PHYS 3330: Modern Optics (Fall 2022)
Syllabus

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I. TIMES AND LOCATIONS

The Aug. 19 lab will be given as two lectures in Room 327.

Lectures:
Monday and Wednesday
1:50 PM – 2:40 PM (Period 6)
327 Physics Building

Lab:
Friday
1:50 PM – 5:00 PM (Periods 6 – 8)
213 Physics Building, "Modern Optics Lab"

Office Hours:
By appointment.

Teaching Assistant:
Lab: Eric Goetz, eric.goetz@uga.edu
Writing: Mona Asadinamin, Mona.a@uga.edu

Course website:
UGA eLC

II. TEXTBOOKS

Required: "*Optics*" by Eugene Hecht, Pearson, 5th Edition.
   "*Physics of Light and Optics*" (2013 Edition), by Justin Peatross and Michael Ware. (**free**)
      This textbook is a free download; you may also order a hardbound version for $14 here.
   "*Numerical Recipes in C*" (2nd ed.), by Press et al. (**free**)
      This book is free to view online; you may also download individual chapters to your computer.

Suggested: "*An Introduction to Error Analysis*" by John Taylor, University Science Books, 2nd edition.
   "*Introduction to Modern Optics*" by Grant R. Fowles, Dover, 2nd edition.

III. COURSE TOPICS

Modeling Data and Testing Hypothesis using Python	Data
Lasers and Gaussian beams	Las
Waves and EM Waves	Wav
Light in materials, Microscopic Treatment	Scat
Light in materials, Macroscopic Treatment	Mat
Waves at interfaces	Fres
Interferometry and the Coherence Properties of Light	Int
Scalar Diffraction Theory - Light as waves	Diff
Geometrical Optics - Light as Rays	Ray
Polarization of Light	Pol
Anisotropic Media	Bir

IV. COURSE GOALS

Theoretical and experimental modern optics.
Data analysis and model testing (using Python).
Scientific writing (using LaTeX or MS Word).
Creativity/Team Work

V. GRADES

Attendance at lecture: 10% of your course grade. A sign-in sheet will be kept. There are 30 scheduled lectures. Each person is allowed 2 absences with no need to supply any justification. Absences in excess of 2 will count as missed lectures; no excuses of any kind will be accepted (health center slips, doctor's notes, coach's notes, etc.). Your attendance score is calculated by: $1 - \frac{<\text{\# missed class}> - 2}{30}$, with a maximum score of 1.

Lab notebook: 10% of your course grade. You will use the online system MS OneNote (or Evernote) to keep your lab notebook; the procedure for getting started is described below. You will share a link of your notebook with the course TA and instructor, who will check that you have been keeping good records, that your data files are labeled, etc. Your TA will check your logbook after every lab session – waiting until the day the manuscript is due to retroactively create notebook entries will not get you any credit. There are 4 required notebooks: for Labs 2 through 5 you will receive a score of 1 for an acceptable notebook, or 0 for a missing or mostly incomplete notebook. You shall submit the lab notebook along with your lab report manuscript. Your lab notebook score is calculated by: $\frac{<\text{total points}>}{4}$.

Manuscript-type lab reports: 40% of your course grade. There are 4 manuscripts assigned over the course, one due approximately every three weeks. You will perform experiments and analyze data with a lab partner. In all cases you must author and turn-in your own, personal manuscript. The class is designed as a written-intensive class, so during the preparation of the manuscript, the process of manuscript preparation, the peer review process as well as manuscript revision are very important, and they all deserve different partial credits. The lab reports are not the "fill-in-the-blank" worksheets to which you may have become accustomed in previous lab courses. Rather, they are 2-3 pages of polished text, equations, and figures that coherently communicate the background, theory, design, results, analysis and discussion of your experiment. You will model your manuscripts after articles in *Physical Review Letters*, and will compose them using either the MS Word or the LaTeX mark-up language. A Word and LaTeX template will be provided to get you started. More information on using LaTeX is given below.

Manuscript outline (15%): Starting from Lab#2, you are requested to submit a manuscript outline on the Sunday of the first week of the lab. The file can be shared with me and TA via cloud or can be directly emailed to us. The outline should contain at least three levels of written points: The first level includes the general manuscript structures, i.e., introduction, experiment, results & data analysis, and conclusion; the second level shall show that the main points that will be discussed in each section; and the third level shall outline what would be discussed in each main point. Comments shall be returned to the student by the TA or me within 3 days.

Manuscript draft (15%): Based on the outline commented by either the TA or me, the student is required to work out a draft report manuscript. The draft shall include most non-experimental related writing and figures, such as the introduction and experiment parts.

