Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates [UG OBTL+](#) or [PG OBTL+](#)

If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to [Data Transformation Status](#) for more information.

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Elbert Chia
Course Author Email	elbertchia@ntu.edu.sg
Course Title	Physics Laboratory Ia
Course Code	PH1198
Academic Units	2
Contact Hours	42
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	Physics at A or H2 level or equivalent
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to:

a. build a basic understanding of experimentation, data handling and error treatment.

b. begin building your basic observational skills and analysis of experimental results.

c. show how experiments further knowledge in physics.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Design methods to take scientific measurements and use them to support experimental conclusions
ILO 2	Determine and discuss the different sources of errors and uncertainties
ILO 3	Write a lab report with appropriate figures, captions, and references
ILO 4	Perform error analysis and understand the propagation of errors
ILO 5	Perform curve fitting by doing weighted or unweighted linear or nonlinear regression using softwares like Origin, Matlab or Python
ILO 6	Keep a proper lab notebook, and exercise basic scientific data management
ILO 7	Discuss deviations between theory and experiment

Course Content

This course will train you in basic experimental physics that include topics in mechanics and basic optics. The laboratory sessions are designed to provide an active learning experience where key concepts can be better appreciated. You will also learn about data acquisition, error analysis, error distribution and fitting procedures.

Reading and References (if applicable)

1. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, 2nd ed, John R. Taylor, University Science Books, 978-0935702750, 1996

2. Experimentation: An Introduction to Measurement Theory & Experiment Design, 3rd ed, David C. Baird, Addison-Wesley, 978-0133032987, 1994

The above reading comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they are available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Week 1: Lab briefing	2, 4, 5		In-person	general briefing; software demonstration
2	Week 2 - 11: Lab sessions (based on assignment by Year 1 Lab Manager)	1-7		In-person	hands-on experiments; discussion with lab TAs; report writing
3	Week 12 - 13: Make-up lab sessions (as applicable)	1-7		In-person	hands-on experiments; discussion with lab TAs; report writing

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Experiments Laboratory Half-/Full-Reports	You would be able to receive feedback from the markers who had graded your reports and use the feedback in the next experiment/lab course.
Experiments Laboratory Notebook	You would be able to receive feedback from the markers who had graded your notebooks and use the feedback in the next experiment/lab course.
Experiments in-Class Assessments	You would be asked warm-up and in-depth questions by the teaching assistant(s) conducting the experiment and can receive feedback from the instructor's observations regarding your level of understanding of your experiment.
Pre-Experiments Online Quiz	You would be introduced to the experiment you would be working on and visualise the methods to conduct the experiment through an online learning portal.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Pre-lab Online Quiz)	LO 1 & 7		12	Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Report/Case study(Experiments Laboratory Notebook)	LO 1-2, 4, 6		16	Individual	Analytic	Relational
3	Continuous Assessment (CA): Oral Test(Experiments In-class Assessments)	LO 2, 4-5, 7		40	Individual	Analytic	Relational
4	Continuous Assessment (CA): Report/Case study(Experiments Laboratory Half-Reports)	LO 1-5 & 7		16	Individual	Analytic	Relational
5	Continuous Assessment (CA): Report/Case study(Experiments Laboratory Full-Report)	LO 1-5 & 7		16	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

- You will be assessed by an online assignment system (NTULearn), Laboratory Teaching Assistant(s) and course instructor(s) from NTU.
- The shown weightage for Components 1 to 3 is the cumulative weightage over 5 different experiments.
- The shown weightage for Component 4 is the cumulative weightage over 2 different experiments.
- The shown weightage for Component 5 is the weightage for 2 different experiments.

Formative Feedback

Formative feedback is given through multiple discussion sessions with the various experiments' teaching assistants as well as through the returned marked laboratory notebooks and reports.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Collaboration	Basic
Communication	Intermediate
Creative Thinking	Basic
Problem Solving	Basic
Sense Making	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

Attendance for all laboratory sessions is mandatory. You are expected to read the lab manual and any reference materials in advance, and to complete the pre-lab online quiz before each session to ensure you are well-prepared for the experiments.

