Physics 211

WHAT TO KNOW FOR THE LAB EXAM

This sheet is intended as a resource for you as you prepare for the laboratory portion of the final exam in PHYS 211. Each of the experiments you performed this semester is listed, along with a summary of things you should know from each experiment. In addition, one set of each of the experiments will be available in Olin 260 starting Friday, December 5. The lab will be open Fri. 1-4, Mon. 9-12 & 2-5, Tues. 9-12 & 1-4, Wed. 9-12 & 1-4, and Thurs. 9-11 with TAs available to assist you.

GENERAL. Know how to determine the uncertainty in a calculated quantity due to the uncertainty in a measurement. Know how to combine uncertainties due to independent measurements. Know how to express results with the correct number of significant figures. Understand how to interpret uncertainties when comparing two experimental results or when comparing an experimental result to a theoretical prediction.

1. **REPRESENTING MOTION.** Be able to interpret graphs of position, velocity, and acceleration; know both the graphical and analytic relationships between position, velocity, and acceleration. Be able to describe the motion related to these graphs.

2. **STATIC EQUILIBRIUM.** Know how to add vectors with known magnitudes and directions. Know how to determine the uncertainty of a net force from the uncertainty in each of the measured quantities.

3. **NEWTON'S SECOND LAW.** Use Newton's second law and force diagrams to determine accelerations and tensions for one- and two-body problems. Know how to relate acceleration to position vs time and velocity vs time graphs. Understand how the motion is affected by changes in the mass and variations in the angle.

4. **AIR DRAG ON A FALLING OBJECT.** Apply Newton's second law to an object subject to gravitational and drag forces. This includes being able to draw force diagrams, and to sketch and interpret the position, velocity, and acceleration graphs. Understand how to analyze data to extract the coefficients in a damping force expression. Be able to recognize terminal velocity from a velocity vs time graph.

5. **INTRO TO THE OSCILLOSCOPE.** Know what quantities are displayed on an oscilloscope screen and how these quantities are used and interpreted in various experiments. Make and interpret sketches of waveforms to illustrate the functions of the major controls: vertical sensitivity (Volts/div), sweeptime (time/div), and trigger level and trigger slope. Know the effects of triggering on the signal of channel 1 or channel 2. Also know when it is important to trigger on a source other than the main signal displayed on channel 1 or channel 2. Be able to determine the period of a signal and calculate its frequency.

6. **NUMERICAL SOLUTION: FALL WITH AIR DRAG.** Understand how an equation of motion (Newton's second law) can be solved using numerical iteration, and know when the approximations are valid. Know how to calculate future positions, velocities, and accelerations of an object given the present values for position, velocity, and acceleration, and the force law.

7. **RELATIVISTIC MOMENTUM AND ENERGY**. Know how to interpret a bubble chamber photograph and be able to identify tracks corresponding to a collision. Calculate the momentum and/or energy of a charged particle that leaves a track in a bubble chamber given the track radius and momentum of a known particle. Apply relativistic conservation laws to collisions and calculate the momentum, energy, and/or mass of an unseen neutral particle.

8. **STATISTICAL UNCERTAINTIES.** Understand the distinction between the spread of measurements (measured by the standard deviation, *s*, of the measurements) and the uncertainty of the ***mean*** for the same set of measurements (measured by the standard deviation of the mean). Know how to express a value and its uncertainty with the correct number of significant figures and be able to interpret the reported measurement. Know that approximately 68% of the measurements in an experiment are expected to lie within one standard deviation of the true mean.

9. **SPEED OF SOUND AND LIGHT.** Understand the experimental set-up that allows the speed of sound/light to be measured. Sketch the source waveform and the detected signal waveform seen on the oscilloscope. Know what happens to the waveforms when the path length is changed. Compute the speed of the wave from the waveforms as they appeared on the oscilloscope and the distances between the speakers, or the laser, mirrors, and detectors.

10. **ABSOLUTE ZERO.** Describe the general experimental set-up that allows the absolute zero of temperature to be determined. Given pressure and temperature data, use the graphical method to determine the absolute zero of temperature. Be able to distinguish between statistical and systematic errors. Understand how systematic errors affect your measurement of absolute zero temperature.

11. **ENTROPY.** Know the difference between a macrostate description and a microstate description as used in the lab. Know what the pegs and the washers represent in the model used in the lab. Be able to list possible macrostates and all possible corresponding microstates. Understand how to represent an interaction and energy exchange in this model. Calculate *W* (the number of microstates) and *S* (the entropy) for a given distribution of washers on pegs. Describe what can be learned from an *S* vs *t* graph and an $\langle n_j \rangle$ vs *j* histogram.

12. **MEASUREMENT OF *g*.** Know what must be measured to determine *g*. In particular, given a set of measurements of the time for a given number of swings, calculate the period *T* and its uncertainty. Know how to propagate uncertainties in both period and length of the pendulum to the overall error in *g* and understand what actions could be used to reduce the overall uncertainty.

The following equations will be provided on the laboratory portion of the PHYS211 final exam:

$$\Delta g_T = g(L, T + \Delta T) - g(L, T) \qquad \Delta g = \sqrt{(\Delta g_L)^2 + (\Delta g_T)^2} \qquad g = \frac{4\pi^2 L}{T^2}$$

$$s = \sqrt{\frac{1}{N}\sum_{i=1}^{N} \left(x_i - \langle x \rangle\right)^2} \qquad \text{standard deviation of the mean} = \frac{s}{\sqrt{N}}$$

$$PV = NkT \qquad x_{\text{new}} = x_{\text{old}} + v_{\text{old}}\,\Delta t \qquad v_{\text{new}} = v_{\text{old}} + a_{\text{old}}\,\Delta t \qquad f = \frac{1}{T}$$

$$W = \frac{N!}{n_o!\,n_1!\,n_2!\cdots} \qquad p = kR \qquad E^2 = p^2 + m^2$$