Completed lab manuscript (50%): Your manuscripts will be graded based on the quality of the measurements (data), the quality of the figures, and the quality of the writing. A rubric is provided to guide the grading. Manuscripts must be submitted electronically in eLC "*Assignment*" as a single pdf file, named according to the template: **Alice_Lab*N*.pdf**, where you replace "*N*" with the lab number you are submitting. Manuscripts must be emailed to me and TA at or before 11:59:59 PM ET on the due date shown in red on the course schedule. Time shall be referred to my computer's clock, not yours. If you intend to cut it close, make sure your clock is properly set to official US time. A lab due Sunday, but turned in between 12:00:00 midnight Monday to 11:59:59 PM Monday is 1 day late, and so forth. Late manuscripts will

be penalized 10% for each day late. Manuscripts more than 5 days late may be eligible to receive a score of 50% if they are of high quality; otherwise they will count 0%.

<u>Revised manuscript (</u>20%+(50-previous manuscript score)% (Note: penalty score will not be included here)): The student will receive a score and comments from TA and me within one week of submission. Then he/she will have a chance to submit a revised manuscript based on these comments and correct the corresponding mistakes. For comments regarding the writing, the student needs to make corresponding changes to rewrite the parts that receive these comments; for comments regarding the lab procedure, setup or data analysis, the student may need to redo the lab, redesign the setup or reanalyze the data based on the comments. The student needs to provide a rebuttal letter to argue why he/she makes the corresponding changes. In the revised manuscript, the parts that the students made the changes should be highlighted. The submission of revised manuscript is 5%, the submission of the rebuttal letter is 5%. The rest of the score will be judged based on the completeness of the revision, the justification of the rebuttal letter, and the overall impression of the revised manuscript based on the rubric of scientific writing.

Final lab report grade: Your lowest manuscript score will be dropped, so that your average manuscript score is calculated by: $\frac{<\text{sum of highest 3 scores}>}{3}$.

Final Project: 40% of your course grade. In 2nd week of the class, each student will pick up a topic for their research project. The project is to work on an optics-based research with a graduate student in different physics lab. The student will learn how to read literature, search literature, operate an advanced optical instruments, collect data, analyze the data and write a final research report. A project manuscript and a Youtube-like video should be submitted to me by the end of the semester (before 11:59:59 PM ET Dec. 6, 2022), with information such as design and principles (including equations and calculations), calibration, data analysis, application data analysis, and evaluation of the system. A standard video format can be found at https://www.youtube.com/watch?v=NFOvg3zZCOU&feature=youtu.be. I will post the video in Youtube so that they can be evaluated by all other students, TA, and me before Dec. 9, 2022 or other allocated time, and will. The final project score is based on the evaluation and report score: the video counts for 50% and report contributes to 50%.

VI. GRADE SCALE

A letter grade will be assigned based on your numerical course average according to the following scale. Standard rules of rounding apply, which can be found here: NIST rules for rounding.

A	100 – 95		C+	74.99 – 70
A-	94.99 – 90		C	69.99 – 65
B+	89.99 – 85		C-	64.99 – 60
B	84.99 – 80		D	59.99 – 50
B-	79.99 – 75		F	< 49.99

VII. RULES CONCERNING WITHDRAWALS AND INCOMPLETES

We will follow the rules of the UGA Bulletin concerning withdrawals and incompletes.

VIII. ACADEMIC HONESTY

All academic work must meet the standards contained in "A Culture of Honesty." Students are responsible for informing themselves about those standards before performing any academic work. As a UGA student, you are responsible for knowing and understanding this policy. If you have any questions about the propriety of actions relating to this course, you are obliged to ask me for clarification beforehand.

IX. COMPUTING RESOURCES

You will need to establish several (free) online accounts for this course. The procedures are described below for the fictitious lab group of "**Alice Apple**" and "**Bob Banana**."

A.   Gmail account

Create a brand new Gmail account for which you and your partner will share a username and password, at http://mail.google.com. Use the following template for your group's Gmail account information:

First: **phys3330** (all lower case)

Last: **applebanana** (a compound word formed from last name of each lab partner, in alphabetic order, all lower case).

Username: **phys3330applebanana**

Password: Use this website: http://www.random.org/passwords to generate a random password for this account.

Write it down!

Your joint email address is then **phys3330applebanana@gmail.com**. Do NOT route any personal emails into this account – use it only for signing up for the Evernote account as described below. You will not use it for any other purpose.

B.   Evernote

You will use Evernote to keep your lab notebook. Both lab partners will need access to the same account. Use the Gmail address created in the previous step to sign up for a free Evernote account for your group at http://evernote.com. I suggest using the same password for the Evernote account as for the Gmail account.

