PHYS 2126 PHYSICS LABORATORY II, FALL 2021
Your first lab meeting is in the week of Monday August 30th.

Professor Contact Information

Instructor:	Lamya Saleh	Instructor:	Paul Mac Alevey
Office:	SCI 3.132	Office:	SCI 3.168
Phone:	extension 5773	Phone:	extension 4634
E-mail:	Lamya.Saleh@UTDallas.edu	E-mail:	paulmac@utdallas.edu

Instructors will send e-mail to UTD e-mail addresses **only**.

Office hours: TAs will be assigned to this course and their office hours have yet to be arranged. Office hours will be posted on the eLearning site for the course. You can also email these TAs with questions that arise during the semester.

Office hours with Dr. MacAlevey are by appointment at SCI 3.168. Office hours with Dr. Lamya Saleh are TBA.

Course Pre-requisites, Co-requisites, and/or Other Restrictions

Any student enrolling in this lab class should either have done or be doing PHYS 2326 (Electromagnetism & Waves), 1302 (College Physics II), PHYS 2422 or equivalent.

Student Learning Objectives/Outcomes

The aims of the course are to encourage:

- Students will think critically & practice reasoning skills[1]
- Students will construct knowledge[2] themselves (rather than getting it from some authoritative source). This requires conducting their own experiments and using their observations to reach conclusions. Fitting curves to data will help analysis of data.
- Students will work in groups of about three. This helps to include the thoughts & opinions of others in the course of reaching a scientific conclusion.
- Students will communicate their conclusions by means of written lab reports.
- Students learn to build scientific models[3] (by actually constructing one)

[1] For those that anticipate doing the MCAT exam, "Reasoning" is regarded as particularly important among the "Scientific Inquiry and Reasoning" skills given in the AAMC document
https://www.aamc.org/students/download/374012/data/mcat2015-cp.pdf

2 Those that have read the recommendations of the American Association of Physics Teachers will recognize that this goal "captures some of the overarching goals of the undergraduate lab curriculum". (From http://www.aapt.org/Resources/upload/LabGuidlinesDocument_EBendorsed_nov10.pdf)

[3] This goal is mentioned in the AAPT document that is mentioned in footnote 1.

Course Description

The course includes experiments electrostatics, electricity in simple circuits, magnetism, and optics. As always in Physics, there is interplay between the theory that you see in a class and experimental work. One is not more important than the other but each informs the other: theoretical predictions are a natural focus of experiment and experimental results help to develop theory. That is why you need to study both. **Expect to see some topics for the first time in this lab course.**

section	days	times_12h	location
101	Monday	1:00pm - 3:45pm	SCI 1.159
114	Monday	1:00pm - 3:45pm	SCI 1.169
134	Monday	1:00pm - 3:45pm	SCI 1.179
102	Monday	4:00pm - 6:45pm	SCI 1.179
115	Monday	4:00pm - 6:45pm	SCI 1.169
120	Monday	4:00pm - 6:45pm	SCI 1.159
601	Monday	7:00pm - 9:45pm	SCI 1.179
604	Monday	7:00pm - 9:45pm	SCI 1.159
103	Tuesday	10:00am - 12:45pm	SCI 1.179
117	Tuesday	10:00am - 12:45pm	SCI 1.169
126	Tuesday	10:00am - 12:45pm	SCI 1.159
104	Tuesday	1:00pm - 3:45pm	SCI 1.159
116	Tuesday	1:00pm - 3:45pm	SCI 1.169
105	Tuesday	4:00pm - 6:45pm	SCI 1.169
131	Tuesday	4:00pm - 6:45pm	SCI 1.179
605	Tuesday	7:00pm - 9:45pm	SCI 1.159
606	Tuesday	7:00pm - 9:45pm	SCI 1.179
106	Wednesday	10:00am - 12:45pm	SCI 1.159
123	Wednesday	10:00am - 12:45pm	SCI 1.179
128	Wednesday	10:00am - 12:45pm	SCI 1.169
107	Wednesday	1:00pm - 3:45pm	SCI 1.169
118	Wednesday	1:00pm - 3:45pm	SCI 1.159
133	Wednesday	1:00pm - 3:45pm	SCI 1.179
602	Wednesday	7:00pm - 9:45pm	SCI 1.169
607	Wednesday	7:00pm - 9:45pm	SCI 1.159
108	Thursday	10:00am - 12:45pm	SCI 1.179
124	Thursday	10:00am - 12:45pm	SCI 1.159
109	Thursday	1:00pm - 3:45pm	SCI 1.159
119	Thursday	1:00pm - 3:45pm	SCI 1.169
127	Thursday	1:00pm - 3:45pm	SCI 1.179
110	Thursday	4:00pm - 6:45pm	SCI 1.179
130	Thursday	4:00pm - 6:45pm	SCI 1.169
603	Thursday	7:00pm - 9:45pm	SCI 1.159
111	Friday	10:00am - 12:45pm	SCI 1.159
121	Friday	10:00am - 12:45pm	SCI 1.179
112	Friday	1:00pm - 3:45pm	SCI 1.169
122	Friday	1:00pm - 3:45pm	SCI 1.159
132	Friday	1:00pm - 3:45pm	SCI 1.179
113	Friday	4:00pm - 6:45pm	SCI 1.179
125	Friday	4:00pm - 6:45pm	SCI 1.169

