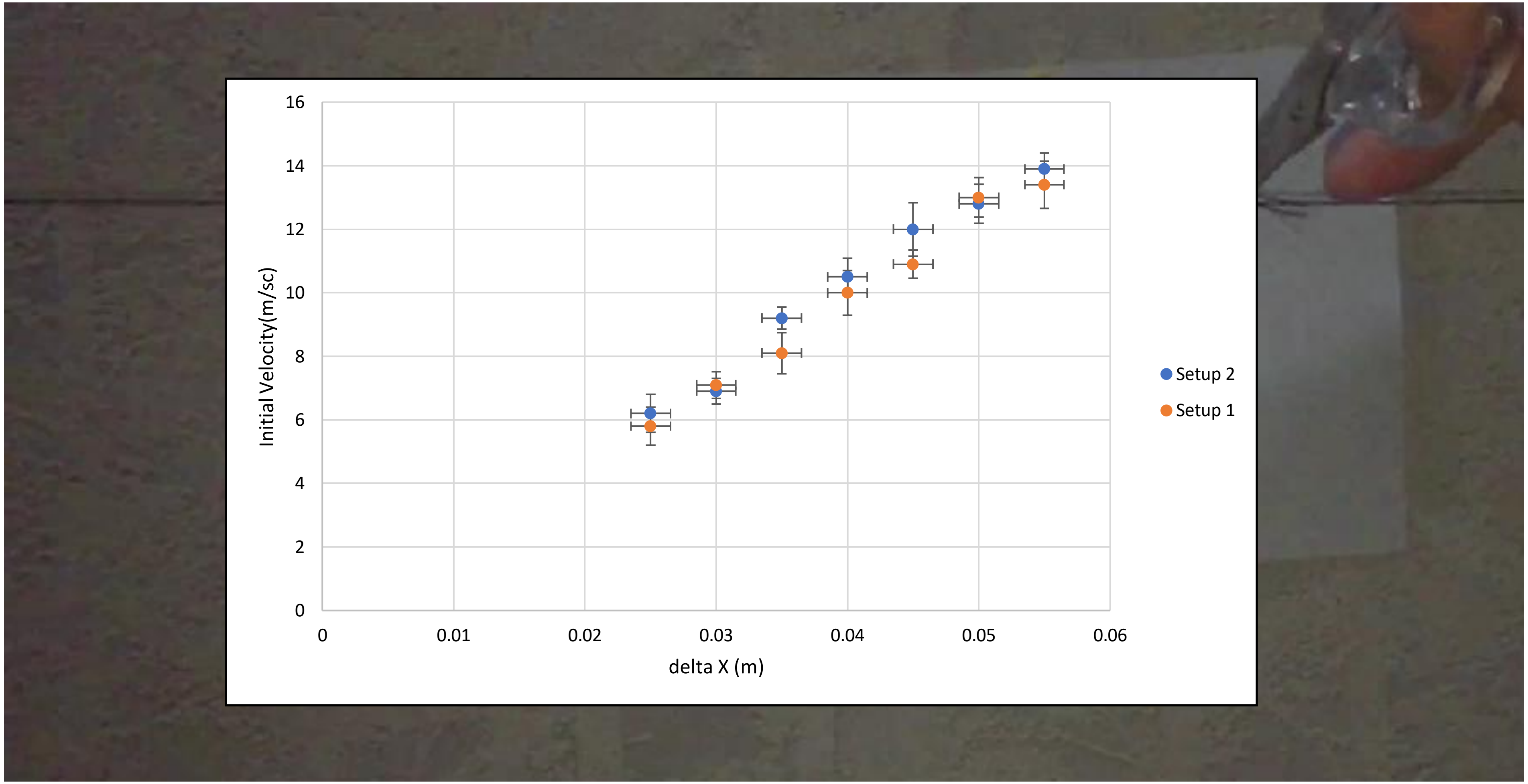
t (s)	x (m)	y (m)	v (m/s)
0.138	6.426E-2	3.027E-2	
0.142	4.765E-2	2.980E-2	4.745
0.146	2.488E-2	2.673E-2	5.144
0.150	4.884E-3	2.680E-2	4.506
0.154	-1.234E-2	3.165E-2	5.863
0.158	-4.357E-2	3.303E-2	6.738
0.163	-6.795E-2	3.942E-2	5.275
0.167	-8.718E-2	3.857E-2	6.038
0.171	-0.118	4.242E-2	6.342
0.175	-0.140	4.165E-2	

