Experiment IX — The Culminating Lab

What will happen in the culminating lab?

For the Culminating Lab, you will be given 20 questions, which you have to answer. You will be allowed to bring a calculator and use the computers, but you will not be allowed to use your lab manual or notes. We will provide you with a summary of common formulas, which arise in error analysis. The questions will be taken at random from the set below. Also, some of the problems listed below contain specific values for a measured quantity; you should expect that the problems you receive will have different values.

How to Prepare for the Culminating Lab

Read over the sample questions in each section.

If you don't understand a question or how to answer it, read the lab write-up or your lab report to refresh your memory.

The week before the Culminating Lab, all the experiments will be set up in the lab. This is your chance to remind yourself what the apparatus looks like and how to do the measurements. Also, the TA's will be available to answer any of your questions.

(Experiments 1-4 omitted here)

Experiment 5 (Tilted air-track)

1. In a few sentences, explain what this experiment was meant to demonstrate.
2. Explain how the sonic ranger works.
3. Suppose the air-track is tilted at an angle of 0.01 radians from level, what will be the acceleration of a friction-less cart?
4. What is the relationship between the tilt of the air-track and the acceleration of the cart? Make sure to define all of your variables (a sketch may be helpful).
5. If a 1 cm block is placed under one leg of the air-track, find the angle at which the air-track tilts.

6. If a 1 cm block is placed under one leg of the air-track, find the acceleration of a friction-less cart.

7. If a 1 cm block is placed under one leg of the air-track, how long will it take a cart to reach the bottom of the track? Assume that the cart starts at rest at the top of the track.

8. If a 1 cm block is placed under one leg of the air-track, how fast will the cart be going when it reaches the bottom of the track? Assume that the cart starts at rest at the top of the track.

9. Make sketches of the position versus time and velocity versus time for a cart, which is let go at rest from the top of a tilted air-track.

10. Make sketches of the position versus time and velocity versus time for a cart, which is started at the bottom of the track with an initial velocity up the track. That is, what was it used to demonstrate or prove.

11. The table below lists the position versus time for a cart moving on a tilted air-track. Use the spreadsheet to calculate and plot the velocity versus time and acceleration versus time. Print out your spreadsheet and graphs.

t (sec)	x(m)	t (sec)	x (m)
0.0	1.00	0.6	2.20
0.1	1.45	0.7	2.10
0.2	1.80	0.8	1.90
0.3	2.10	0.9	1.53
0.4	2.20	1.0	1.10

12. A cart starts at x = 0.5 m with an initial velocity of 1 m/sec heading up the air-track. Assuming that the air-track is tilted at 0.01 radians, use the spreadsheet to calculate and plot the position versus time and the velocity versus time of the cart. Print out your spreadsheet and graphs.

Experiment 6 (Centripetal Force and Acceleration)

1. In two or three sentences, briefly describe the purpose of this experiment, that, what was it used to demonstrate or prove. Explain what each of these parts of the apparatus is used for: the hanging mass, the spring, the rotating arm, and the mass and pulley.

2. How is the rotational frequency related to the mass if the centripetal force is constant?

3. Explain how you can find the spring constant. Measure it.

4. How precisely can the period of one revolution be determined if 20 revolutions are measured.

5. Explain the difference, if any, in the precision between measuring the period by counting 40 revolutions once and counting 10 revolutions four times and averaging. (assuming a fixed timing error for each measurement.)

6. Explain why we line up the pointer under the free hanging mass.

7. What effect could a very massive spring have?

8. What would be the effect on the calculation of the force from measuring the rotation rate with the mass a small amount out from vertical. (i.e. why would the force be wrong?)

9. A student finds that rotational frequencies of 1.2 Hz, 0.84 Hz, 0.7 Hz and 0.6 Hz are needed to align the pointer with masses of 100 gm., 200 gm., 300 gm, and 400 gm, respectively. Use the spreadsheet to make a log-log plot of the rotational frequency versus the mass and find the slope of the resulting straight line (hint: plot the log of the frequency versus the log of the mass rather than the spreadsheet's log plotting option). Include a hard copy of your plot and don't forget to find the slope.

