PROTOCOL

(1) Laboratory Report

To prepare a laboratory report correctly, students are advised to follow the guidelines given here. These instructions are designed (1) to ensure uniformity for laboratory reports, and (2) to help minimize errors and omissions.

A technically correct report will earn 95% points. This is to emphasize the fact that real life work, no matter how good, is not perfect. Additionally we want to encourage students to show their understanding of the experiment *and* their interest in the work. This can be done by doing things **in addition to** what is required. The experiment can be extended, additional graphs may be plotted or some other aspect of the experiment may be highlighted. In all such cases, the student will be awarded points over and above the limit of 95/100. It should also be pointed out that the limit set here is not to curb the potential of earning an *A* grade in the course. If students consistently keep earning 95 points, they *will* be awarded an *A* grade.

NOTE: Because of a change in protocol, we encourage partners to work as a team. The part, *What I learned in this lab* will be a joint effort. The two reports will, therefore, be very similar (though not identical). This will not be objectionable. Some individuality will be appreciated.

Table 1: Preparing a Report

#	Description	points
1	***Cover Page***: This page will include name of experiment, student' name, name of the partner, course name, section number, table number and the date.	2
2	***Principle***: A brief statement of *Principles* should be given. A defining diagram, wherever applicable, is also required. The final equation, which represents the principle mathematically, should be given and numbered. No discussions or derivations are required.	5
3	***Objectives****:* Students should copy the *purpose* or the *objective* of the experiment from the manual. If it has been modified by the instructor, then the modified *objectives* should be written down.	2
4	***Setting Up****:* For each part of the *objectives,* students should only *describe* the technique used in the experiment (for that part) to convert the equation from the *Principles*, into the equation of a straight line (or a second order polynomial) and then write the final equation. All steps of derivations need not be given. Points will be given for writing *correct* technique, for each part of the experiment. A diagram of the experimental set up is required. It should be given after the setting-up and before the procedure.	8

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#	Description	points
Please note that there is no separate section, called *Diagrams.* Diagrams should be given where they belong. If a diagram is required for the *Principles* part, it should appear there. If it is suitable for the *Setting-up* section, it should appear in the *Setting-up* section. A sketch of the experimental arrangement of the apparatus used is needed. Circuit diagrams for electricity experiments are a must! Diagrams need not be made professionally, but still these should be made with due care and attention. A ruler should be used to draw neat diagrams. *Under no circumstance should all diagrams be lumped together and dumped in one place*		
5	***Procedure***: Students should write, in their own words, in a concise manner, how they performed the experiment. *It need not be a detailed description of how you performed the experiment.*	5
6	***Data***: Students should enter all data taken in the laboratory during the experiment, in the data sheet(s) provided in the manual. Data should be treated with *respect*. It is a very important part of experimentation. Data is a *sacred* entity. It is *fact*; which, if reliable, truthful and repeatable, may override *expected outcome* of the experiment.	15
Because of the way experiments are designed, calculations are divided into *pregraph* and *post-graph* calculations. Students must not mix them up and each type of calculation should be given in its own place.		
7	***Pregraph Calculations****:* Calculations that convert laboratory data into (x,y) tables for plotting graph(s) are *pregraph* calculations. These calculations must be shown. If these are of a repetitive nature, sample calculations only should be given. Tables of (x,y) values should be made on the computer and a printout *must* be included in this section of the report. If pregraph calculations are done on the computer, the computer printout will replace ***Pregraph Calculations***. It should be attached to the report.	7
8	***Graphs****:* Graphs must be plotted using a computer. The computer should be asked to calculate and display the straight line equation ***with a large number of decimal places***. Values of slope and intercept will be read from this equation. The computer must also be asked to calculate and display the r^2 value for each straight line. The size of the graph should be adjusted to cover the entire page. The title of the graph and the x,y axes labels should be pulled inside the boundary of the graph. Unnecessary decimal places, in the two **scales**, must be removed.	15
9	***Postgraph Calculations****:* All calculations based on the slope and/or the intercept of graphs are *postgraph calculations.* These must be given after the graph sheets have been introduced in the report. Error calculations are part of post graph calculations. There should be no separate section, called ***Errors***.	8