Distance from the head to the point of the stretch

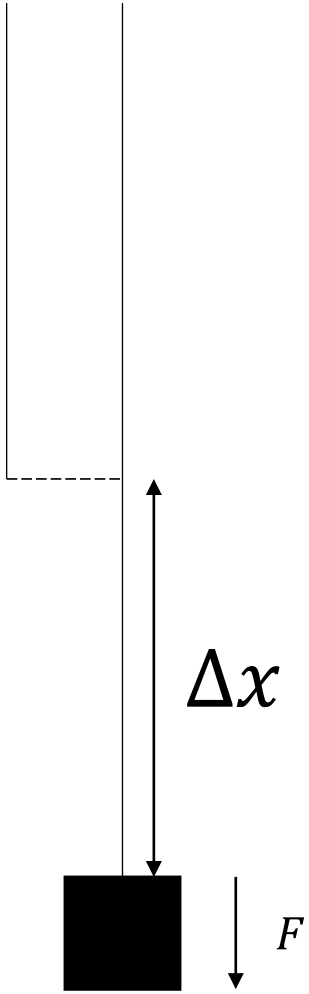




Experimental Setup 2



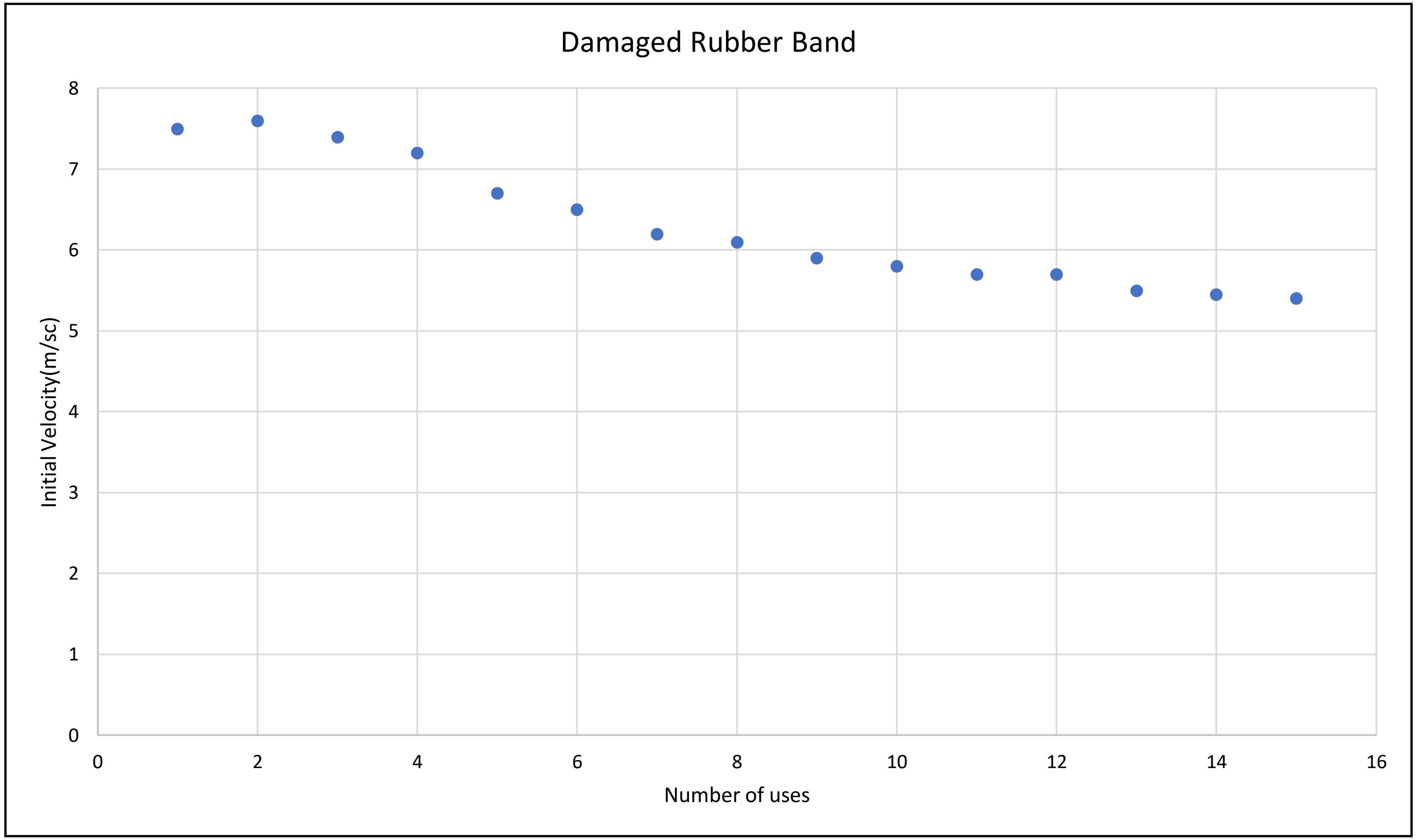
Determination of the rubber stiffness



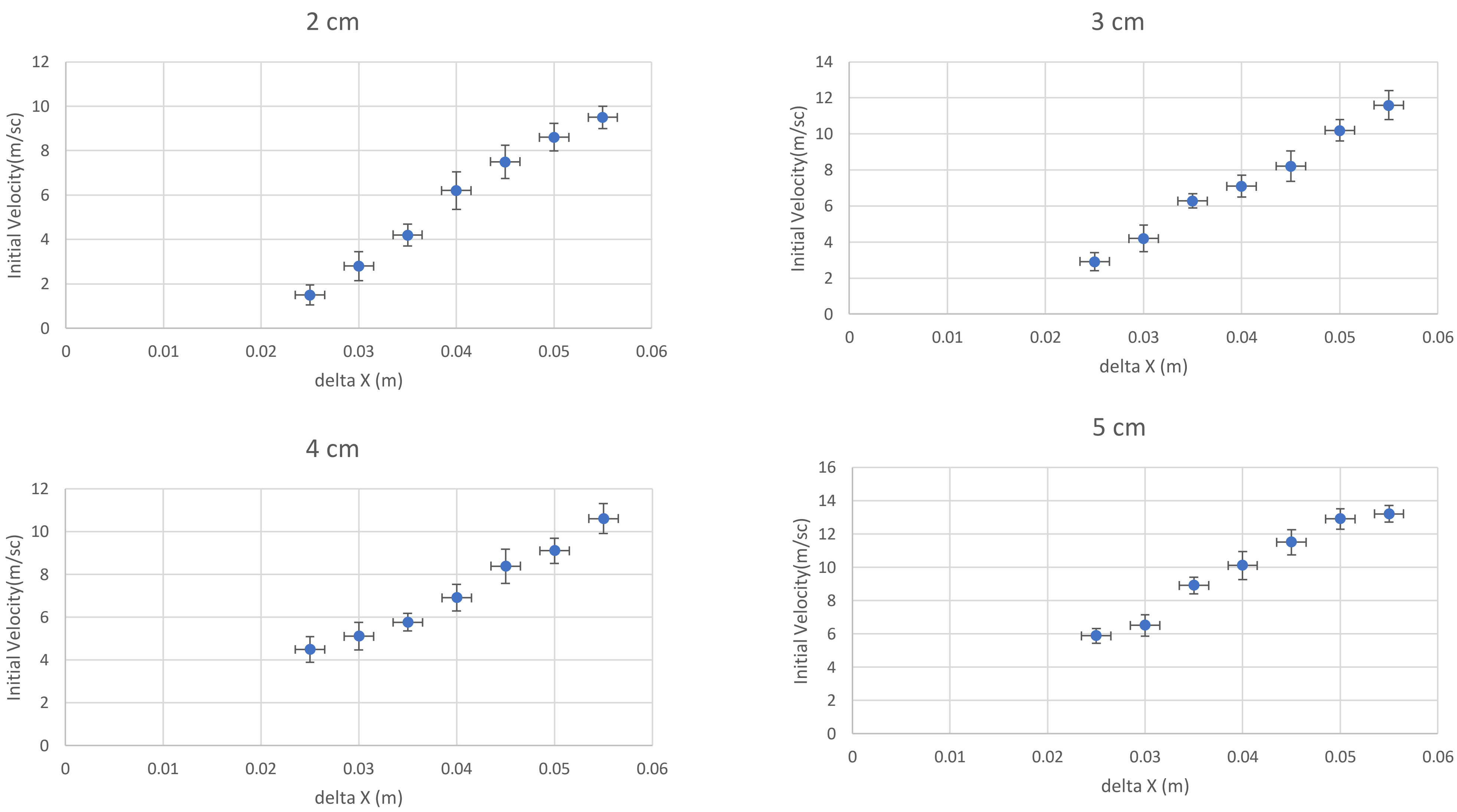
