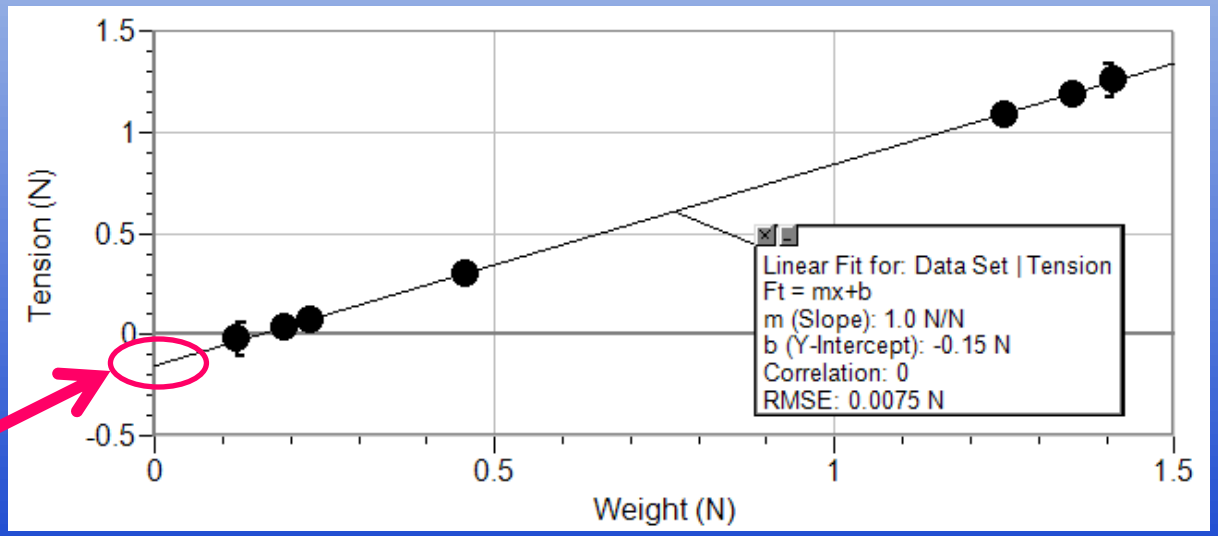
Making Sense of Y-Intercepts in Introductory Laboratories



Session IA05

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Modeling Instruction at UNE

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Discovery Labs in Modeling

- Each unit begins with the demonstration of a paradigm experiment.
- With assistance, students design their own procedure, collect data, create a graphical model, and then interpret the graph.

Modelinginstruction.org

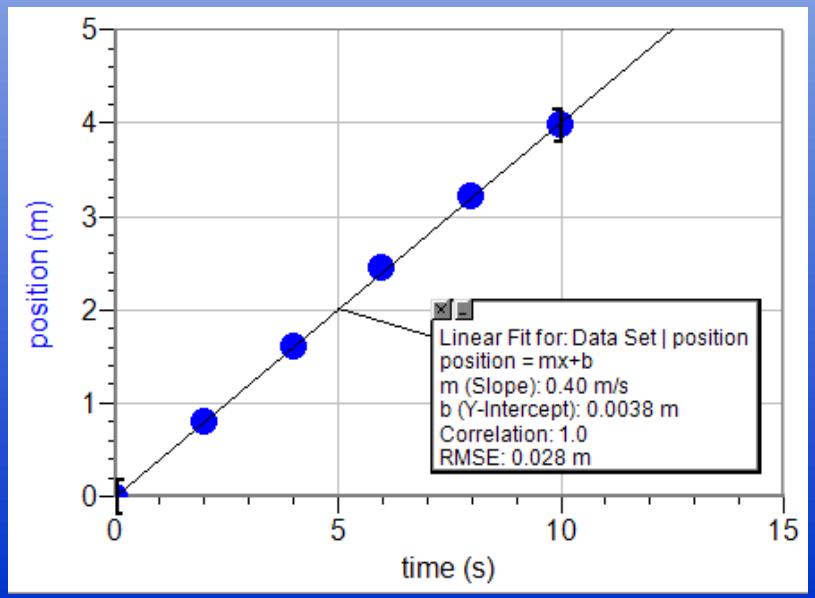
American Modeling Teachers Association

Supporting Modeling Instruction around the USA and the world.

Basic Interpretations

- Some labs are centered on definition building.
- Example: Tumble Buggy

How does position depend on time?



- Interpretation: the definition of velocity is set as the slope of position vs. time

Basic Interpretations

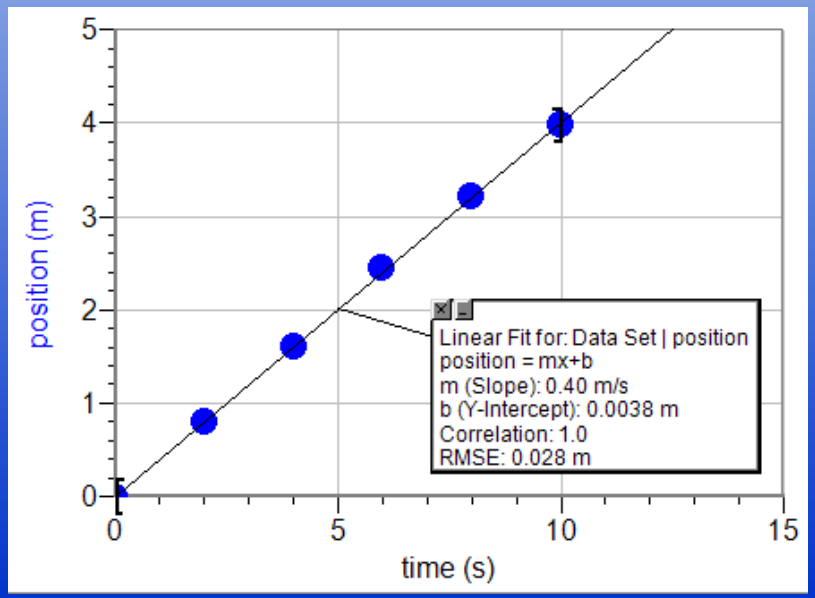
- Some labs are centered on definition building.
- Example: Tumble Buggy

How does position depend on time?

