Hands-On Astronomy

A Laboratory Manual

Department of Astronomy
University of Florida

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with assistance from
Dr. Francisco Reyes

TENTH EDITION
Revised and edited by A. Garcia
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AST 1022L: Schedule for Spring Term, 2022

Week Of		No.	Activity	Comments
January	3	-	None	Labs Start Next Week
	10	0	Syllabus/Math Science Basics	Homework Assignment
	17	1	Impact Craters	
	24	2	How Big Is The Sun?	
	31	3	Light Is A Wave	
February	7	4	The Astronomical Telescope I	
	14	5	The Astronomical Telescope II	
	21	6	Modern Photometry and Astrometry	
	28	9	You Can Weigh Jupiter	CLEA Lab
March	-	-	No Labs	Spring Break
	14	7	Astronomical Spectroscopy	
	21	12/8	The Flow Of Energy Out Of The Sun/What Is The Sun Made Of?	CLEA Lab
	28	10	Measuring The Hubble Constant	CLEA Lab
April	4	11	Features Of The Moon	
	11	-	Makeup Labs	
	18	-	Makeup Labs	
	25	-	No Labs This Week	No Final Exam

Night Labs on Thursdays at Campus Teaching Observatory (CTO):

13. Observe The Moon
14. Observe The Deep Sky
15. Observe The Planets

Optional Day-Time Lab At CTO

16. Observe The Sun
22. Space Weather

Note: Some labs require clear skies. If there the weather is overcast, instructors should be prepared to trade dates with in “indoor” lab that does not require a clear sky

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Forward

This manual resulted from a complete two-year revision of the undergraduate astronomy laboratory course, AST 1022. The revision represents an effort to replace the former, rather passive exercise, with real, hands-on laboratory experiments. The 17 original experiments presented here were conceived, tested, and written up by Professor Alex G. Smith. The final design and fabrication of the many pieces of apparatus testify to the skill and dedication of our Observatory Engineer, Mr. John Baker. Dr. Francisco Reyes, who was in charge of the day-to-day operation of AST 1022, contributed ideas through many conferences. None of this would have been possible without the enthusiastic support and encouragement of Professor Stanley Dermott, former Chairman of the Department of Astronomy.

Essential financial support for acquisition of the necessary computers and other equipment was provided by the Department of Astronomy, the office of the Vice Provost of the University, Dr. Gene Hemp, and the office of the Dean of the College of Liberal Arts and Sciences, Dr. Willard Harrison. Our most sincere appreciation is expressed to all who contributed to equipping of what we believe is one of the finest laboratories of its kind.

In the design of experiments, recognition was given to the fact that some AST 1022 students have not had a course in astronomy, much less a course in physics. An underlying goal of the experiments is to teach a little astronomy and a little physics, but most importantly to impart a feeling for the methodology of science. Regardless of their inclinations and future careers, the lives of all students will be impacted *in a major way* by science. Hopefully we can help them to see that science is *not* a mass of "laws" engraved in stone and carried down a mountain by an old man with a white beard. Hopefully they may come to appreciate science as a very human endeavor, an ongoing process, carried on by people like themselves, and subject to the limitations and errors of all human endeavors. Three of the exercises are computerized, rather realistic simulations of observations made at a major astronomical observatory. Not only do these exercises impart some feeling for such observations, but they give the student practice in running scientific applications on a computer. The simulations were developed under Federal sponsorship at Gettysburg College.

A very key role in the laboratory is played by our carefully selected graduate teaching assistants. These teachers will provide necessary background information for each experiment. They will provide one-on-one assistance to students who need help in operating unfamiliar apparatus, and they will assist students in interpreting and evaluating their results. Students are urged to take full advantage of this available individual tutoring in a small-class environment.

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Acknowledgements

Several improvements and additions have been added to the AST-1022L lab manual over several years from contributions, corrections and comments from the instructors of the course. We would like to thank all of the instructors for their contributions and a special thanks in particular to Eric McKenzie, Todd Vaccaro, Aaron Grocholski, Vera Boonyasait, Cynthia Gomez, Justin Schaeffer, Robert Morehead, Kelsey Jorgenson, James Hotchkiss, Rebecca Pitss, Shivani Shah, Savannah Gramze, and Alex Garcia.

We wish to thank Professors Steve Eikenberry and Veronica Donoso for their corrections, suggestions and comments regarding the text of the lab manuals and their critical comments regarding the subjects and material of the experiments.

Laboratory Guidelines

No one likes rules – not even college professors. However, history and common sense show that rules are the cement that keeps civilization from disintegrating into total anarchy. The following suggestions, far from being arbitrary, are the result of many years of experience. They are designed to be fair to all, and to give you the most enjoyable and profitable experience.