$$F = \frac{k\Delta x^2}{2}$$

$$\boxed{k = \frac{2F}{\Delta x^2}}$$

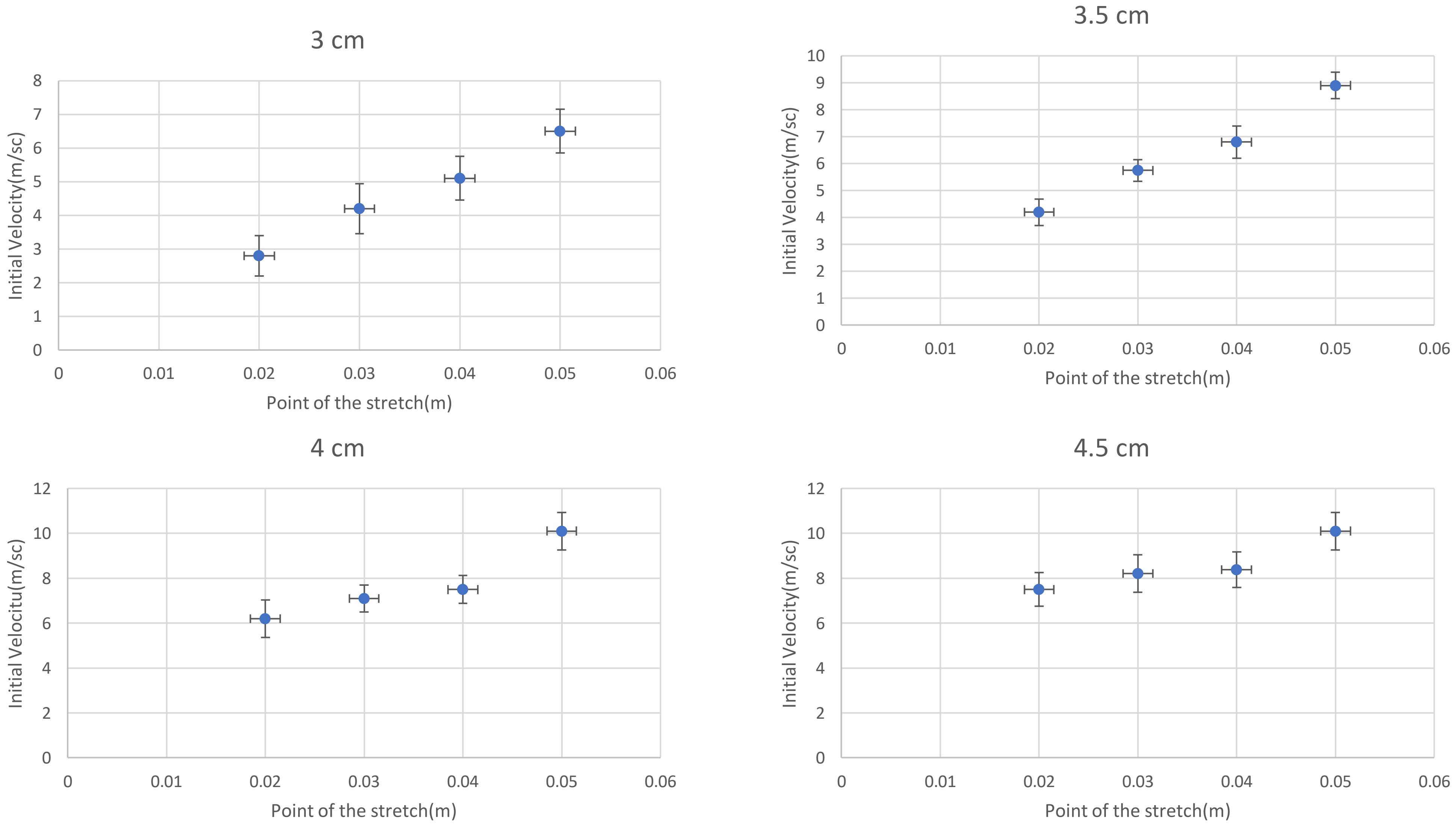
A problem with multiple uses of rubber



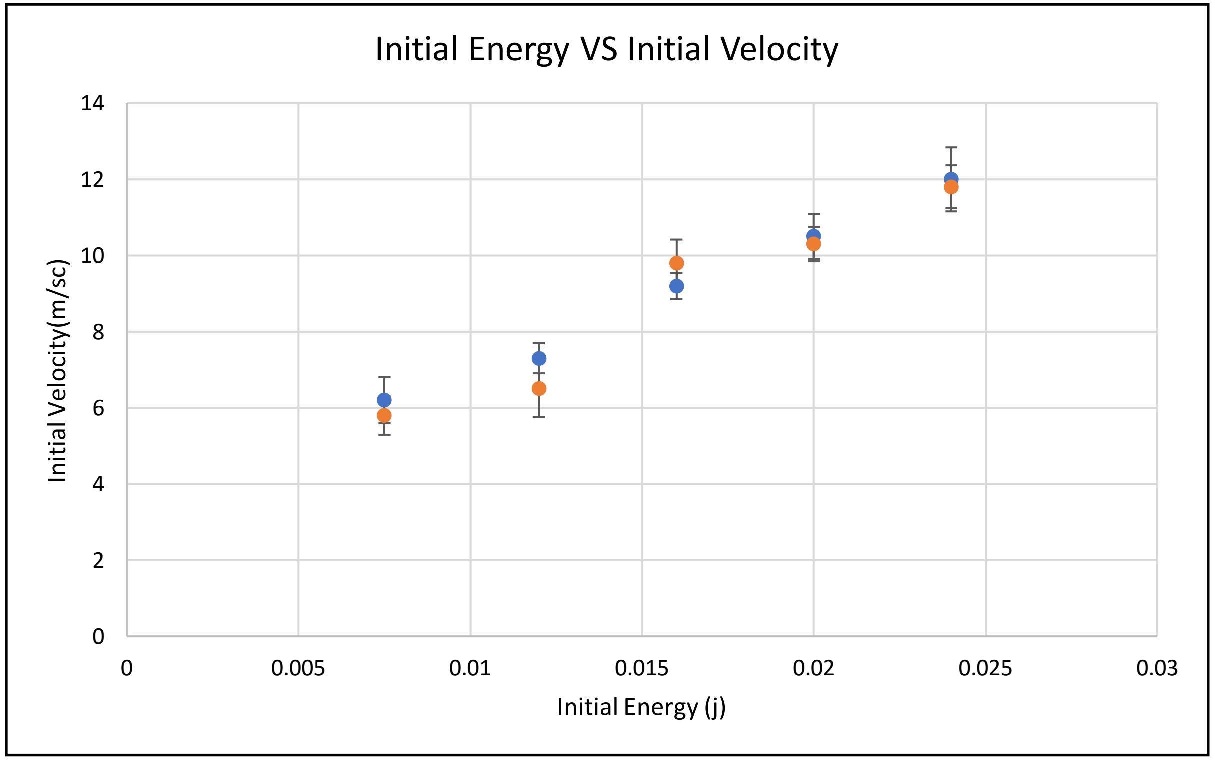
Distance from the head to the point of the stretch