$$x = v \cdot t + x_o$$

slope = velocity

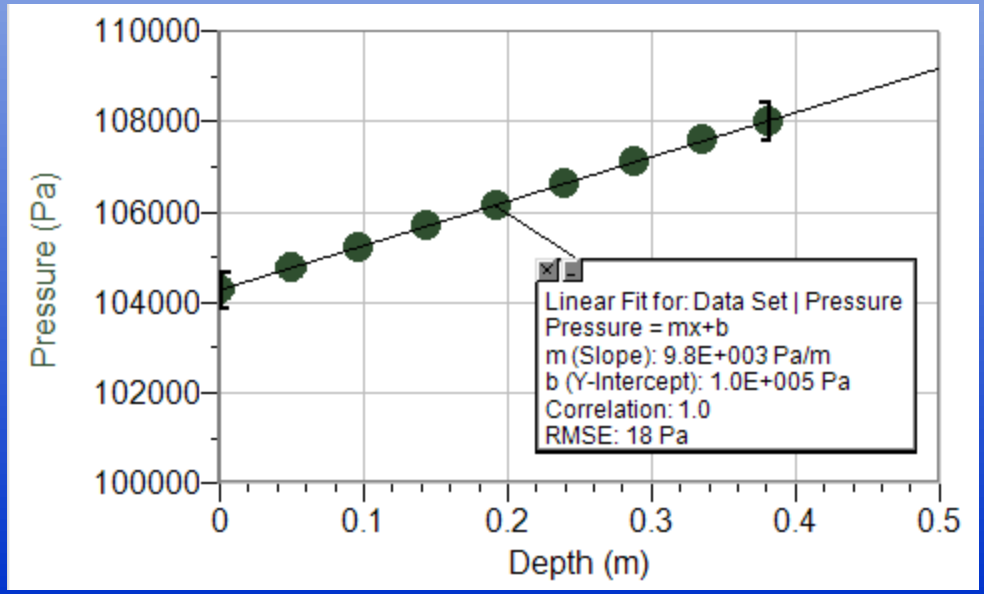
y-intercept = initial position



Complex Interpretations

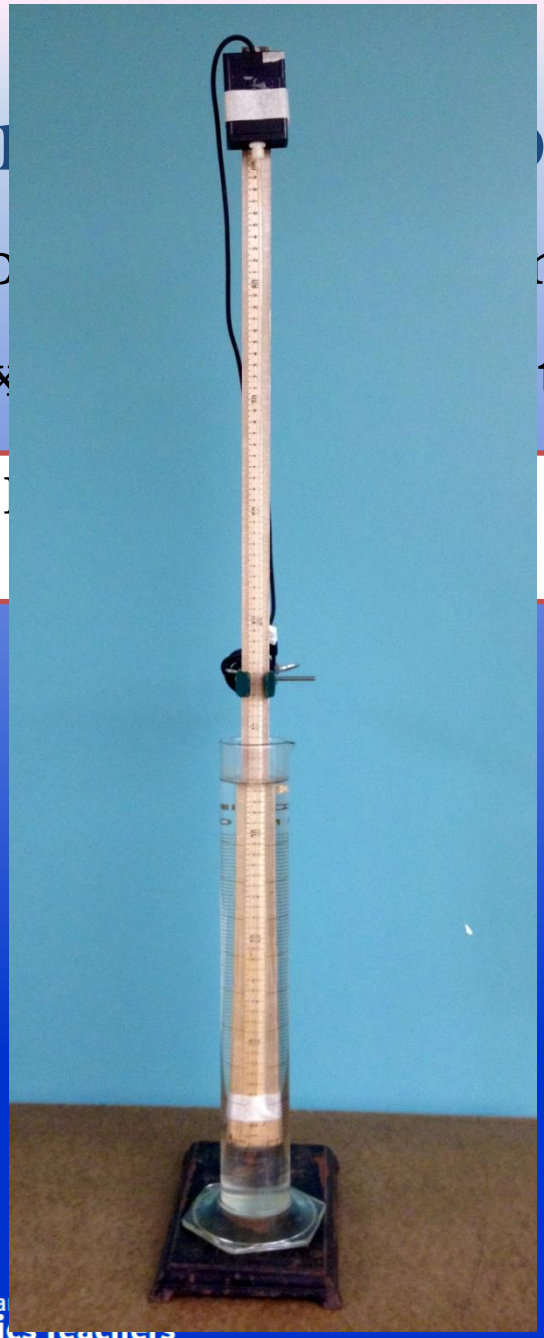
- Some labs require more advanced analysis
- Example: Hydrostatic pressure

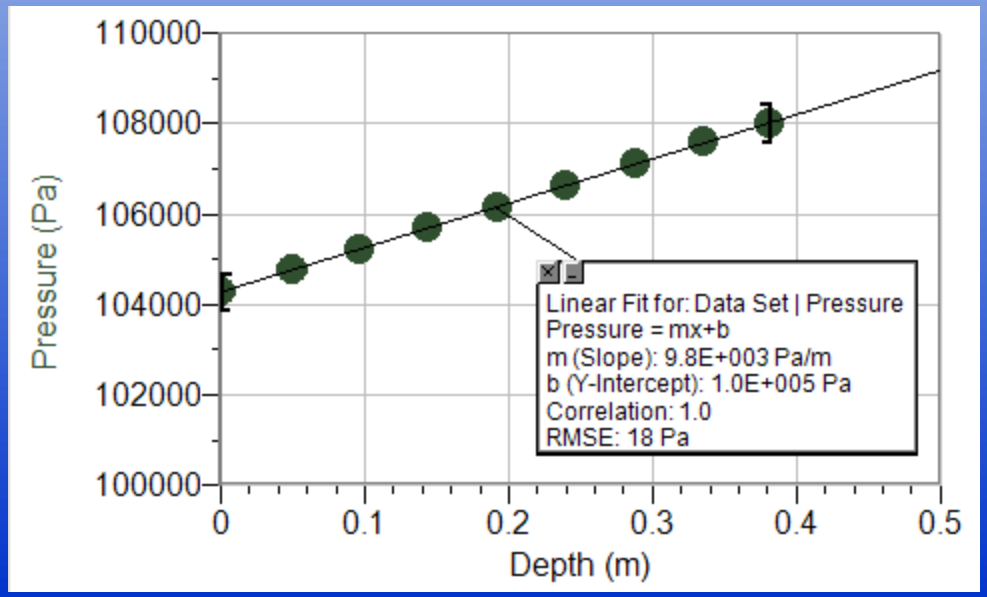
How does pressure depend on depth?



