MEAM 147 Post-Lab 1

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Essential Lab Skills: Measurements, Movies, and MATLAB

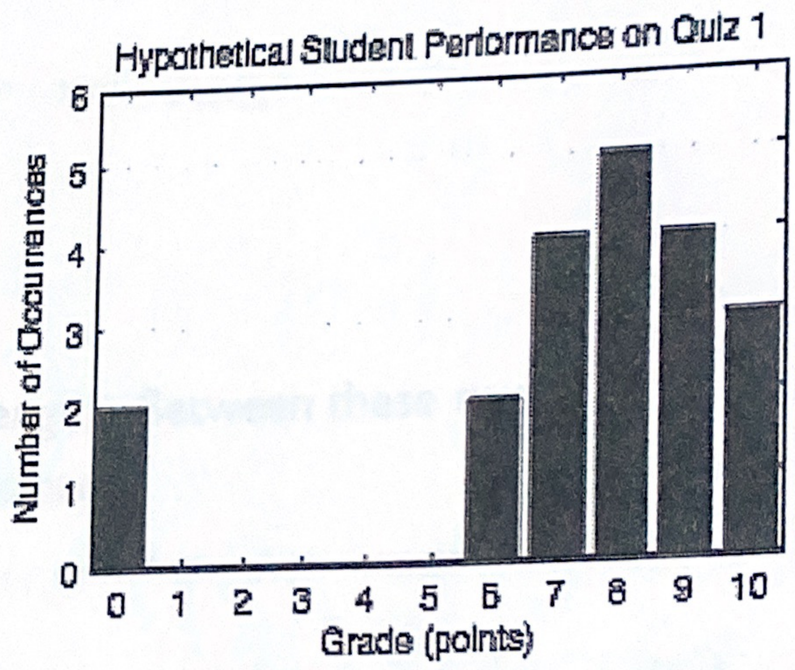
Introduction to Mechanics Lab

University of Pennsylvania

Complete this assignment in paper form, writing out your answers for each question below. You may talk with other students about this assignment, use a calculator and other tools, ask the teaching team questions, and consult outside sources; however, what you write down must be your own work. On computational problems, please show all steps and box your answer.

Please do not attach it to your lab, as these two assignments are graded separately. Late submissions will be penalized by 10 points for each day that transpires between the deadline and your submission. This assignment is worth a total of 50 points.

1. The MATLAB plot at right shows a hypothetical set of quiz grades. We can view this information as 20 measurements of MEAM 1470 student preparedness, where the quiz is the measuring instrument. We will call this preparedness variable , and it has units of points. What is , the arithmetic mean of this full data set? *(4 points)*



$$\frac{2\times0+2\times6+4\times7+5\times8+4\times9+3\times10}{20}$$

$$= \boxed{7.3 \text{ points}}$$

2. What is , the standard deviation of this full data set? *(4 points)*

calculator: $S_x = \boxed{2.77 \text{ points}}$

3. Do you trust the above values of and to be good estimates of the population mean and population standard deviation for student preparedness on this hypothetical lab? Explain why or why not. *(3 points)*

Yes, because it shows how comfortable students are with the material and how much that may vary.

4. When you experimentally measure something several times, which value is most important? The first one? The one that matches your predictions? Explain your answer. *(3 points)*

The value that is important is the average of all measured values, not including measurement blunders that are far from other values

5. Both a dial caliper and a steel ruler can be used to measure length. Between these two options, when would the dial caliper be a better choice? *(3 points)*

The caliper would be a better choice when more significant figures (more precision) is needed (like needing to measure on the order of 10^{-3} in)

6. Between these same two options, when would the steel ruler be a better choice? *(3 points)*

Use a ruler when less precision and sig. fig.s are needed (or the order of 10^{-1} in).