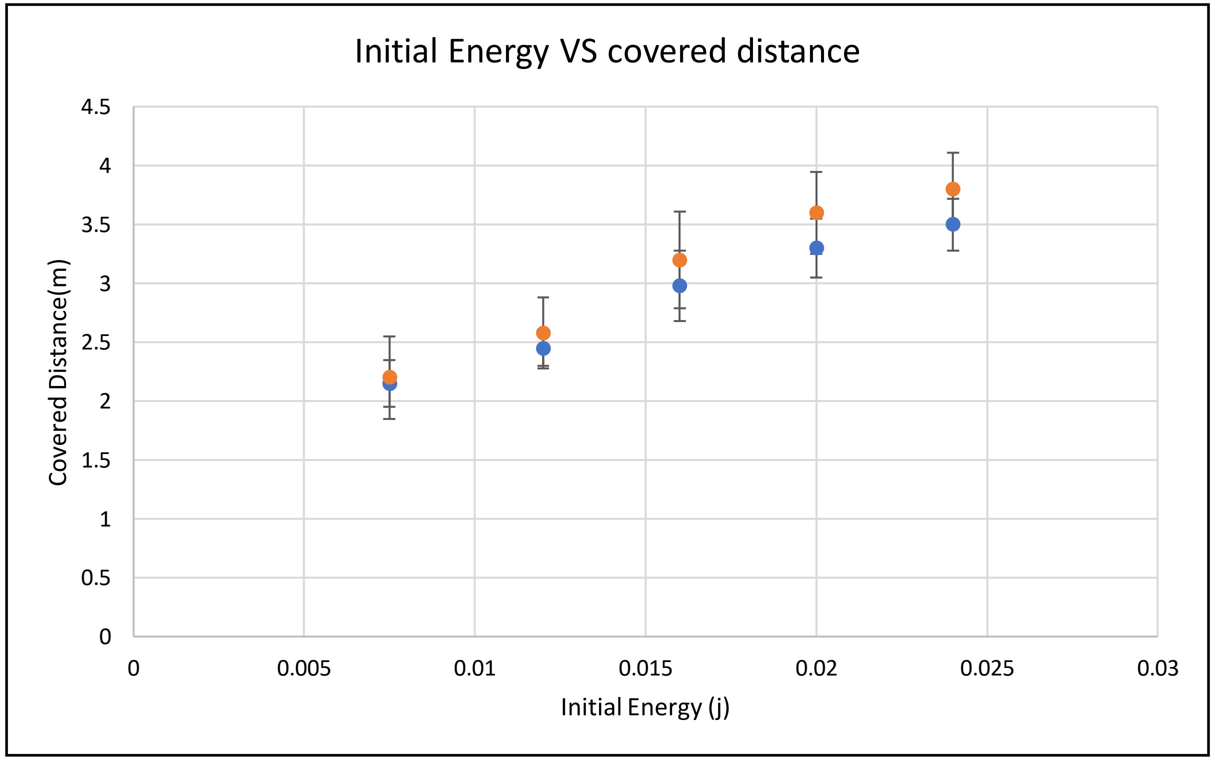


Delta x - constant



Uniformly VS Non-uniformly

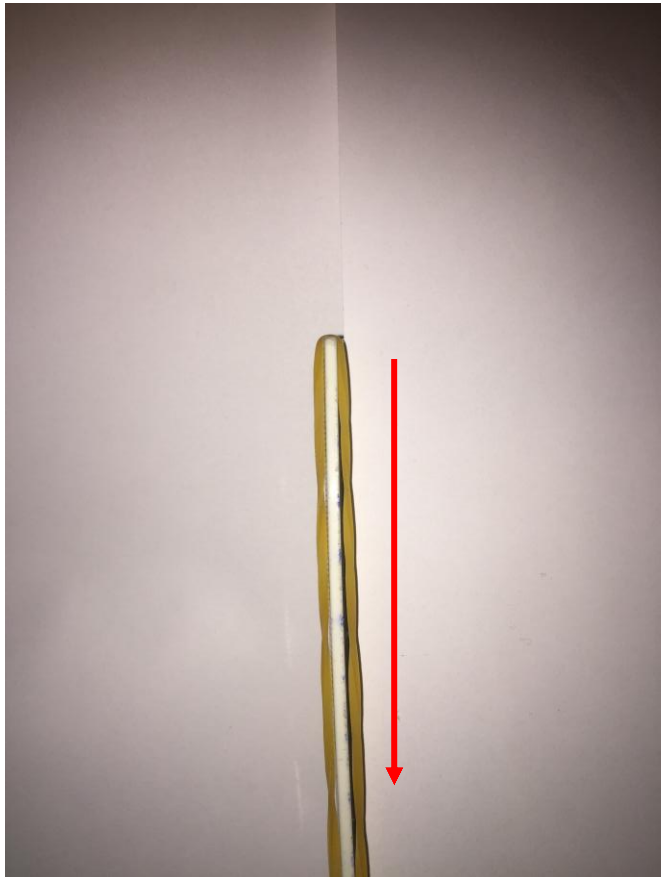


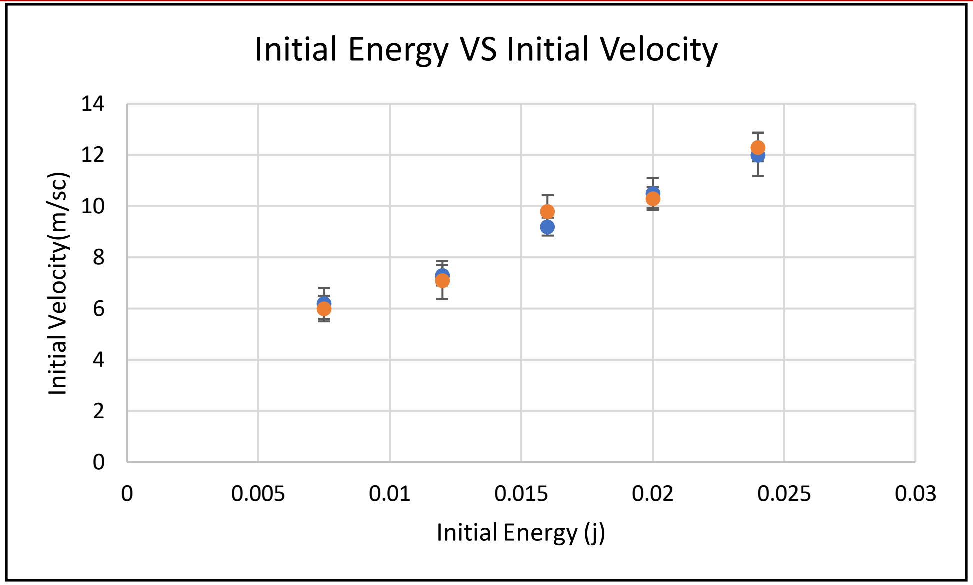


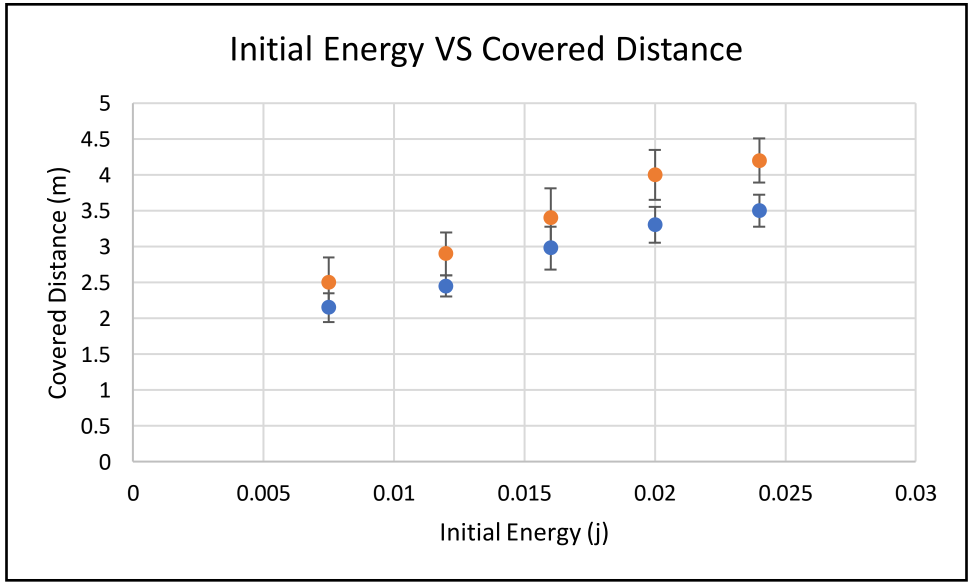
Uniformly

Non-Uniformly

Second type of shooting







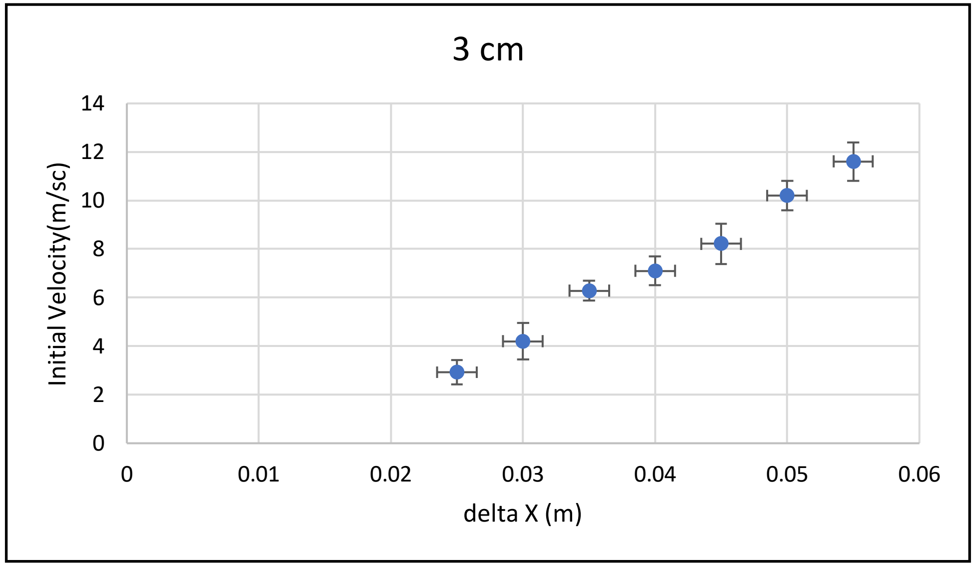
Uniformly

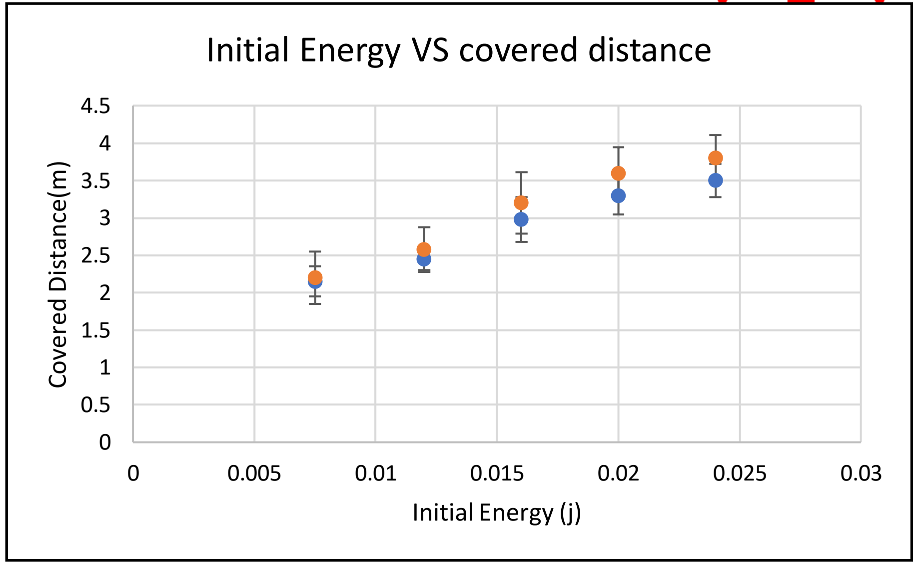