In accord with the efforts of UTD to de-densify classes in the first few weeks of the semester, the first lab will be done remotely. (Materials for Electrostatics I lab have been posted in the manual on eLearning.)

You will be doing some in person labs. Only come to the physics labs in SCI when your group meets in person and when your section is scheduled to meet. (If you haven't got a group assignment then ask the TA for your section of PHYS 2126.)

Groups of 10 students will meet in the physics labs beginning on Sept 13th as in the schedule below. Notice that group 1 meets in person on Sept 13th. Group 2 meets in person on Sept 20th and group 3 meets in person on Sept 27th. This pattern repeats in the following weeks.

A lab meeting will end 2 hours 45 minutes after its beginning time.

The lab week for PHYS 2126 begins on Monday and ends on Friday.

Each row of the schedule below lists Mondays only. Sections that meet on the following Tuesday, Wednesday, Thursday and Friday will be doing the same experiment as the one listed for Monday.

Lab Week	Experiment
Aug 23	*No labs scheduled this week*
Aug 30	Electrostatics I; Report due **All students do Electrostatics I remotely**. All materials needed are on the eLearning site in the folder called 'Manual for Fall 2021' in the subfolder for Electrostatics I. All students submit the report using the link in the eLearning folder for Electrostatics I by **midnight of Aug 30.**
Sept 6	**University closed for Labor Day –** *No labs scheduled this week*
Sept 13	Electrostatics II; Pre-Lab & Report due All students submit the prelab using the link on eLearning at or before the beginning of the meeting time for their section. **Group 1 meets in person** in the physics labs in SCI. **Groups 2 and 3 do Electrostatics II remotely**. All materials needed are on the eLearning site in the folder called 'Manual for Fall 2021' in the subfolder for Electrostatics II. All students submit the report using the link in the eLearning folder for Electrostatics II by 12:00 PM of the night on which their section meets.
Sept 20	Electricity I; Report due **Group 2 meets in person** in the physics labs in SCI. **Groups 3 and 1 do Electricity I remotely**. All students submit the report using the link in the eLearning folder for Electricity I by 12:00 PM of the night on which their section meets.
Sept 27	Electricity II; Pre-Lab & Report due **Group 3 meets in person** in the physics labs in SCI. **Groups 1 and 2 do Electricity II remotely**. All students submit the report using the link in the eLearning folder for Electricity II by 12:00 PM of the night on which their section meets.