Co retations

- So more advanced analysis
- Ex tic pressure





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Complex Interpretations

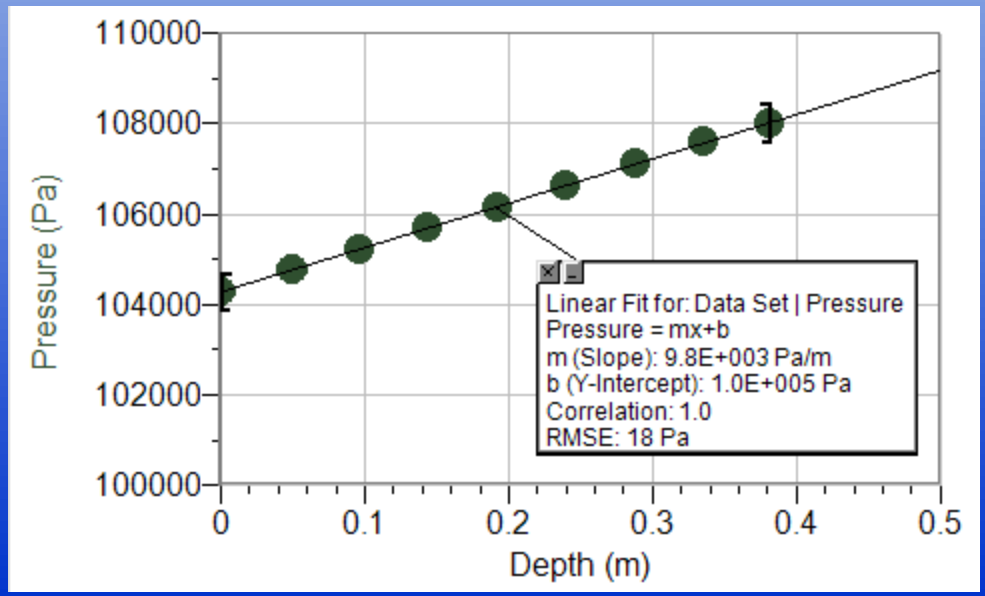
- Some labs require more advanced analysis
- Example: Hydrostatic pressure

How does pressure depend on depth?

$$P = \rho \cdot g \cdot \Delta z + P_o$$

slope = density * g

y-intercept = initial pressure



Importance of Graphical Analysis

- "Many undergraduates taking introductory physics seem to lack the ability to use graphs either for imparting or extracting information."

- "Among the many skills that can be developed in the study of physics, the ability to draw and interpret graphs is perhaps one of the most important."

McDermott : American Journal of Physics **55,** 503 (1987)

Importance of Graphical Analysis

- "The revised MCAT will also give prominence to a set of scientific inquiry and reasoning skills. A typical set of questions will provide a few paragraphs of background information including some data in graphical or tabular format."

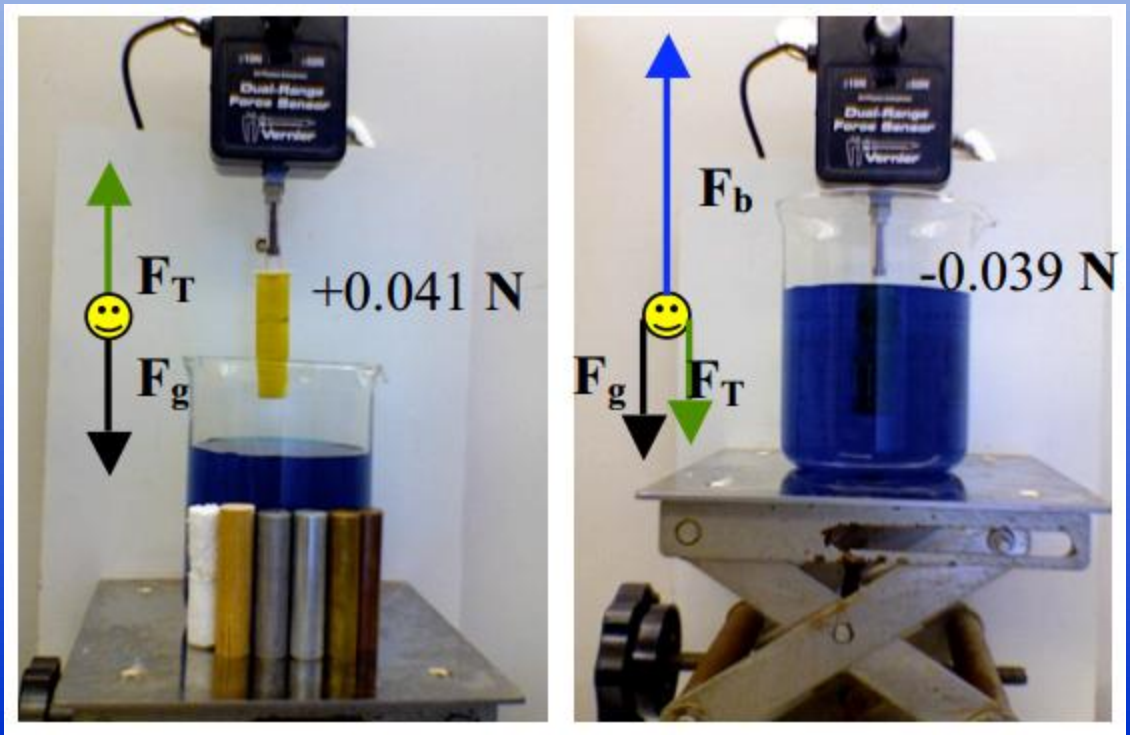
Hillborn: American Journal of Physics **82**, 428 (2014)

Meaningful Y-Intercepts

- Find experimental scenarios rich enough to support a y-intercept just as meaningful as the slope.
- A laboratory can host multiple opportunities to hone the art of sense-making.
- What follows are 4 labs that we use at UNE:

Buoyancy

How does tension force depend on weight?

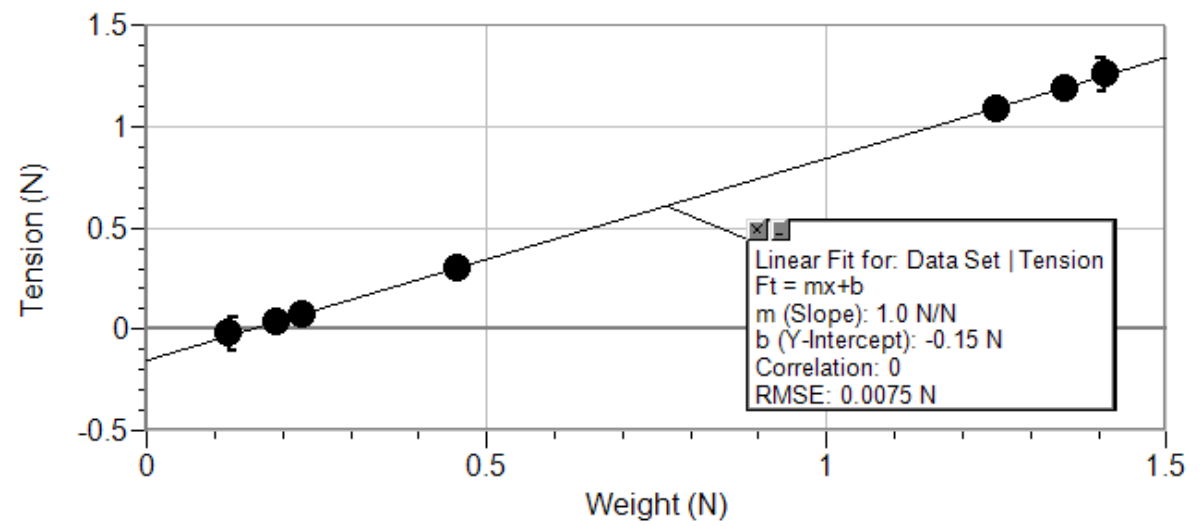


Vesenka: "Multiple Representations of Buoyancy", American Physical Society, Joint Fall 2009 Meeting of the New England Section of the APS and AAPT, October 16-17, 2009

Buoyancy

- The interesting interpretation IS the y-intercept.