In Evernote, make a notebook called **applebananaLogbook**. In this notebook create 5 new notes named "**applebananaLab**N" where N = 1…5. Each day you commence work on lab N, remember to sign-in to YOUR group's Evernote account on whatever computer you are using. Create a horizontal line of "=" signs to set-off each day's entries, and put the date on the very next line. What should you put in your note?

- When your apparatus generates data files that you will need to use in your future data analysis, drag those into the **applebananaLab**N note and comment on what they are.

- If you record data by hand, enter the data into the **applebananaLab**N note in tablular form. Paper scraps with numbers on them WILL GET LOST!

- If you do a quick calculation while you are in the lab, write the results in the **applebananaLab**N note, along with any equations. Remember, you can drag and drop plots from IPython notebook (see later in this document on how to you IPython).

- If you have ideas for the next step you need to perform when you come back next week, write that in the **applebananaLab**N note.

- If you sketch any drawings of your apparatus, I suggest you take a picture of them with a digital camera and upload it to the Evernote. You can get a picture (or anything!) into Evernote easily by emailing it to a special e-mail address (**NOT applebanana@gmail.com**) that can be found when you sign-in to the Evernote application. (You can also drag and drop an image file, of course)

- For the Final Project, please create a Note named "**applebananaProject**", and follow instructions above while you are working on the project.

In order to receive a score for the lab notebook portion of your course grade, you **_must_** right-click on the **applebananaLogbook** and choose to "share this notebook" with **PHYS3330@gmail.com**. This will allow the TA to examine your logbook and assign a score; the TA will not be able to modify the notebook.

If Alice wishes to access this notebook from her own computer, she has two choices. If she doesn't currently use Evernote (i.e., doesn't already have her own person account), she should simply install Evernote on your machine and log into the **phys3330applebanana@gmail.com** account. If she already has a personal Evernote account, she can either logout of it and login to the **phys3330applebanana@gmail.com** account within the Evernote program, or use the Evernote web interface to access the applebanana account while leaving her application still signed on to her personal account.

C.   LaTeX

You will use the LaTeX program for composing your manuscripts. I strongly suggest making a free account on the website https://www.sharelatex.com rather than attempting to install LaTeX on your own machine. With this system your manuscript files will be stored in the cloud, and available from any computer. Also, the sharelatex website has an excellent set of links to other online resources (https://www.overleaf.com/for/authors) to help you, for example, to learn latex, to generate symbols and formula's by drawing with your mouse, and more. Even if you use your own installation of LaTeX, I highly recommend keeping this resource webpage open, as you do not need a sharelatex account to use it. I will provide a template file to use as a starting point for your manuscripts – it will be available through the eLC.

Good tutorial websites in addition to those linked at sharelatex are:

http://en.wikibooks.org/wiki/LaTeX

http://en.wikibooks.org/wiki/LaTeX/Absolute_Beginners

http://en.wikibooks.org/wiki/LaTeX/Mathematics

D.   Python

In this course you will be use scientific computing software to perform data analysis and prepare figures for your manuscript. There are many good options: Mathematica, Matlab, and python are three popular ones. The "official" choice for the course – the one I will use for all examples – is python, but you are free to choose another if you are already comfortable with something else. Python has the advantages that it is free, and is used extensively in other courses in the Department (notably in PHYS1311-1312).

You can install a free, basic version of Python on your own machine by going to the website http://www.enthought.com/products/epd_free.php. A more extensive version, also free (to anyone in the academic community) is also available: http://www.enthought.com/products/edudownload.php. I suggest the second option.

I recommend running IPython with the notebook interface: http://ipython.org/ipythondoc/dev/interactive/htmlnotebook.html.

Steps:

1. Launch a terminal window (mac:/Applications/Utilities/terminal) or a command window (windows: All Programs → Accessories → Command Prompt).

2. If using Python during a lab session, change your working directory to your group's Dropbox folder for the lab you are working on. For example, to work on Lab 1 on a windows machine in Room 213, Alice or Bob would type:

   `cd \Users\labuser\Dropbox\PHYS3330\applebananaData\Lab1`

3. If using Python on your own computer to do your analysis, Alice would type (assuming her username on her own machine is aapple),

   `cd /Users/aapple/Dropbox/applebananaData/Lab1`

   if she has a mac, or if she has a windows 7 machine:

   `cd \User\aapple\Dropbox/applebanandaData\Lab1`

   (This assumes Alice has already shared the **applebananaData** folder to her personal Dropbox account as described above).