Oct 4	Electricity III; Pre-Lab & Report due **Group 1 meets in person** in the physics labs in SCI. **Groups 2 and 3 do Electricity II remotely** Submission of work is as above.
Oct 11	Electricity IV; Pre-Lab & Report due **Group 2 meets in person** in the physics labs in SCI. **Groups 3 and 1 do Electricity IV remotely**. Submission of work is as above.
Oct 18	Electricity V; Pre-Lab & Report due **Homework on 'Graphs & Trendlines' is *due. Use the link on eLearning to submit it.*** **Group 3 meets in person** in the physics labs in SCI. **Groups 1 and 2 do Electricity V remotely**. Submission of work is as above.
Oct 25	Multimeters; Pre-Lab & Report due **Group 1 meets in person** in the physics labs in SCI. **Groups 2 and 3 do Multimeters remotely.** Submission of work is as above.
Nov 1	Ohm's law; Pre-Lab & Report due **Group 2 meets in person** in the physics labs in SCI. **Groups 3 and 1 do Ohm's law remotely**. Submission of work is as above.
Nov 8	Geometric Optics; Report due **Group 3 meets in person** in the physics labs in SCI. **Groups 1 and 2 do Geometric Optics remotely.** Submission of work is as above.
Nov 15	**Homework on 'Analyzing a circuit' is *due. Use the link on eLearning to submit it.***
Nov 22	**University closed for Fall Break**
Nov 29	*No labs scheduled this week*
Dec 6	*No labs scheduled this week*

Required Textbooks and Materials

We use a manual that **will be posted on eLearning. Questions appear in both the Introduction (if there is one) and Instructions sections of the manual. Answers to questions from the Introduction will be your prelab. Answers to questions from the Instructions will be your report**. Notice that there is no introduction for either electrostatics I or for electricity I and so there is no prelab due for either experiment. **All questions asked have corresponding answer spaces at the end of the instructions for each experiment.**

Suggested Course Materials

You should have a calculator (only be a 'scientific' one is ever needed), pencil and pen.

Assignments & Academic Calendar

Please read the preface posted on eLearning before labs begin. (The preface is included in this syllabus). No prior familiarity with physics labs is assumed. Ask questions during office hours before your lab meeting if needed.

Course Policies

1. Please contact the instructors if a question arises about these course policies. (TAs don't have permission to change these policies.) The syllabus and contact information for all TAs will be posted on eLearning.

2. Your grade is weighted as follows;

   a. 85% of your grade will be your average of grades on Lab Reports. **The Report with the lowest percentage will be dropped**.

   b. 15% of your grade will be the average of grades on Pre-labs & any homework. **The Pre-lab or homework with the lowest percentage will be dropped**

3. Each description of an experiment in the manual includes an *Introduction* and *Instructions*. **Questions that are asked (in bold type) in the *Introduction* must be answered in your pre-lab by each individual student. Templates for pre-labs and for the two homework assignments are posted on eLearning. The template corresponding to the current semester must be used.** (There are no pre-labs for Electrostatics I or for Electricity I.) **Pre-labs or homework assignments submitted on or before the due date will be graded. Any pre-lab or homework assignment must be written individually, using your own voice to answer any question that is asked.** Names & section numbers must appear on any work that is submitted in order that credit can be attributed properly. Your TA is free to insist on this when assigning a grade to the report.

4. **No student is allowed to copy or paraphrase work from any other source and turn it in for a grade.** (See policy #9 for more on scholastic dishonesty.) **All Pre-labs, homework and Reports submitted for grading must be the work of the student named at the top of the Pre-lab, homework or Report. Any work submitted for a grade must be written individually, using your own voice to answer any question that is asked**. Names & section numbers must appear on any work that is submitted in order that credit can be attributed properly. Your TA is free to insist on this when assigning a grade to the report.

5. **Questions that are asked (in bold type) in the *Instructions* must be answered in your Report by each individual student**. **Templates for Reports are posted on eLearning. The template corresponding to the current semester must be used. Reports submitted on or before the due date will be graded.** Please remember that your TA will be grading the Report that you submit. Thus, both the clarity of your work and effective communication are important. Reports will be given credit as indicated (in the template) in brackets after each question. **Any Report must be written individually, using your own voice to answer any question that is asked**. Names & section

numbers must appear on any work that is submitted in order that credit can be attributed properly. Your TA is free to insist on this when assigning a grade to the report.

6. Manuals are in an eLearning folder on the homepage called "Manual for Fall 2021". This manual will contain a folder corresponding to each experiment on the schedule. The folder for each experiment will contain a description of the experiment, photos of apparatus and templates for reports and pre-labs (if due).