How does tension force depend on weight?



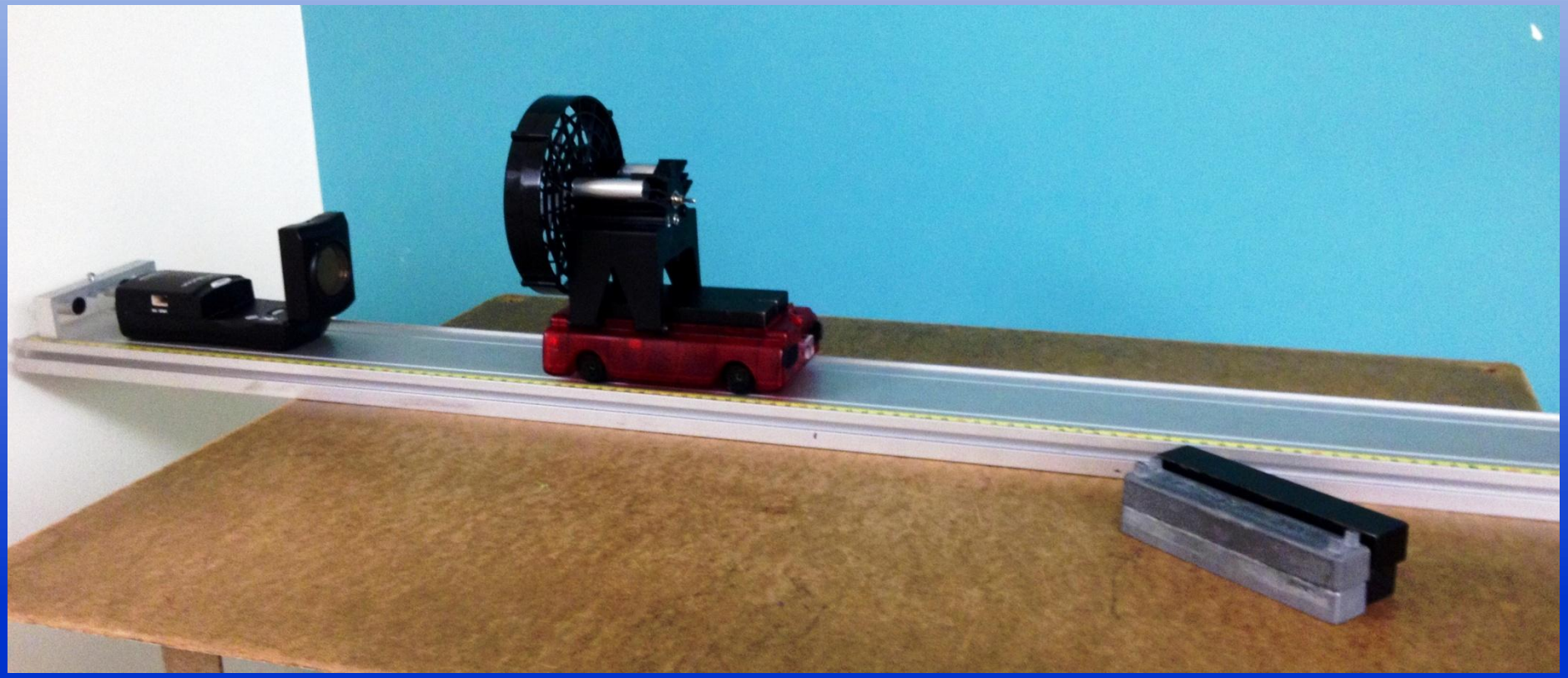
$$F_T = 1 \cdot F_g + \rho \cdot V \cdot g$$

Buoyant force

slope = 1

Newtons' 2nd Law

- How does acceleration depend on mass?



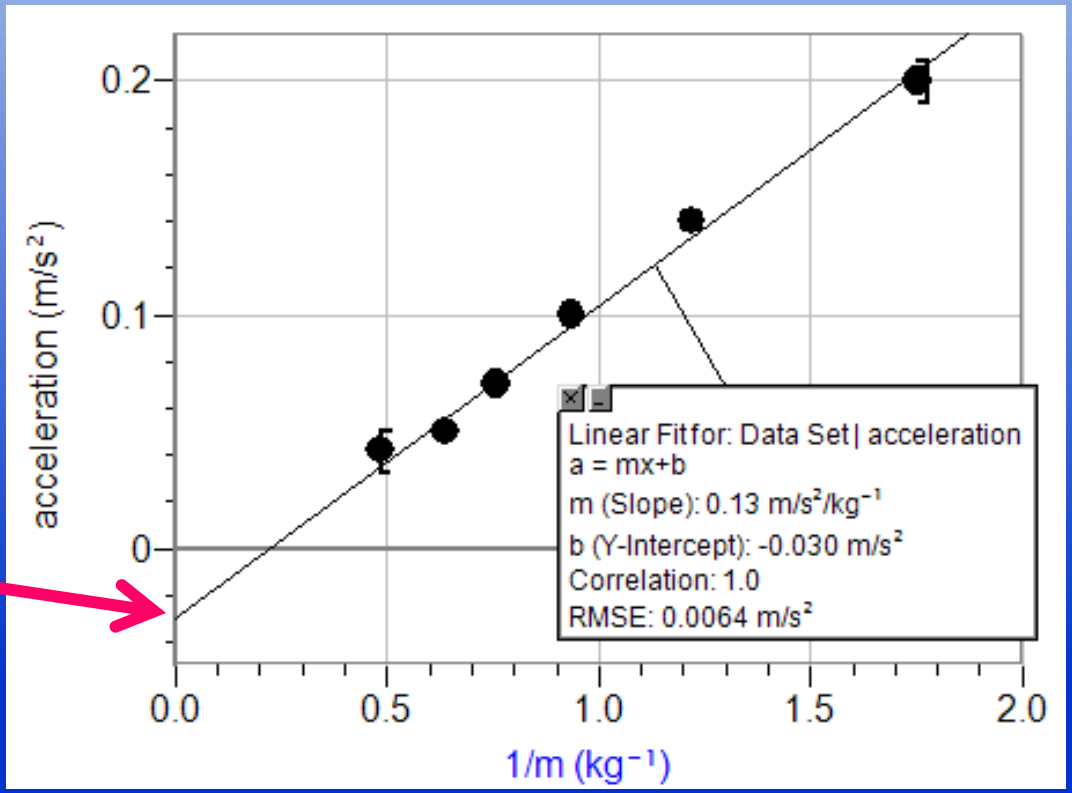
Newton's 2nd Law

How does acceleration depend on mass?