Non-Uniformly

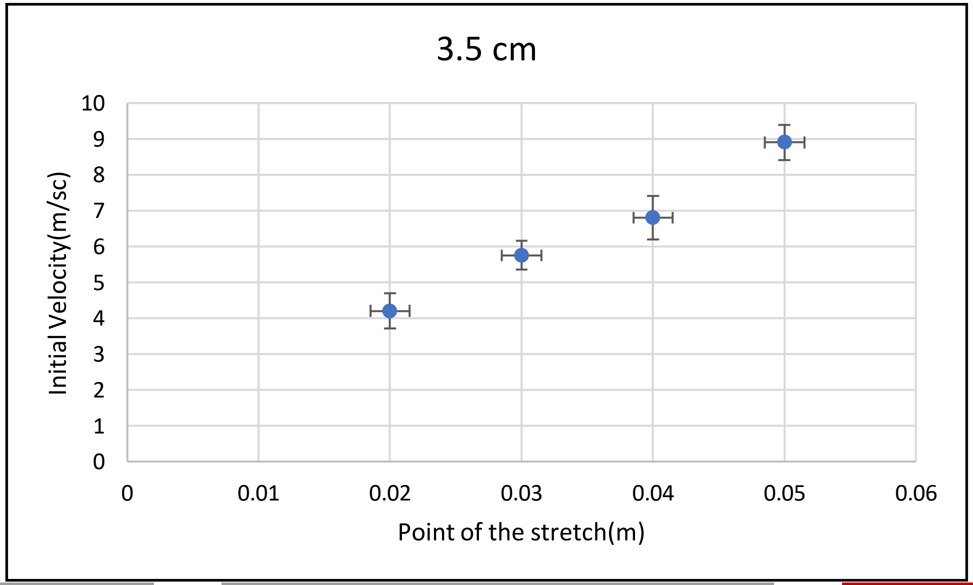
Conclusion

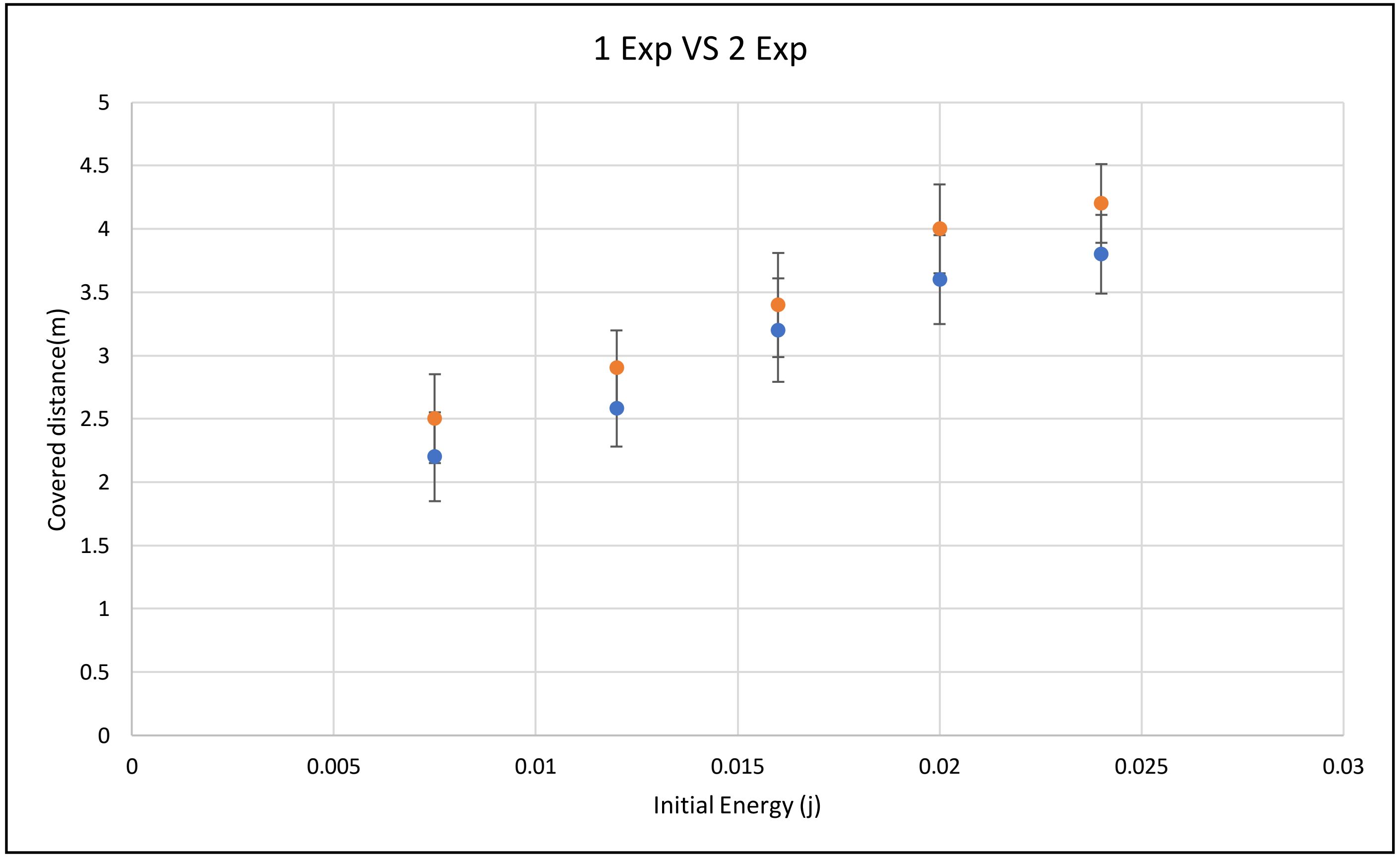
Important parameters

- Rubber band Stiffness;
- Rubber tension;
- The distance from the rubber head to the grip point;
- Air resistance;









1 EXP - I was stretching from both sides

2 EXP - I was stretching only on one side

Thanks for your attention!