7. Imagine you are setting off on a walk along the shore are starting at your hotel in Clarens, and you want to get to the Chillon Castle (Château de Chillon). Your guidebook says it is a 2.0 kilometer walk from Clarens to the resort town of Montreaux, but it does not say how much farther you have to go to get to the castle. Over breakfast, an American tourist tells you it's about a two mile walk from Montreaux to the castle. Assign appropriate uncertainties to these measurements and combine them to get a good estimate for the length of your upcoming walk, in kilometers. Remember to propagate your measurement uncertainties. Briefly discuss why you assigned the relevant uncertainty to each measurement. *(7 points)*

Uncertainty for 2.0km = $0.2 \times 0.1\text{km} = 0.02\text{km}$

Uncertainty for 2mi = $0.2 \times 1\text{mi} = 0.2\text{mi}$

Total = $2.0\text{km} \pm 0.02\text{km} + 2\text{mi} \pm 0.2\text{mi}$

↓ mi → km

$= 2.0\text{km} \pm 0.02\text{km} + 3.2\text{km} \pm 0.32\text{km}$

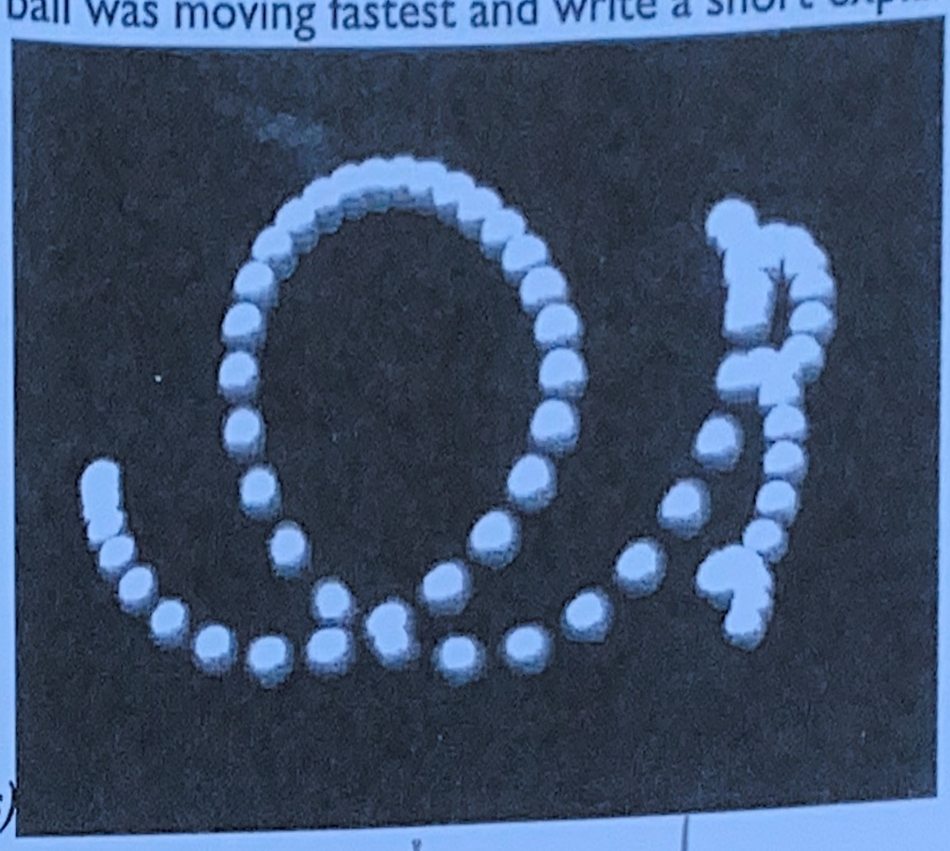
$\Delta\text{Total} = \sqrt{0.02^2 + 0.32^2} \approx 0.32\text{km}$

$\text{Total} = 2.0\text{km} + 3.2\text{km} = 5.2\text{km}$

$\Rightarrow \boxed{5.2\text{km} \pm 0.32\text{km}}$

To assign uncertainties to the given measurements, I multiplied the smallest measurable order of magnitude (ex. 0.1km for the 2.0km measurement) by 20%.