4. Now launch python by executing the following command in the terminal window:

   `ipython notebook --pylab inline`

5. A web browser will open to the "IPython dashboard" http://127.0.0.1:8888/. If the browser is NOT chrome or Firefox, you must: (1) open either chrome or Firefox; (2) cut and paste the URL into the new browser window; (3) close the original browser window. Note that this is not a website on the internet – you are simply using a web browser to interface

with the IPython process running locally on your own computer. (You can substitute the words "localhost" for "http://127.0.0.1" if you like.)

6. Now you can create a new IPython notebook.

7. If you want to copy other python notebooks into this directory (for example, a curve fitting templates that you have downloaded from the course website), simply drag and drop the *.ipynb or *.py into the appropriate part of the "IPython dashboard" window and a copy will be put into the directory you changed to in step 2 above.

A good tutorial for common python tasks, including plotting, histogramming, and curve fitting can be found in eLC.

X. TIPS FOR GOOD LAB WRITE-UPS

This course will provide you with multiple opportunities to develop and hone your skills of conducting and reporting science. Your instructor and TA can give you feedback on your efforts, but it is ultimately up to you to incorporate our suggestions into your future work. We are confident that, as the course progresses, your abilities will also increase; so, too, will our expectations of the quality of your work.

Your manuscripts should be approximately 2-3 pages in length, but this is only a rough guide. You must say everything you need to say, of course, but don't be periphrastic.

There are five main sections to a proper manuscript: Abstract, Introduction, Methods, Results and Conclusion.

1. *Abstract*. The abstract is the most important part of any academic manuscript. It should be approximately 4-6 sentences in length, and must clearly communicate the entirety of the paper to the reader. Often the abstract is the only thing which gets read, and so you must pack in every important point. It should

   - Tell what the main physics question is.
   - Tell why this is an important question to answer.
   - Tell what experiment was done to probe the question.
   - Tell what the results of the experiment or measurement are.
   - Tell what the primary physics conclusion you draw from the work is.

2. *Introduction.* The introduction should describe the basic physics you are testing, and the basic theory of the experimental approach you are using.

3. *Methods.* This is where the details of the experimental procedure go. Tell how the apparatus works, discuss details of the setup, calibration procedures, etc.

4. *Results.* Here is where you present your data and analysis, usually in the form of figures (i.e, plots). Here is also where you make whatever important physics conclusions are warranted by your data (i.e., whether your data validates or invalidates a particular model, based on a chi-squared test of significance).

   Make sure that any important numerical quantities are accompanied by an uncertainty, and make sure you have described, in the methods section, how those uncertainties were determined. When comparing two quantities, the comparison must be made in light of the uncertainty in each quantity. For example, to compare $x_{\text{experimental}} = 1.3(5)$ to $x_{\text{theoretical}} = 1.2334(9)$, you should say that they differ by less than $0.3\ \sigma_{\text{experimental}}$ (which is not even close to a statistically significant difference). Saying "the percent difference is 5.1%" conveys no useful information. Taylor's text is an excellent resource for the basics of estimating uncertainties and error propagation.

   You must give quantitative justifications for any assumptions and approximations you make. Simply stating that some effect is "small and therefore ignorable" is not acceptable. Why should your reader believe this conclusion?

   You must make a quantitative argument that convinces the reader that you are not making a terrible mistake by assuming certain effects to be negligible. Ask yourself, "would I be satisfied by this discussion if I were a colleague, or competitor, or a journal referee?"

   Any figure important enough to show is important enough to be discussed in the text of the paper. Figures do not stand on their own.

Every plotted data point should have an error bar, except in rare cases.

Any symbol or expression used in your paper must be defined mathematically and clearly explained. This includes any symbols or expressions in figures, diagrams and equations. The symbol or expression should be explained either in the body of the text or in the figure caption, or both.

Figure captions must actually explain, not simply label, the figure. The caption should clearly state what is being plotted against what, and what conclusions you want the reader to drawn from the figure.

Finally, if your data does not fit the theory, you must address the discrepancy directly. If you do not comment on obvious discrepancies, this tells your reader that you don't know what you're doing and they shouldn't believe anything you say. Either the theory is wrong, the experiment is awed, or both, but you must say something!

Your attitude in writing your manuscript must be that you do not "already" know the validity of the theories you are testing. You must make limited conclusions based solely on your experimentation, not based on the fact that you "know" the right answer. If your data does not match up with predictions, you must positively identify (not simply speculate on) the source of the discrepancy.

5. _Conclusion._ The conclusion is important – don't skimp. It is different from the abstract in that you should make judgments about what was good and bad about your work, and what your results might mean for future work.

This syllabus is a general plan for the course. Deviations announced to the class by the instructor may be necessary.