გეგმა

- მოვლენის ახსნა
  - *რატომ ხდება რეზინის გასროლა;*

- თეორიული მოდელი
  - *პოტენციური და კინეტიკური ენერგია;*
  - *საწყისი სიჩქარე;*

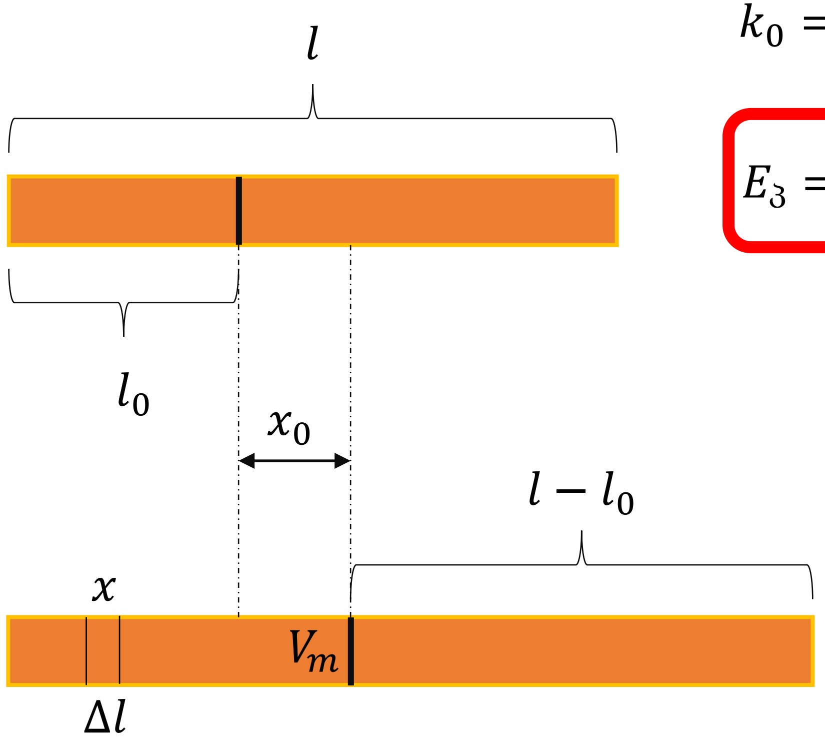
- ექპსერიმენტული ნაწილი
  - *ექსპერიმენტული დანადგარი;*
  - *რეზინის დაჭიმულობა;*
  - *მანძილი სათავიდან დაჭიმვის ადგილამდე;*
  - *რეზინის სიხისტის დადგენა;*
  - *რეზინის სიხისტის ცვლილება;*

- თეორიული და ექსპერიმეტნული შედეგების შედარება
  - *თეორიული და ექსპერიმენტული გრაფიკები;*

- დასკვნა
  - *მნიშვნელოვანი პარამეტრები;*
  - *მონაცემთა ანალიზი;*

თეორიული მოდელი

კინეტიკური და პოტენციური ენერგია



$$k_0 = \frac{kl}{l_0}$$

$$\boxed{E_3 = \frac{kl}{2l_0} {x_0}^2}$$

$$v = \frac{x}{l_0} V_m$$

$$E_{31} = \frac{\Delta l}{2l} m \frac{x^2 {V_m}^2}{{l_0}^2}$$

$$E_{31} = \frac{m{V_m}^2{l_0}^2}{2l{l_0}^2 * 3} = \frac{ml_0{V_m}^2}{6l}$$

$$E_{32} = \frac{l - l_0}{l} m \frac{{V_m}^2}{2}$$

$$E_3 = E_{31} + E_{32} = \frac{m{V_m}^2}{2l}(l - \frac{2l_0}{3})$$

$$\boxed{E_3 = \frac{m{V_m}^2}{2l}(l - \frac{2l_0}{3})}$$

$$E_{\text{ვ}} = \frac{m{V_m}^2}{2l}\left(l - \frac{2l_0}{3}\right)$$

$$=$$

$$E_{\text{ვ}} = \frac{kl}{2l_0}{x_0}^2$$

$$ {V_m}^2 = \frac{2kl^2{x_0}^2}{2ml_0\left(l - \frac{2l_0}{3}\right)} = \frac{kl^2{x_0}^2}{ml_0\left(l - \frac{2l_0}{3}\right)}$$

