Pre-lab questions:

I. Measurement of e/m for electrons

1. Look up the magnitude and direction of earth’s magnetic field in Minneapolis. Write expressions for the total field (magnitude and direction) at the center of the Helmholtz coils in terms of quantities you will measure in the lab.
2. How many independent voltages will you use in this experiment? Briefly describe the function of each.

II. Photoelectric effect

1. What is the purpose of calibrating the monochromator? What are the sources of error in this process and how do they affect the result of the calibration?
2. What are the sources of error in part-B of the procedure, while you are measuring the electron energy as function of incident wavelength? In particular, what are additional sources of error in the wavelength of light, which were not present in part-A? What are the sources of error in the electron energy measurement?

III. Photon counting statistics

1. Toss 10 identical coins for 50 times. Record the number of heads being up for each toss. Plot the histogram of your results. Does the resulting distribution look like a Gaussian or Poisson distribution?
2. Increasing the bias voltage across the SiPM makes it easier for an electron to be "liberated", causing the detectable avalanche signal seen in a photon event. What disadvantages might there be with a high bias voltage? Hint: What sources of background might be present here?

IV. Counting statistics & radioactive decay

1. For the Geiger counter, sketch a graph counting rate vs tube voltage. On this graph, label any points or regions where:
   - You should operate the tube
   - The tube may be damaged
   - The slope is zero
   - There are any asymptotes

   If any of the above does not apply/exist, indicate this with a brief note in the margin. Include on your graph any voltage values (relative or absolute) that the lab manual gives you.

2. In part B, why must you know the time when the Br sample was removed from irradiation? Which of your measured parameters are sensitive to the irradiation end time and which (if any) are not? Why?
   Hint: how is t=0 defined in the data acquisition?

V. Semiconductors: Ge bandgap and the Hall effect

Band Gap:

1. What are the sources of error in your temperature measurement and how can you minimize them?

Hall Effect:

1. In figure-6, what are the purposes of Philips PM2525 voltmeters and the ammeter next to the power supply HP62234A?

VI. Blackbody radiation: A spectroscopic study

1. The lab manual mentions that the 2D array of a CCD is sampled after a set integration time. Why is this integration time necessary? How will changing the CCD integration time affect the resulting intensity histogram of your data?
2. In part A section 3 of the procedure, you are given the equation $\rho = 0.0264(T-60)$ $\mu\Omega$cm and are told that this can be used to find an expression for T which depends on the ratio of the filament's resistance at temperature, T, to its resistance at room temperature. Explain how to do this.

VII. X-ray crystallography

1. What is the Bragg equation? Differentiate this equation to get δd as a function of $\delta\theta_{\text{Bragg}}$.
2. There is a mistake in the $dI/d\lambda$ vs. λ plot. Can you identify it?

VIII. Millikan oil-drop experiment

1. The lab manual says, "Before you begin your experiment, calculate the time it will take for a 1 μm diameter sphere to fall a distance of 1 mm and how long it will take for such a sphere to reach terminal velocity." Do this calculation keeping in mind the correction to air viscosity mentioned near the end of this lab.
2. Explain how vibrations and convection currents might affect your experiment. How might the lab manual's suggestion help mitigate this?

IX. Helium energy levels

1. Under what condition(s), the E_1' and E_1 obtained from the collector current vs. electron energy plot will have this simple relation: $E_1' = 2*E_1$. After acquiring experimental data, what is the proper way to determine the first excitation energy?
2. What should the proper value of the filament voltage be used? Why a higher value of the filament voltage should not be used?

X. High-resolution spectroscopy of hydrogen and sodium

1. As suggested in the manual, provide a table of the 25 or 30 strongest mercury lines that you expect to use in your calibration. Hint: copy / paste the NIST data into a spreadsheet, then sort by the appropriate column.

2. Find an expression for $\Delta\lambda$ in terms of the appropriate uncertainties from your calibration equation. Given $\Delta\lambda$, find an expression for the uncertainty in the Rydberg's constant, ΔR_H. What physical parameters might affect the refractive index of the air inside the spectrometer? Do you expect their effects to be negligible ($\Delta n \sim 0$)?

XI. Zeeman effect

1. Why is the observation angle with respect to the direction of the magnetic field important?
2. What are the important differences in the set up for the Normal versus Anomalous Zeeman effect?