7. **For students that have been asked to isolate by the University: I'll post data on eLearning so that you can write a report even though you can't meet in person**

8. **Any late work can only be accepted (at the instructor's discretion) if you send us a doctor's note with contact information.**

9. It is of great importance to you as a student that others perceive your degree as having value. That value is diminished if others suspect that a grade can be obtained through dishonest means. Academic dishonesty also gives me a false picture of the capabilities of the individual that is being dishonest. In a wider context, it gives me a false picture of what can be reasonably expected of my students.

In order to further the objective of eliminating scholastic dishonesty, the University has a student code of conduct at https://policy.utdallas.edu/pdf/utdsp5003. **Students enrolling in the course are bound by this policy**. **Any suspected cases of scholastic dishonesty will be passed along to the Office of Community Standards and Conduct.**

10. In the event of inclement weather etc., check the UTD Web page http://www.utdallas.edu/ for notice of any unexpected closure of the university (in which case, lab will not meet). The university will also announce its reopening after this kind of closure. After UTD has announced reopening of the campus, **look for an *announcement on eLearning*** that will tell you about the schedule for this lab.

11. In previous semesters, then following scheme has been used for generating course grades. If x is a score then,

$x \geq 95$	A+	$70 > x \geq 65$	C+
$95 > x \geq 90$	A	$65 > x \geq 60$	C
$90 > x \geq 85$	A-	$60 > x \geq 55$	C-
$85 > x \geq 80$	B+	$55 > x \geq 50$	D+
$80 > x \geq 75$	B	$50 > x \geq 45$	D
$75 > x \geq 70$	B-	$45 > x \geq 40$	D-
		$40 > x$	F

As we approach the end of the course, TAs can give you an **estimate of your** grade but no grade is official unless given by Dr. Lamya Saleh or Dr. P. Mac Alevey at the end of the semester.

12. In the event of inclement weather etc., check the UTD Web page http://www.utdallas.edu/ for notice of any unexpected closure of the university (in which case, lab will not meet). **After** the **University announces** its reopening, an *announcement on **eLearning*** that will tell you about any revised schedule for this lab.

Preface

The most important goals of these labs are to;

- Give you a chance to construct knowledge yourself (rather than getting it from some authoritative source)
    - Let you think critically & practice your reasoning skills

- Learn to build scientific models (by actually constructing one)

The starting-point is observations made in PHYS 2126 labs of things that actually happen. You will have to pay particular attention to your actual observations because the model of electricity that you construct will be based on them.

What are scientific models?
Scientific models are arrangements of fundamental ideas that explain physical phenomena. The fundamental ideas in the model must be suggested by physical observation. The model must have some predictive power.

I want you to do more than use a model that someone else made. I want you have a hand in coming up with a model. You will do this by making observations and thinking about their significance in relation to other observations that you have made.

An example of a model that you have encountered in physics I is Newtonian mechanics. It probably wasn't presented as a model in your class but is a model nonetheless. It contains three laws that are suggested by observations. (Newton's three laws are the 'fundamental[4] ideas' that are part of any scientific model.) It is an extremely successful model in that Newton's model explains the motion of objects in many circumstances.

Models are built by asking ourselves questions & suggesting tentative answers (often called hypotheses). The hypothesis is scientific if it is subject to comparison with physical reality. (While it may be interesting, any non-testable hypothesis is outside the realm of natural science.) There must at least be approximate agreement between physical reality and predictions made using the hypothesis if we are to accept it as not being false.

Why/How do we practice reasoning and critical thinking skills?

Even if you don't usually think about scientific models, you will still need to think critically about the information that you encounter. You practice critical thinking when you put things together for yourself rather than just going along with conclusions made by other people. (Even though you might set out to reach your own conclusions, you might end up agreeing with the conclusions of other people.)

Critical thinking is easier if you ***make observations yourself*** because you'll know exactly what happened etc. (I try to avoid indirect 'observation' where you have to take my word for it that a certain result/observation is what happens. In this manual, 'observation' always means 'direct observation'.) ***I***

[4] Remember that 'fundamental' doesn't mean 'easy'!

hope that you don't think that I am underestimating your abilities when observations are simple. I'm not. I just want you to be thorough and to be sure of the fundamental observations before your use them to make conclusions. Even though the observations might be simple, it is not easy to use them to make conclusions that help us construct a model.

