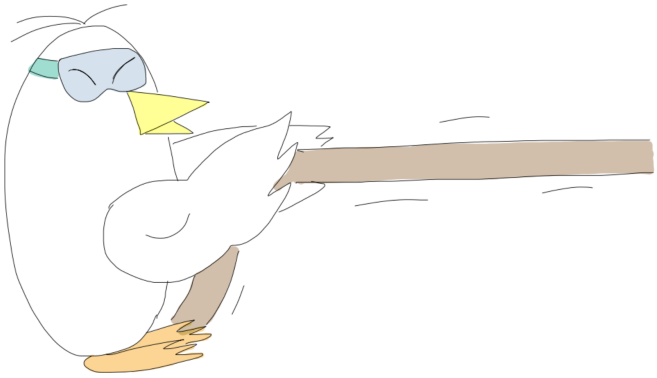
'Iolani Science Olympiad Invitational 2024

Division C

# MATERIALS SCIENCE LAB



**Team Name** _____

**Team Number** _____

Honolulu
2024

# 1 Instructions

You have been given the following materials:

- Strand of thin rubber
- Strand of thick rubber
- Vernier caliper
- Spring scale
- Ruler

Using these materials, you will investigate some properties of rubber. You may use whichever strand you want for each part. **Show all calculations**.

# 2 Stress and strain

1. (3 points) Determine Poisson's ratio for the band.

2. (5 points) Draw a stress-strain curve for the rubber band, using at least 5 points. Use true stress.

3. (2 points) Draw a stress-strain curve using engineering stress.

4. (2 points) Find the yield strength using a strain offset of 0.002.

5. (3 points, tiebreaker) Calculate the shear modulus.

# 3 Hysteria!

6. (2 points) As load is applied, the stress-strain curve takes a certain path; however, during unloading, the stress-strain curve doesn't retrace its path. Identify and explain this phenomenon.

7. (3 points) Draw the unloading true stress-strain curve on your graph for problem 2.

8. (1 point) What does the area between the loading and unloading curves represent?

## 4 A creepy problem

9. (5 points) Suppose a constant load of 10 N is suddenly applied to one of the strands. Using the Kelvin-Voigt model of viscoelastic materials, predict how long it would take for the strand's length to double as a function of the viscosity $\eta$. Show which strand was used.

## 5 Chemistry problems from a physicist

*For problems 10-12, assume that the lab is at* $23^\circ C$.

10. (4 points) The Flory theory of rubber suggests rubber elasticity is governed by entropy changes. Assuming entropy changes linearly with stretch, find the change in entropy per unit change in length. Specify which strand was used.

11. (5 points) Find the molecular mass between crosslinks using your data and previous answers.

12. (3 points) For the thick strand, what is the average force per polymer chain for a load force of 10 N?