$$\boxed{V_m = lx_0\sqrt{\frac{k}{ml_0\left(l - \frac{2l_0}{3}\right)}}}$$

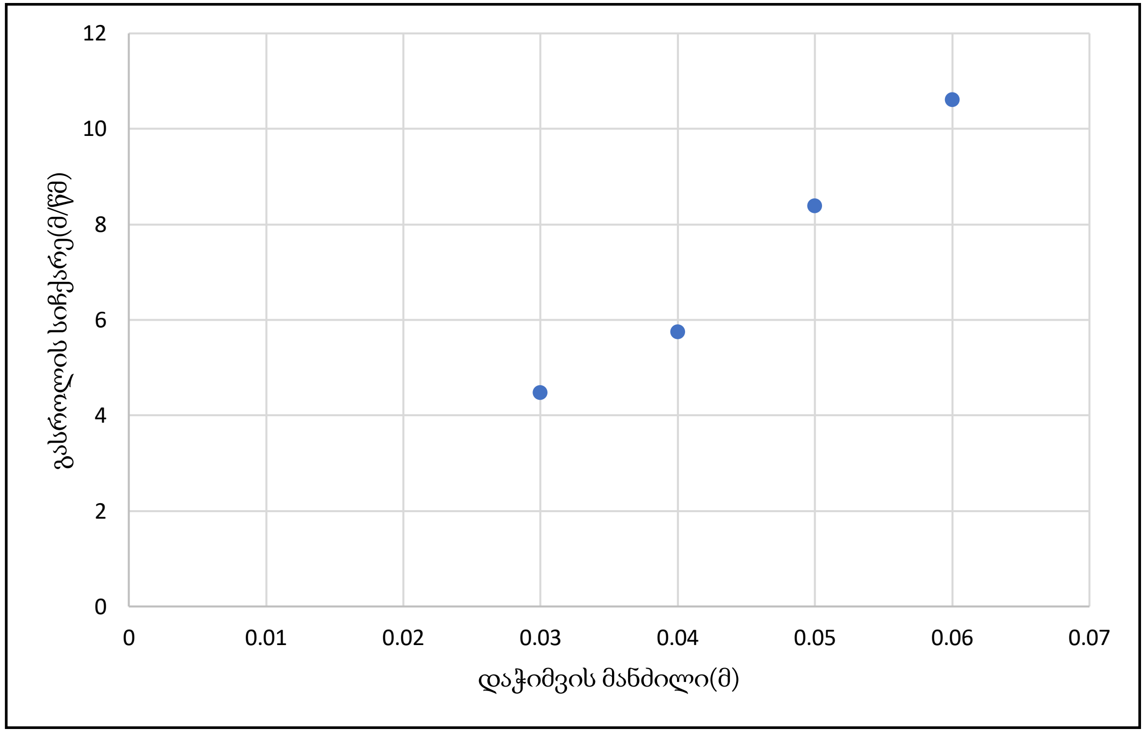
$$V_c = \frac{\sum m_i v_i}{m}$$

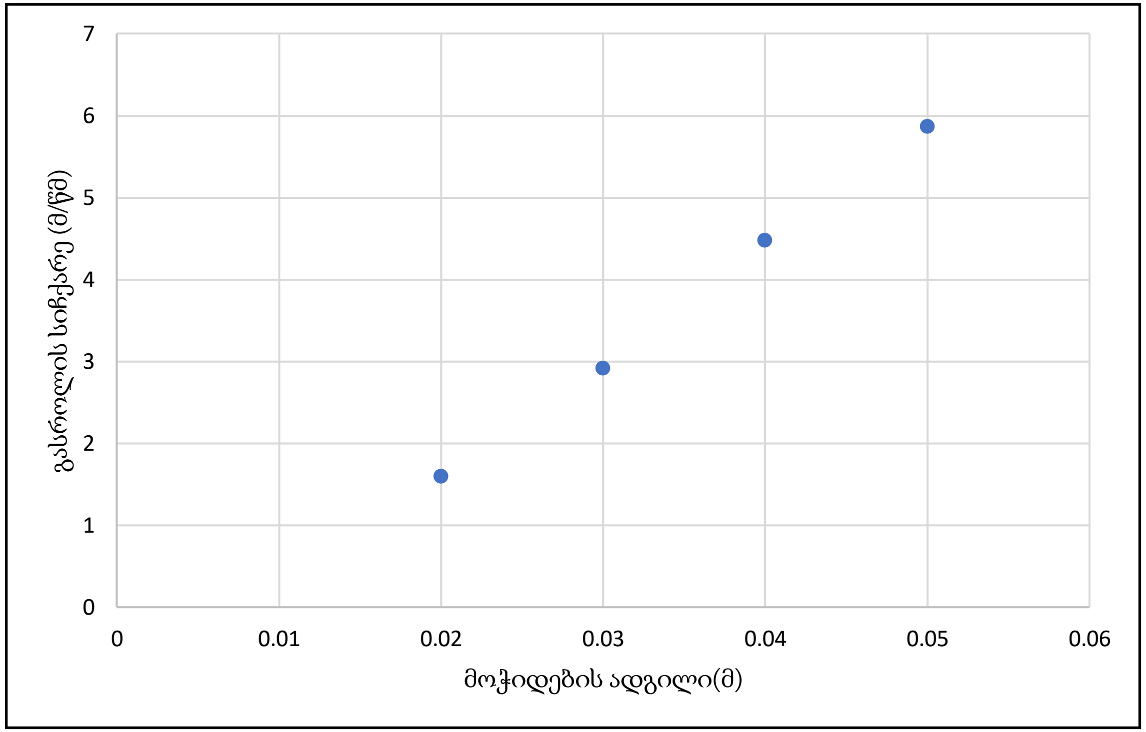
$$\sum m_i v_i = \int_0^{l_0} \frac{\Delta l}{l} m * \frac{x}{l_0} V_m + \frac{l - l_0}{l} m V_m = \frac{m V_m}{l l_0} * \frac{{l_0}^2}{2} + \frac{l - l_0}{l} m V_m = \frac{m V_m}{l} (l - \frac{l_0}{2})$$

$$V_m = l x_0 \sqrt{\frac{k}{m l_0 (l - \frac{2 l_0}{3})}}$$

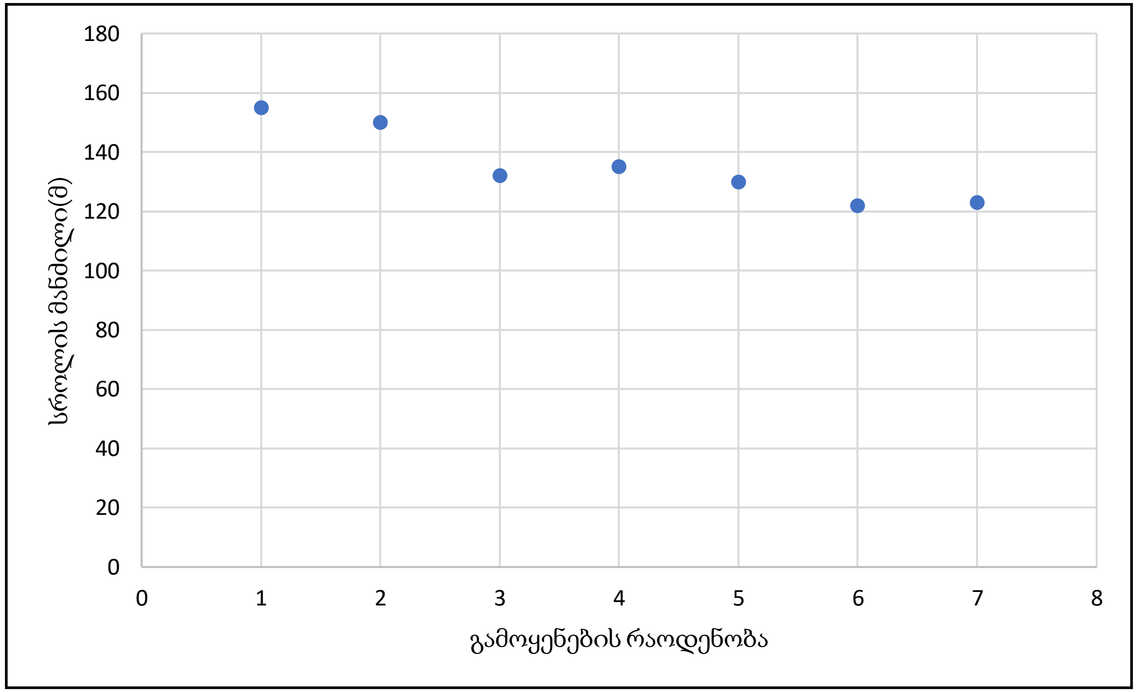
$$\boxed{V_c = \frac{V_m}{l} (l - \frac{l_0}{2})}$$