Implications:

The goals chosen have certain implications.

- *Lab Apparatus must be simple*. This reduces the time needed to figure how any particular measuring device works. Needlessly complicated equipment just puts you in the position of taking the word of someone else that the equipment operates as you are told. Needless complexity makes it very hard to think critically

- *Lab reports have a simple structure*: *in this lab, reports involve writing answers to questions*. Questions on lab reports often involve 'pulling together' several observations so that a useful idea is seen more clearly. The simple structure is intended *to give you time to think critically* and think about the significance of your observations

- We'll concentrate on *systems* (including electrostatics & DC circuits) *in which a small number of fundamental ideas is enough to make a model* that can explain your observations. These systems also have the advantage that it is possible for us to make all the necessary observations with the simple apparatus that we'll use

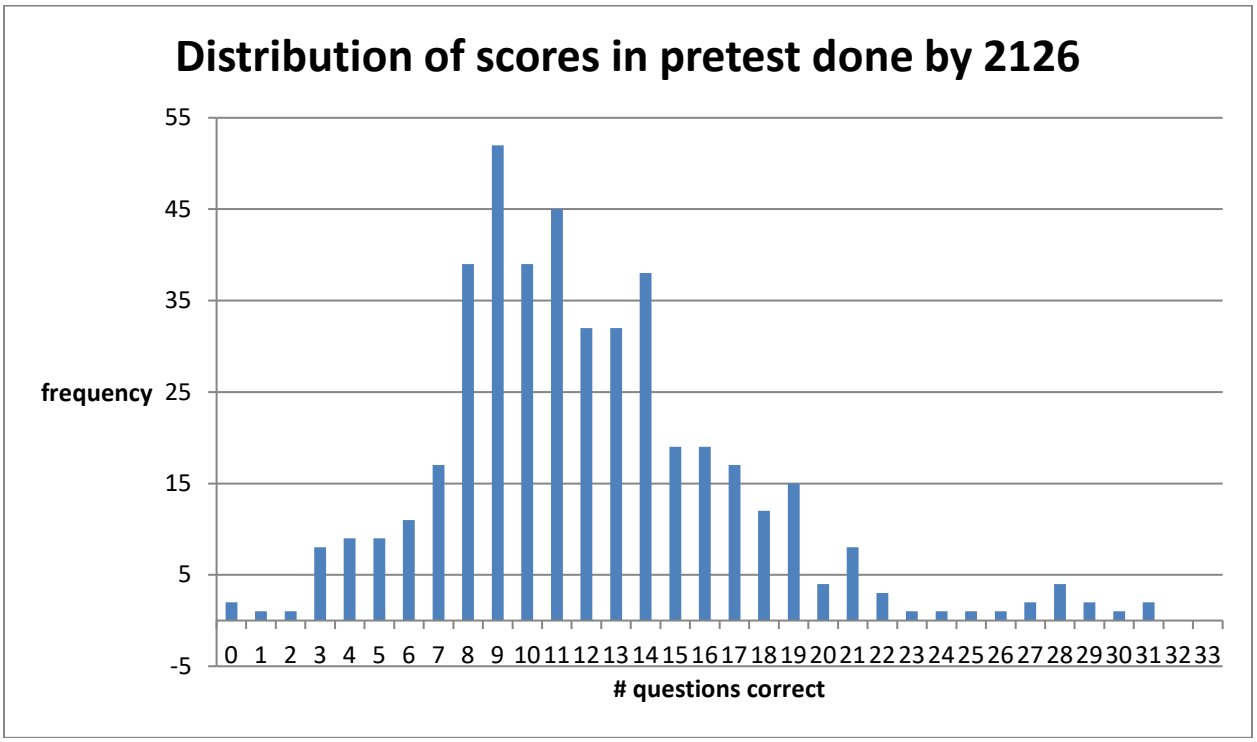
- *'Covering' new material is not a very important goal in these labs*. Actually, the involvement of too much unfamiliar material makes it difficult to think critically and to build models

If we restrict ourselves to observations that we have made then **some familiar terminology will be out of our reach**. Good examples are the terms; **'electrons', 'protons', 'neutrons**', **'voltage', 'current' and 'resistance'**. Observations come before any terminology that explains the observations. Since we won't be directly observing these fundamental particles in this lab, you won't need to use these terms. ***Put these terms aside when you need to explain an observation in this course***. From another perspective, not using these terms won't hinder your explanation of anything that you'll see in these labs. (Of course, all your conclusions will be consistent with electrons, protons and neutrons when you want to explain these 'microscopic' observations later.)