8. The picture below was created by overlaying all of the frames from one movie. The object in the movie is a standard ping pong ball, and the movie was shot at 29.97 FPS. Circle the region of space where the ball was moving fastest and write a short explanation of how you figured that out. *(3 points)*



Each image of the ball is more spaced out here, meaning it moved further in the time between each frame. Therefore, it had a higher speed here.

9. Calculate the maximum speed of the ping pong ball in the image above(A ping pong ball is 40mm in diameter, use this as your scale). Provide your answer in meters per second and ignore uncertainty for the moment. Clearly write down all of your measurements, show all of your steps, and box your answer. *(6 points)*

$$v\left[\frac{m}{s}\right] = \frac{d[m]}{t[s]} \qquad t[s] = \frac{1\ [frame]}{29.97\ [frame/s]} \approx 0.033\ [s]$$

$$d[m] = d[px] \times \frac{x\ [m]}{P[px]}$$

Assume 0.04m = 30px, ball moved 60px in 1 frame

$$d[m] = 60[px] \times \frac{0.04\ [m]}{30\ [px]} = 0.08\ [m]$$

$$v[m/s] = \frac{0.08[m]}{0.033[s]} \approx \boxed{2.4\ m/s}$$

10. Your answer to the previous question was calculated from several uncertain measurements. Follow the rules presented in the lab workbook to calculate the uncertainty of this ball speed estimate. Show all of your steps, and box your answer. *(6 points)*

≈6px blur ⇒ uncertainty from blur = $6\,px \times \frac{0.04m}{30px} = 0.008m$

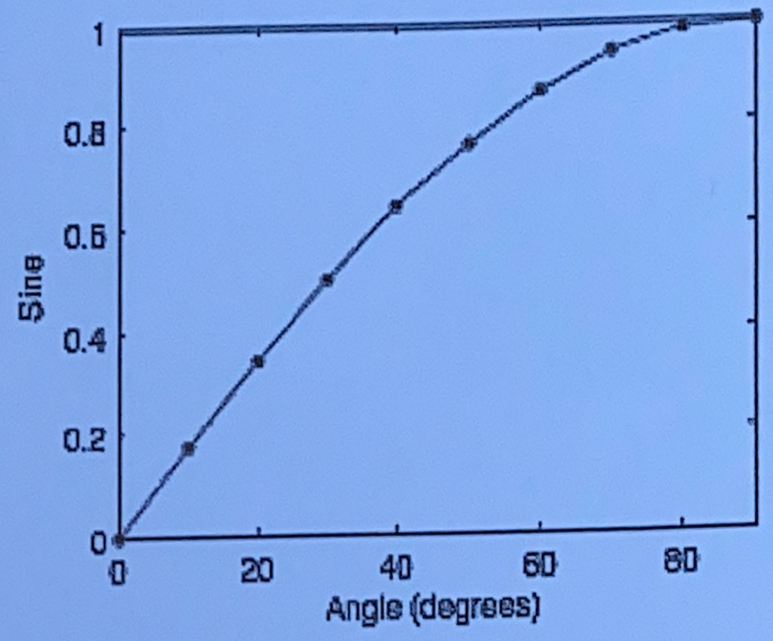
$\Delta v = v\sqrt{\left(\frac{0.008_m}{0.08m}\right)^2} = 2.4 \times 0.1 = 0.1$

$\Delta v = \pm 0.1 m/s$

11. Write out a list of MATLAB commands that would plot a group of points on the sine function from 0 degrees to 90 degrees. For example, creating the plot at right would be a good goal. *(8 points)*

```
x = linspace(0, 90, 9);
y = sind(x);

plot(x, y, 'bo-')
axis([0 90 0 1])
```



For 2 bonus points, you can run your commands in MATLAB, fix any errors, publish the script, print out a copy of your successful graph/code, and submit it