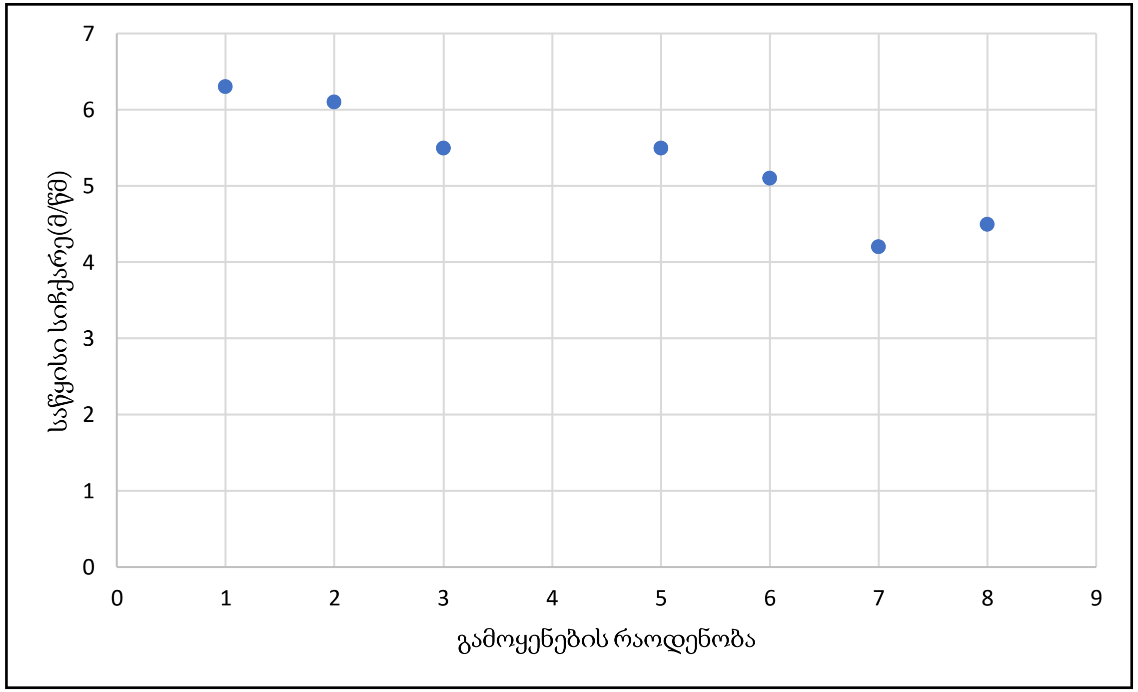
გასროლის სიჩქარის გამოკვლევა





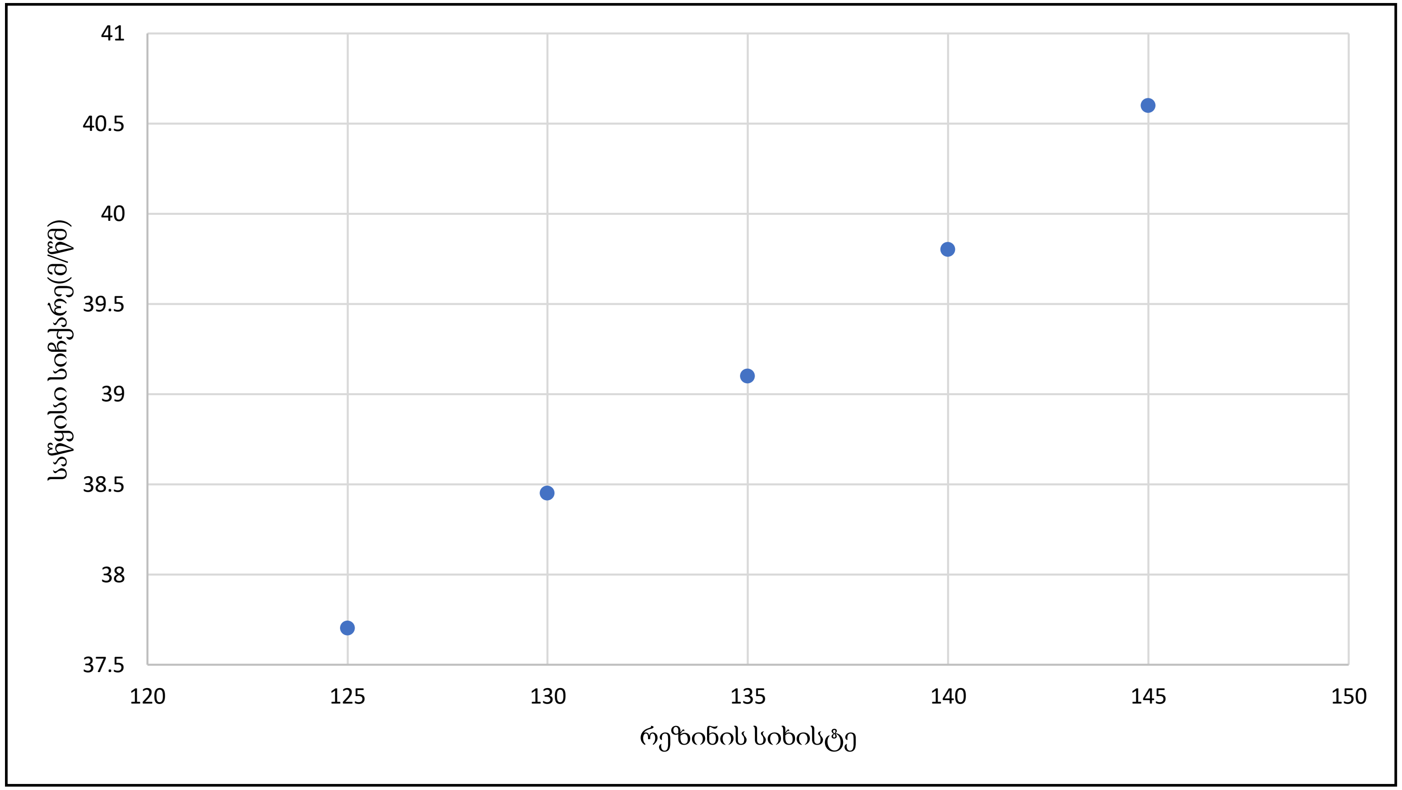
რეზინის მრავალჯერადად გამოყენება





phenomenon | Theoretical model | **experiment** | conclusion

რეზინის სიხისტის ცვლილება



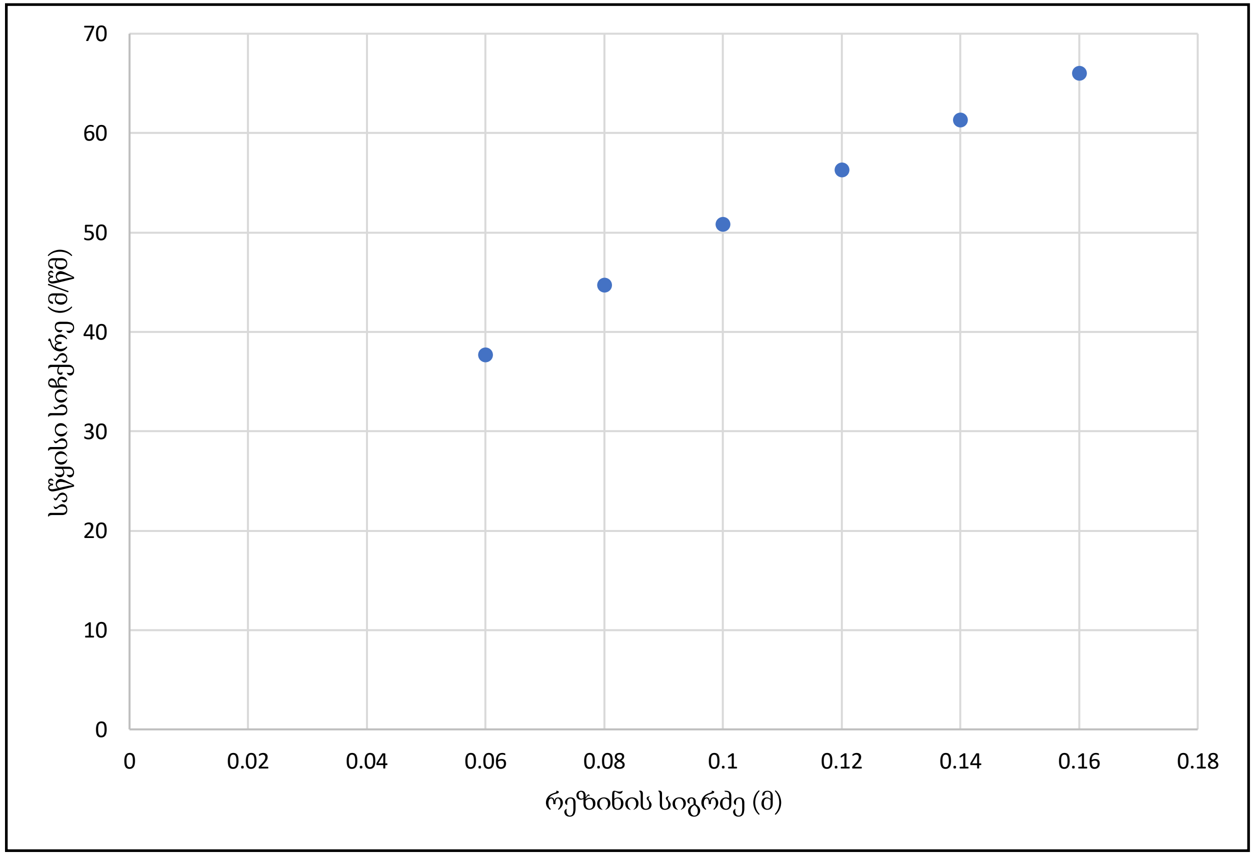
phenomenon

Theoretical model

experiment

conclusion

რეზინის სიგრძის ცვლილება



ექსპერიმენტული პროგრამები

Tracker
Video Analysis and Modeling Tool

Excel