$a = F_{fan} \cdot (1/m) - F_f/m$

slope = force applied by fan

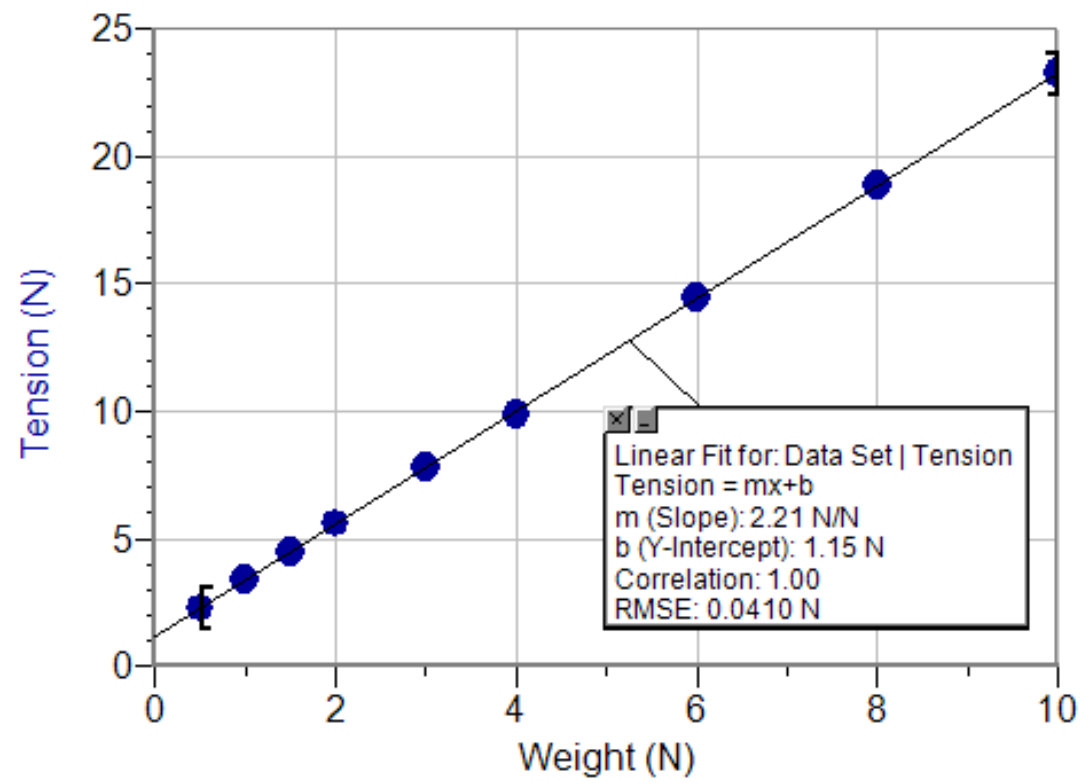
y-intercept =
Friction force / mass
or $\mu \cdot g$