Maintenance Of The Lab

We are fortunate to have an attractive and well-equipped laboratory – one of the best of its kind. Let's keep it that way. An important rule: **NO FOOD OR DRINKS ARE ALLOWED IN THE LAB.** Is these mere peevishness? No! Sad experience has shown that food and, especially, drinks inevitably result in ugly stains on carpets and benches. Crumbs and liquids are not good for computer keyboards or other delicate equipment. If your urge is irresistible, there is always the hallway.

Some of the apparatus is unavoidably delicate; if you have doubts or questions, consult your instructor before charging ahead.

Do not under any circumstances alter the software on the computers. Even though you may regard yourself as an expert, you may cost other students large amounts of time.

Attendance

Attendance during the day and night labs is required. As obvious as it might seem, you cannot write a report or describe an experiment that you did not perform. Copying data from someone else and making them appear as if they were your own is not only unacceptable, it constitutes cheating. Professional careers have been ruined by just such dishonesty. If extenuating circumstances prevent you from attending a lab, check with your instructor regarding a makeup. They may, for example, be able to arrange for you to attend a duplicate lab the same week.

Reports

Reports are, in a sense, the "payoff" for the work you do in the labs. Professional scientists succeed or fail based on the quality of their publications ("publish or perish"). If you embark on a professional career, it is likely that you will be judged extensively by the reports you present to colleagues. Learn to do it well!

A report should be intelligible to a reader who is not necessarily familiar with the details of the experiment (try to put yourself in their place). A good report will be concise, without irrelevant detail, but it will reveal the purpose of the experiment, the methods of obtaining the data, the results derived from the data, and the conclusions drawn from these results. The general outline of these reports is given below, but more specific instructions will be given on each report

– Abstract

– Introduction

– Methods and Purpose

– Data

– Discussions

– Conclusions

It is everyone's experience that writing up the work helps greatly in understanding what went on during the experiment. A common occurrence is the discovery of some piece of data, or some note, you wish you had taken during the experiment. It is probably not a bad idea to try to visualize the report while you are actually performing the experiment.

Grading

Reports will be graded according to how well the laboratory work was done and, especially, on how well you communicate the results. All reports carry the same weight in the calculation of the final grade.

Final Note

Now that we have been a bit grumpy, let us reiterate: Our primary purpose in designing and equipping this laboratory was to present YOU with a profitable and enjoyable educational experience. Please approach it with a spirit of fun and adventure; we think you will enjoy it!

"I Hate Science..."

Teachers often hear these words uttered from the mouths of their students. It seems incomprehensible that anyone could say such a thing! Curiosity lies at the heart of science, and curiosity is a basic human trait. Science is, to put it simply, curiosity with guidelines.

The reason so many students might dislike science is that it is presented to them in many classes as a *product*. The teacher tediously rattles off scientific fact after fact, often without mentioning anything about how these principles came about. The student is expected to simply regurgitate this information, some of which might seem inconceivable, back to the teacher. Because of this, many students hate science and think of it only as an erudite body of knowledge. The late astronomer Carl Sagan wrote:

"It is enormously easier to present... the wisdom distilled from the centuries of patient and collective interrogation of Nature than to detail the messy distillation apparatus. The method of science, as stodgy and grumpy as it may seem, is far more important than the findings of science"

For practicing scientists, science is almost wholly a *process*. Through this lab book and class, it is hoped that the student may gain significant insight as to the process of science and how, through detailed observation and independent experimentation, scientists come to agree on what are considered scientific facts.

The basic idea of science is not that hard to understand. Many of us, regardless of whether or not we think we like science, invoke the scientific method every day. Say you are riding your bicycle and you suddenly get a flat tire. You realize right away that the air escaped from the tire too fast for it to be a leak in the valve. You get off your bicycle and look at the tire. After a little searching you find a tack through the rubber tread. You conclude that you got the flat because the fire was punctured by a tack.

You just performed science! A phenomenon occurred that seized your curiosity, you observed it carefully, and based upon the data collected from these observations you can up with an explanation or hypothesis that best explains the occurrence. This is the **method of science** in its most fundamental form: observe, collect, data, draw a hypothesis. In science, a hypothesis is tested through repeated experimentation and is either confirmed, changed or dismissed.

It should be stressed that in this class, just as in scientific practice, there is no "right answer". Many times when performing experiments we don't know what the results are going to be. Careful data collection is the key to the success of an experiment. When performing good science, we do not dismiss "bad" data points, or massage the data so that it will conform to the results expected. If an experiment is performed properly and carefully, we must trust our data, regardless of whether we think it will yield the desired results. We must also assign errors to the data we collect. Errors give us an idea of how careful our observations were, and to what degree we can trust our data. The conclusion of the experiment is the answer or explanation that best describes *all* of the data, in light of the errors.

Science is by no means perfect, but it is the best tool we have for acquiring truth from Nature, and it does not merit hatred. It is the goal of this book, and the hands-on teaching in this course, that students will acquire a new appreciation for science and its methods.

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