Experiment 7 (Ideal Gas Law)

1. In two or three sentences, briefly describe the purpose of this experiment, that is, what was it used to demonstrate or prove. Be sure to explain what each of the two apparatus were used for.

2. How precisely can you measure temperature in the Charles law apparatus? How precisely can you measure the pressure?

3. In the Boyle's law apparatus determine the volume of the air in the gauge.

4. Explain how we can use the Charles' Law apparatus to determine the absolute zero.

5. Suppose that the temperature of the bulb in the Charles' law apparatus increases from 0 °C to 100 °C. By how much will the pressure increase?

6. To what temperature would you have to raise the Charles law apparatus so as to double the pressure? (Assume the apparatus starts at room temperature).

7. Using the Boyle's law apparatus, a student finds volumes of 40, 30, 20, and 15 cm^3 at pressures of 7.5, 10, 15, and 20 $lb/in.^2$ Use the spreadsheet to make a log-log plot of P versus V and find the slope of the resulting straight line (hint: plot the log of P versus the log of V rather than using the spreadsheets log plotting option.). Does the data agree with Boyle's law? Briefly Explain.

8. Using the Charles' law apparatus, student finds pressures of 760, 950, and 690 mm Hg at

temperatures of 26 °C, 100 °C, and 0 °C. Use the spreadsheet to make a plot of P versus T and find the slope of the resulting straight line. Does the data agree with Charles's law? Briefly Explain.

9. How could you check that the thermometer is correctly calibrated at 0 °C?

10. Without using a thermometer, how can you establish a temperature of 100 °C?

11. Using the thermometer accurately, measure room temperature and estimate the uncertainty in this measurement. Be sure to give proper units.

Experiment 8 (Equipotentials and Fields)

1. In two or three complete sentences, briefly describe the purpose of this experiment.

2. What was this apparatus used to demonstrate?

3. In one or two sentences, explain what an equipotential line is.

4. Suppose you have measured the electric potential at several different places, explain how you can find the electric field.

5. Load a clean sheet of paper into the top of the apparatus and attach the current board which consists of the two points (an electric dipole) to the underside of the apparatus. Using the probe, map out on the sheet of paper the equipotential curves at 1/2 and 1/4 with the DC supply voltage set at 7.0 V. You should do at least 10 points for each curve so that you can clearly see the shape and position of the two curves.

6. Load a clean sheet of paper into the top of the apparatus and attach the current board which consists of the two parallel lines to the underside of the apparatus. Using the probe, map out on the sheet of paper the equipotential curves at 3 V and 5 V with the DC supply voltage set at 7.0 V. You should do at least 10 points for each curve so that you can clearly see the shape and position of the two curves.

7. Load a clean sheet of paper into the top of the apparatus and attach the current board which consists of the two points of a point and a line to the underside of the apparatus. Using the probe, map out on the sheet of paper the equipotential curves at 1 V and 2 V with the DC supply voltage set at 7.0 V. You should do at least 10 points for each curve so that you can clearly see the shape and position of the two curves.

8. Load a clean sheet of paper into the top of the apparatus and attach the current board, which consists of a U-shapes line to the underside of the apparatus. Using the probe, map out on the sheet of paper the equipotential curves at 2 V and 6 V with the DC supply set at 7.0 V. You should do at least 10 points for each curve so that you can clearly see the shape

and position of the two curves.

9. Shown below is a sketch of the equipotential lines around a charges object. Assume that the surface of the object (the dashed region) is an equipotential surface and that each equipotential contour differs by 0.1 V from adjacent contours, with the object being at the highest potential. Sketch the electric field lines from the object (make sure you draw at least 8 field lines, with some drawn above, below, to the left, and to the right of the object). *Note: objects you find in the exam may have different size or shape.*