Table 1: Preparing a Report

#	Description	points
10	***Results*** This is ***the*** most important part of the report. A properly presented result will reflect proper understanding of the experiment. An improper, careless or disorganized ***Results*** section will spoil all the work, no matter how carefully done. *Please be aware of the large and varied deductions applicable to the improper presentation of "Results".* ***Results*** are the answers of ***objectives,*** and (may be) more. First make sure that all that is set forth in *objectives*, has been carried out and so entered in *Results*. Additional items for *Results* may be given after the mandatory part has been completed.	15
11	Write *Conclusions* drawn from the work, and *Discussions* about the experiment. These need not be exhaustive but should reflect your understanding of the experimental work.	5
12	***What I Learned In This Experiment.*** A good, hearty and original discussion (about a page long) is needed. We ask the two partners to sit down and discuss among themselves, what they learned in this class. You may also include things like learning to *use a timer, the role of the photogate, use of the cricketgraph program*. But remember you cannot repeat the same thing for many experiments. You should talk about the techniques used in *setting up* part of the experiment. The field is wide open and we challenge your thinking, ingenuity to compile what you learned. An evaluation of the work that you did is also of importance.	10
	Total	95
Note: If results and / or graphs are totally unacceptable, the report will not be given even a *C* grade! A *C-* or a *D* grade will then be entered		

(2) Errors

Students should note that the equipment and techniques available in this laboratory are capable of producing accurate results. A typical experimental result should match the expected values to within a few percent. In many experiments only a 1% difference is expected. In some others it could be as high as 3%. For each experiment, described in the manual, the instructor will apprise the students of the expected degree of accuracy. Getting accurate results, however, requires careful and systematic table work by the students. If enough care and diligence is not shown, results may be seriously affected which in turn, will lead to high error percentages.

It is important to note that an error in excess of 5% is not acceptable. In case large errors are encountered, students should check their calculations and graphs. If no error is found, students should consult the instructor. If an inconsistency in data is discovered, the instructor may recommend redoing the table work. If no inconsistencies are found, students should then give their opinion as to what went wrong and why. **Errors, in such cases, should not be calculated because they are meaningless!** Obviously one is not comparing apples with apples!

Below are given the formulae for calculating percent error and for finding percent deviation between two experimental values.

$$\%\ \text{error} = \left(\frac{\text{expected - experimental}}{\text{expected}}\right) \times 100 \qquad \%\ \text{deviation} = \left(\frac{\text{experimental (1) - experimental (2)}}{\text{experimental (1) + experimental (2)}}\right) \times 200$$

(3) Results

As stated before, *Results* is the most important part of a lab report.

Following are some guidelines for compiling the *Results* section of the report:

1) All results must be presented under the sub-heading *Results*. This subheading should be followed by the general *title* for results. The necessary title can be inferred from *objectives of the experiment*, or in some cases, from the title of the experiment.

2) *Results* should be given in a table. The table needs to have its own title, different from the general title, described in section (1) above.

3) If the experiment has several parts, the result of each part needs to be given in a table of its own with a sub-title of its own. For these sub-titles one should refer to the *procedure* where a proper title appears for each part of the experiment.

4) The results table should comprise of (a) experimental values (b) expected values (c) percent errors (or deviations).

5) Each entry must have correct MKS units.

6) Each entry must be properly defined or explained. Numbers entered without description or explanation will not be accepted.

7) Never, repeat never use the words *slope* and *intercept* in *Result.* Students must realize that *slopes* and *intercepts* are mathematical properties of graphs and are not physics. Hence *slopes* and *intercepts* and the like, can never be the results of a physics experiment. Slopes and intercepts must be interpreted (i.e. translated) into physics and only the interpretations should be presented as results.

   Similarly mathematical expressions, equations etc., should not be given in *Results.*

8) When writing results for different sections or parts of an experiment, each section or part should be properly described, and students must refrain from writing: *Part A*; *Part B* and so on. Whatever this *Part A* and *Part B* was, must be written down explicitly.

9) *Results* must never be mixed with calculations or discussions. Students must never, repeat never write things like: *Calculations & Results* or *Results & Conclusions / Discussion* etc.

10) *Results* must be given *after* all calculations and *before* conclusions and discussions. There should be no calculations of *any kind* in *Results*.