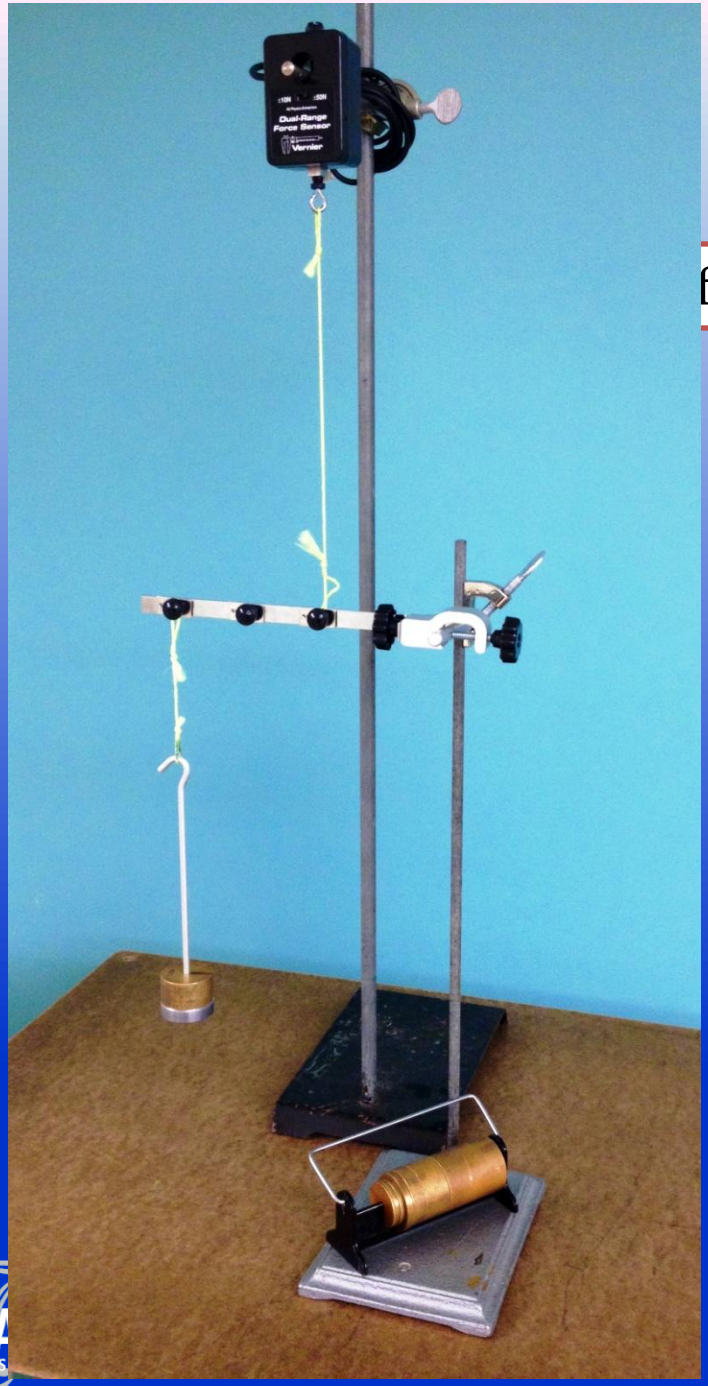


$a = \Sigma F/m$

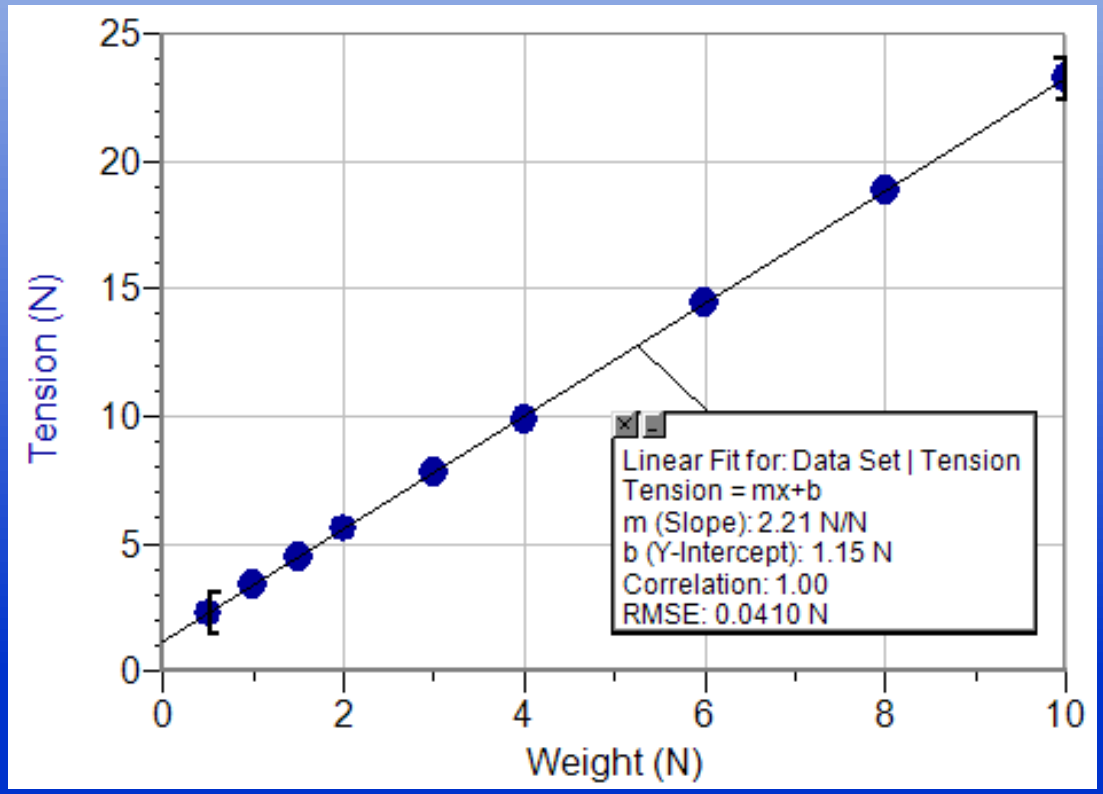
Torque

How does lift force depend on weight?





ft force depend on weight?



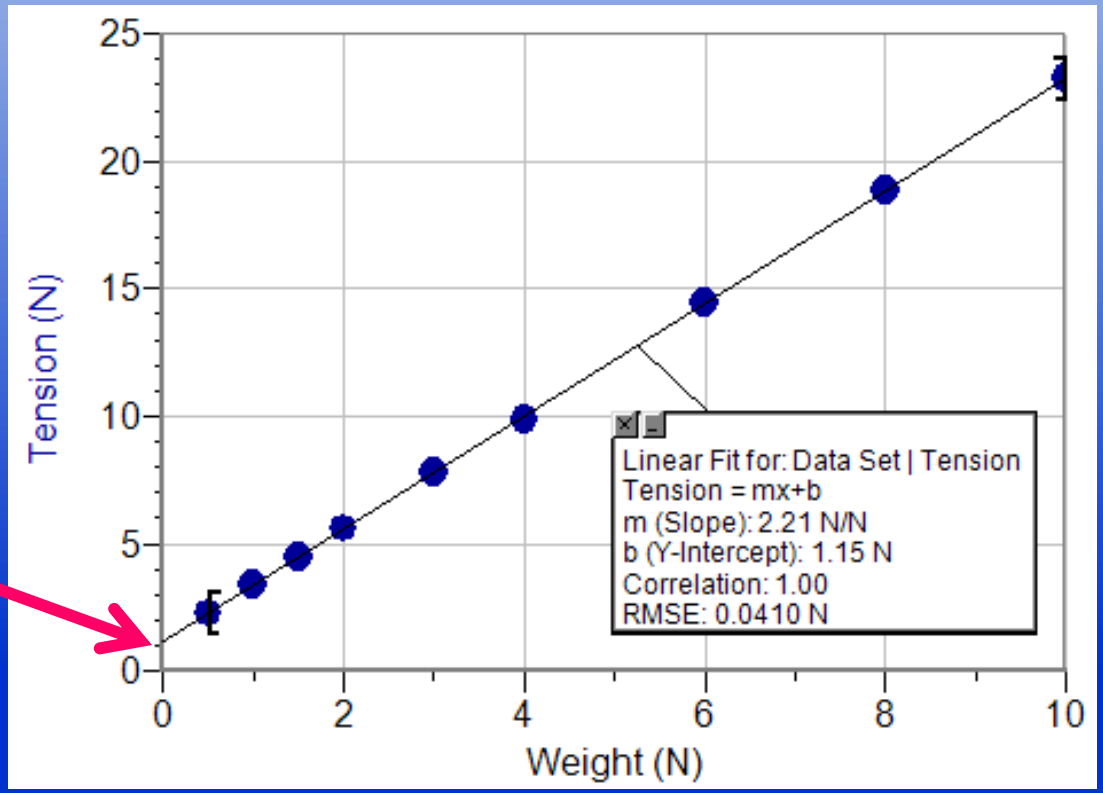
Torque

How does lift force depend on weight?

