

Physics 3 Laboratory

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Room 157b

Laboratory Induction

- Things to remember
- Writing reports
- Treatment of errors

Things to Remember -1

- The lab comprises, five elements
 - Experiments
 - Reports
 - IT module
 - Transferable skills
 - Group Project (S1 only)

Requirments for completion of the P3 lab						
	S1			C1		
	number	credit	total	number	credit	total
Induction						
Experiment (lab)	4	4	16	3	4	12
Report on Exp.	1	3	3	1	3	3
IT	1	4	4	1	4	4
Skills revolution	1	1	1	1	1	1
Group proj. (lab)	1	16	16			
TOTAL			40			20
Group proj. (lab) marked on the 20pt scale						

Things to Remember -2

- Yours labs marks are likely to be higher than your exam marks - don't lose the opportunity to improve your degree classification
 - Make sure you do the right number of experiments
 - Make sure you attend the right things
 - Make sure you hand everything in ON TIME
 - Make sure you keep up to date

Things to Remember - 3

- Read the instructions, e.g.
 - The marking criteria we use is given in the Lab guide - play the game!
 - Record keeping, analysis, understanding etc
 - **Note all experiment marking begins with an oral!**
- Use the demonstrators to learn from, not just as aids to complete the experiment
- Learn to work by yourself (no pain no gain)

Lab Record

- You will maintain an informal lab record covering all experiments you perform
 - A4 bound book
 - Hand written, but including computer prints of figures, table and graphs
 - 6-12 pages in length
- These will be handed in at year end for inspection by the external examiner

Lab Record - 1

- A lab record is for your benefit
 - You will use it on which to base your report
 - You will use it to present your experiment at marking

Lab Record - 2

- Read the instructions
 - The criteria your marker will be using are listed in the Lab guide
 - Note oral component

Lab Record - 3

- A lab record should contain
 - An Abstract (the practice is worth doing) - see reports
 - Notes on technique
 - Actual measurements made (all of them!)
 - Analysis of results
 - Analysis and presentation of errors - see later
 - Conclusions (the practice is worth doing) - see reports

Written Report

- You will submit a formal report covering one of your experiments
 - Word processed, including figures, table and graphs
 - 8-16 pages in length
- These will be handed in at year end for inspection by the external examiner

Writing Reports - 1

- Reports are different from Records!
 - You will NOT be there to argue your case
 - The demonstrator may not remember you or the experiment!
 - The demonstrator may not know your lab
 - Demonstrators don't like marking them
 - Make it easy to mark
 - Make it high quality and not too long
- Report writing is a key transferable skill
 - We do it all the time (papers and grant applications)
 - In employment, your boss's boss will see your report but often not you!

Writing Reports - 2

- Read the instructions
 - The criteria your marker will be using are listed in the Lab guide

Writing Reports - 3

- Understand who you are writing it for
 - You are writing it to your peers (ones who have not yet done the experiment)
- General tips
 - No one likes to read wall-to-wall text
 - Pictures
 - Diagrams
 - Use sections paragraphs and sentences!
 - No one understands pages of equations
 - Use the ones you need
 - Explain the terms, trends and underlying physics

Writing Reports - 4

- Structure, structure, structure
 - Title, name date!
 - Abstract (100- 200 words summary), phrases like
 - Using a helium neon laser and a rotating mirror over an optical path length of .. we measure the speed of light to be
 -compared to earlier techniques this
 - ...we show the speed to be $4.0 \pm 0.2 \text{ m/s}$.
 - Thereby establishing.....
- Most “papers” only have their abstracts on the web - it is the “selling” pitch for the main text

Writing Reports - 5

- Structure, structure, structure (cont)
 - Introduction, phrases like
 - As postulated by Einstein, the speed of light is a fundamental....Previous attempts to measure the speed of light include....
 - In this work we adopt a new technique....
 - Theoretical Context
 - The speed of light in air is modified from that of vacuum by ...
 - the relationship between the frequency of the mirror and displacement of

Writing Reports - 6

- Structure, structure, structure (cont)
 - Apparatus and method, phrases like
 - Figure 1 show a schematic of the experimental arrangement
 - The He NE laser has a 3mw output at 633nm...
 - The rotating mirror is formed from a
 - Over a period of several weeks the experiment was run
 - Results
 - Figure X shows a graph containing....
 - Using a least squares fit we find the average speed to be..

Writing Reports - 7

- Structure, structure, structure (cont)
 - Discussion and Conclusions, phrases like
 - This results compares favorably with...
 - The main sources of error in our measurements arises...
 - The accuracy of the measurement could be improved....
 - Acknowledgements and references

Writing Reports - 8

- Reports vs Papers
 - Scientific paper usually report the outcome of one experiment, your report may cover a series
 - Within report often better to group method, results and discussion together for each experiment

Treatment of Errors - 1

- A sensible discussion of errors is the difference between anecdote and science
- Read the instructions
 - The lab guide contains a good set of error guidelines

Treatment of Errors - 2

- Precision vs. accuracy
 - $2 \times 2 = 3.90103?$
 - Very precise but inaccurate
 - $p = 3.1$
 - Fairly accurate but not very precise
- Sadly people (and especially politicians) quote numbers with a precision which which their accuracy does not justify

Treatment of Errors - 3

- Random error vs. systematic error
 - e.g. reading the time from your watch
 - Random error about one second (easy to estimate)
 - Systematic error could be anything depending how well it was synchronized to GMT
 - Random errors easy to estimate and reduce (take more measurements)
 - Systematic errors hard to estimate and treat (these always kill you in the end)

Treatment of Errors - 4

- Concepts to understand
 - Addition of errors
 - Errors add in quadrature (i.e. $\text{SQRT}(x^2 + y^2)$)
 - Standard deviation
 - Calculation from a set of measurements
 - Error in the mean
 - Dependence upon the number of measurements
 - Axis choice to give a straight line graph
 - e.g. Log, power
 - Always plot dependent variable (the thing you measure) on y-axis
 - Least squares fitting
 - Best fit gradient and intercept

Treatment of Errors - 5

- Tools of the trade
 - Your calculator!
 - Excel
 - Mean, standard deviation, error of the mean
 - Graph plotting (BUT NOT FIT), best fit
 - BUT don't use them as a black box
 - Ask a demonstrator to explain

Treatment of Errors - 6

- Top(ish) tips
 - The best way to measure the random error is make repeated measurements
 - Work out the critical measurement and concentrate on making it better
 - Systematic errors are the ones which embarrass you - watch them - discuss them - remove them