Another difficulty with terminology occurs when we observe electric circuits. All of us have heard of voltage, current and resistance though the meaning of these terms may not be totally clear. The root of this difficulty is probably that you haven't observed circuits directly yourself. Part of the solution involves not using ***the terms voltage, current and resistance to explain anything in these labs***. As above, it will be difficult for most of us to avoid using familiar terminology when trying to describe DC circuits.

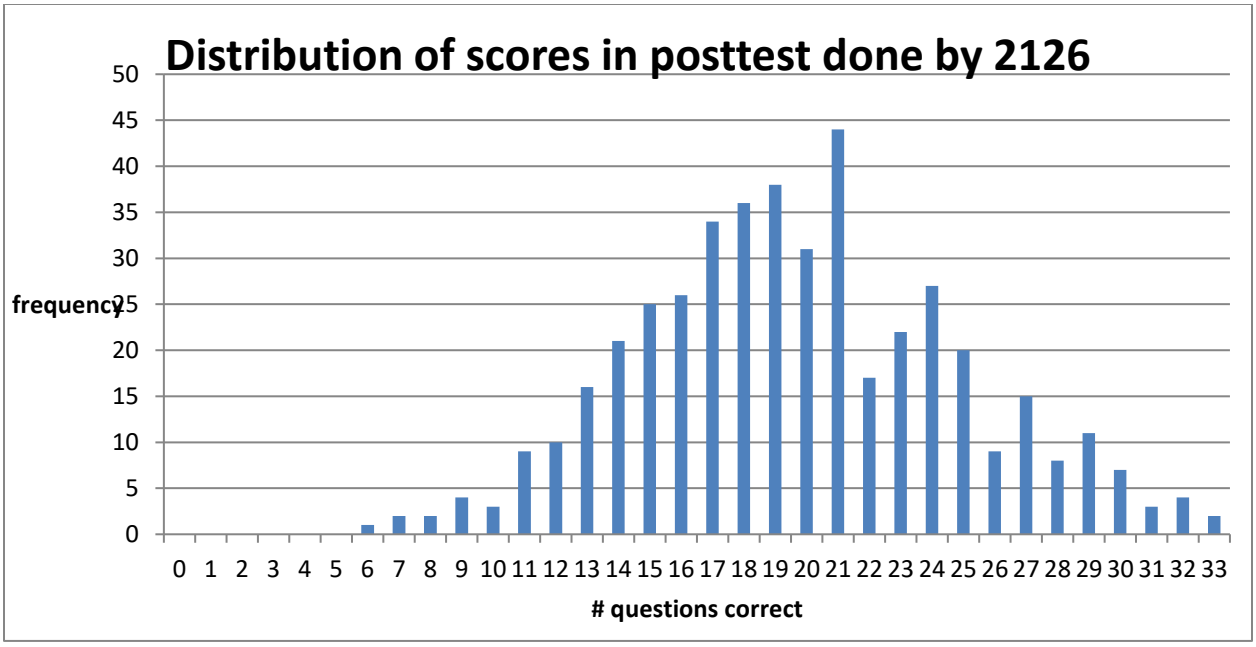
But should we? **Students often ask me why they can't use concepts (such as voltage, current and resistance) that they are already familiar with. The answer is simple: it is frequently the case that the student is familiar with the terminology but doesn't really know much about the underlying concept**. The only way around this is to build the concept yourself from 'scratch'.

Few students have asked me to justify this claim but (true to the spirit of the course) I use observations that I have made myself. Here is a graph from a previous semester of the number of students (the frequency on the y-axis) that get a given number of questions correct in a pretest.