$$F_T = (r_2/r_1) \cdot F_g - C$$

slope = ratio of lengths

y-intercept = complex



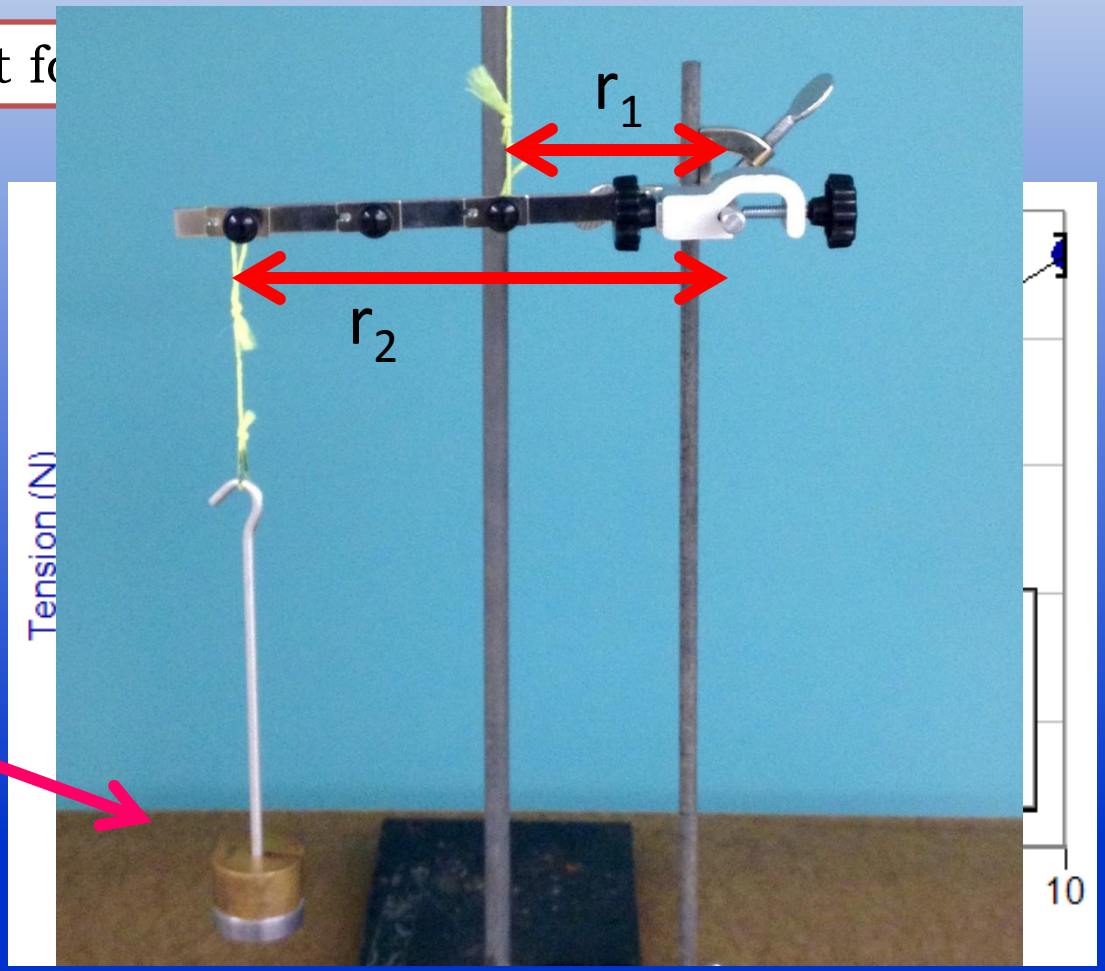
Torque

How does lift f

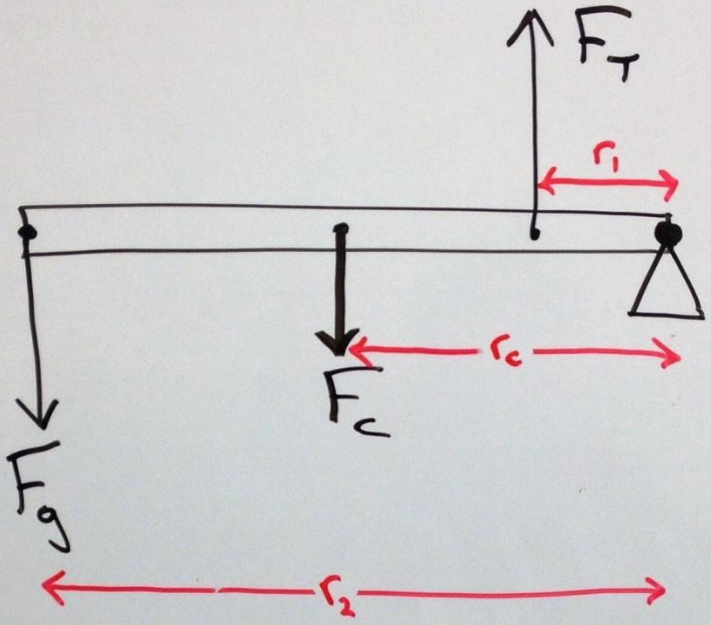
$$F_T = (r_2/r_1) \cdot F_g - C$$

slope = ratio of lengths

y-intercept = complex



Torque



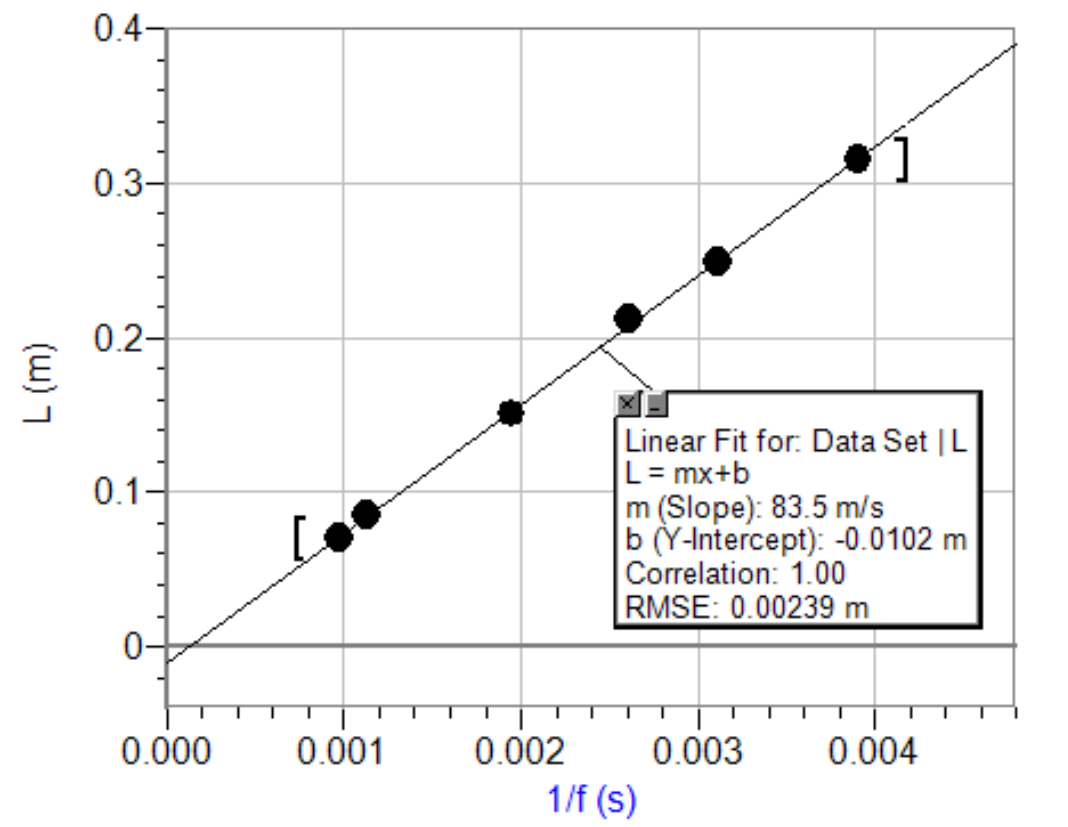
$$\tau_1 = \tau_2 + \tau_c$$

$$r_1 F_T = r_2 F_g + r_c F_c$$

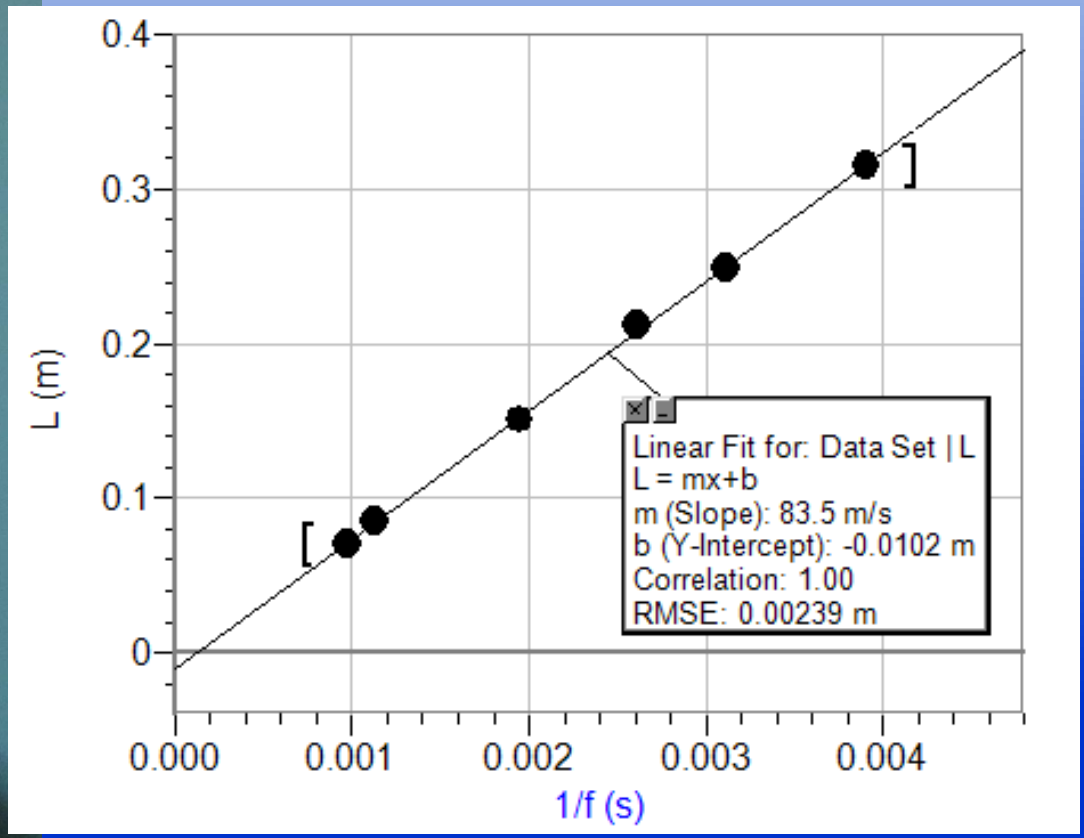
$$F_T = \frac{r_2}{r_1} F_g + \frac{r_c F_c}{r_1}$$

Resonance

How does length of tube depend on frequency?



tube depend on frequency?



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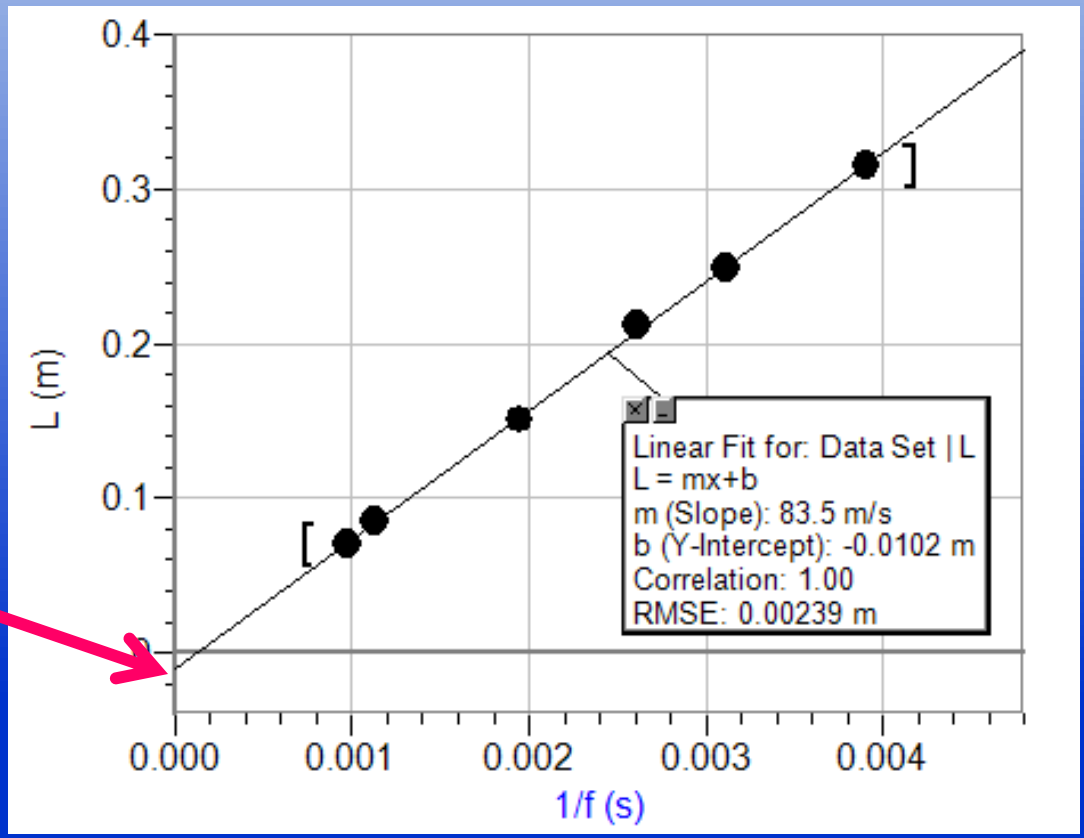
Resonance

How does length of tube depend on frequency?

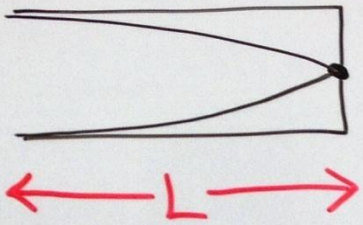
$$L = (v/4)\cdot(1/f) + C$$

slope = speed of sound / 4

y-intercept = complex



Resonance



$\lambda = 4(L + .3D)$

End Correction

Diameter =3.3cm

0.3*D = 0.3*3.3m
= 0.99cm

y-intercept = 1.02cm

$V = \lambda f$

$V = 4(L + .3D)f$

$\frac{V}{4f} = L + .3D$

$L = \frac{V}{4} \cdot \frac{1}{f} + .3D$

Conclusions

- Students need more and varied opportunities for graphical analysis in physics contexts.
- The Modeling Instruction lab style provides the opportunity for slope interpretation.
- Carefully chosen labs can offer an additional layer of rich analysis.

Questions?

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