The first thing that you should notice is that the average number of questions answered correctly is about 12 out of 33. (The average is 36.7% $\pm$ 0.7%.) If someone really is familiar with the concepts behind DC circuits then it is quite possible to get all of the questions right. However, only 15 students out of the 447 got more than 22 questions right. The fact that only 15/447 = 3.35% got more than 66% does not suggest mastery of the underlying concepts. ***Be careful; familiarity with terminology is not the same as familiarity with the underlying concepts***.

I don't like pointing out a problem unless I know of a solution. This course can address the problem. A graph of the results in the posttest done by the same 447 students is;



The average is much higher: $60.0\% \pm 0.7\%$ (almost 20 questions correct) with almost half getting 20 or more questions right. (Nobody got fewer than 6 questions right.) These graphs are quite typical of the results that we see in PHYS 2126.

You'll be refining ideas that underlie these terms as you develop a model of electricity. Unfortunately, half-understood ideas about voltage, current and resistance delay your understanding. Using them puts you in the awkward position of not knowing if what you suspect is actually true or if the problem is with partly understood terminology. It is very easy to confuse a fundamental idea with a piece of technical terminology that is often used to describe the fundamental idea. ***A practical solution is to leave those terms aside and temporarily develop a set of 'home-made' terms ourselves***. (I'll help through suggestions and instructions in the manual.) This will put enough 'distance' between the familiar terms and your understanding in order for a better understanding to develop unhindered. After we are sure of our understanding, it will be easy to exchange our terms for the more usual ones. Since you'll have been involved in defining our 'home-made' terms from the beginning, you'll know exactly what they mean. We'll **use these 'home-made' terms until we do the lab called Multimeters**.

Practicalities

I have found it to be useful to return right to the beginning of DC circuits and to take as little as possible for granted. Rather than tell you (again) how DC circuits work, I invite you to put things together for yourself. ***Please have patience with yourself: it is not easy to put ideas together if you haven't had to do this before.*** (This is just as true if the subject matter is dismissed as being 'simple'). I hope that learning the skill in this context will help you to put ideas together in other contexts later.

Make good use of ***office hours***. A quick ***question asked early*** is often all that is needed to make progress on a Pre-Lab. By all means, tell me or your TA if you don't understand something. However, ***complete answers to questions are not helpful. It is important that you grapple with the questions yourself***. Expect any of us to ask you what you think (and why) before saying much more.

Beware of blindly following instructions in the manual. You are not being asked to follow a recipe so don't expect my instructions to be a detailed list of directions. Expect to have to read ahead and think about my instructions before doing anything.

If a question asks you to explain something then an answer of "yes/no" or "I can't explain" is not sufficient. Don't move on until you find explanations for things. Please write neat answers for your TA. This should be easy for questions that involve simple observations or data items. ***For more complicated questions, consider writing your first answer on another piece of paper. Only write your answer on the Report that you'll give the TA after you have thought about your 'draft' answer and are sure that it answers the question that was asked***.

Format of Questions for Lab Reports.

I mentioned earlier that the format for reports is simple in PHYS 2126: you just write *answers to questions*. These questions are designed to lead you through the thought process that I'd lead you through if we were talking to each other. Some questions are about observations that you have made and are not difficult. However, the function of these questions is to remind you of something helpful just before I ask a more difficult question. This is the reason that marks offered for different questions vary so much.

I don't want to put words in your mouth while leading you through a thought process. In many instances I could be more specific in the way a question is asked but only at the cost of telling you the answer to a later question. This puts some limitations of the specificity of my questions.

The requirement that you learn actively means that I have to phrase my questions in terms I know that you are familiar with. Of course, it is easier to ask question when we have access to a set of well-defined & physically useful terms. Those terms will often be unavailable since we will be in the process of approaching an understanding of those useful terms!

At the same time, if you find a better way of asking a particular question then please email it to me.

Comet Creed

This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

"As a Comet, I pledge honesty, integrity, and service in all that I do."

UT Dallas Syllabus Policies and Procedures

The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus.

Please go to http://go.utdallas.edu/syllabus-policies for these policies.

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.