All experimental data must be recorded honestly and accurately. Plagiarism, data fabrication, and unauthorized sharing of results are considered serious academic misconduct.

Lab notebooks and reports must be submitted by the specified deadlines. Late submissions may be penalized unless prior approval has been obtained.

Safety protocols must be strictly followed at all times. Proper laboratory attire is required, including clothes with sleeves, full-length pants, and covered shoes. Food and drinks are not allowed in the lab under any circumstances.

Policy (Absenteeism)

Absence Due to Medical or Other Reasons
If you are sick and unable to attend your laboratory or discussion sessions, you have to:
1.   Send an email to the lab manager regarding the absence and request for a replacement / make-up laboratory or discussion session.
2.   Submit the original Medical Certificate* or official letter of excuse to administrator.
3.   Attend the assigned replacement session (subject to availability).

*The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:
- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

	Far Exceeds Expectations (61 - 70)	Exceeds Expectations in some areas (51 - 60)	Meets Expectations (31 - 50)	Meets Expectations in some areas (11 - 30)	Below Expectations (0 – 10)	Score
Data Entry suggested consideration point(s); • Did the student record all relevant data as required by the experiment? • Did the student record their experimental settings, should if the need arises to redo the experiment? • Did the student have rough sketches of their experimental set-up? • Did the student note down any additional procedure or experimental steps to supplement the lab manual's instructions? • Has the student listed down any interesting observations? Were there any extra investigations into any mentioned interesting observations?	All data were recorded. Excellent portrayal of the experimental set-up. Detailed procedures outside of the lab manual instructions were recorded and explained. Listed & attempted investigation of interesting observations.	All data were recorded. Detailed experimental set-up information was recorded. Listed some interesting observations with cursory investigations.	All data were recorded. Some experimental set-up information was recorded.	Some data were recorded. Some experimental set-up information was recorded.	Little to no data was recorded.	/ 70
	(26 - 30)	(20 - 25)	(13 - 19)	(1 - 12)	(0)	
Uncertainties & Experimental Errors suggested consideration point(s); • Is the student able to obtain uncertainties within the reasonable bounds of the apparatus used or from calculations? • If an experiment requires so, is the student able to perform error propagation correctly? • Has the student included or derived any error propagating expressions as rough workings?	All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Correct uncertainties from error propagation. Method was provided. Detailed derivation & method was provided.	All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Correct uncertainties from error propagation. Brief derivation & method was provided.	Most of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic.	Some of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic.	No uncertainties were presented.	/ 30
					[1]Total :	/ 100

[1]Normalised to 100%.

Appendix 2: Examiner's Assessment Rubrics for PH1198 Physics Laboratory Ia
Component 3: In-Class Assessments

	Far Exceeds Expectations (61 - 70)	Exceeds Expectations in some areas (51 - 60)	Meets Expectations (31 - 50)	Meets Expectations in some areas (11 - 30)	Below Expectations (0 – 10)	Score
Experimental Aspects suggested consideration point(s); • Is the student able to understand the theoretical reasoning for this experiment? • Did the student do their own research on topics they are unfamiliar with? • How much did the laboratory teaching assistant have to guide the student? (First laboratory course for freshmen. Low expectations on any prior lab experiences.)	Has an excellent grasp of rudimentary physical concepts before instruction. Readily applies new concepts to the experimental context. Has done extensive research into the experimental topic prior to attempting experiment.	Has a strong grasp of rudimentary physical concepts before instruction. Able to apply most new concepts to the experimental context. Has done some research into the experimental topic prior to attempting experiment.	Able to understand most rudimentary physical concepts before instruction. Able to apply some new concepts to the experimental context.	Able to understand rudimentary physical concepts after instruction. Able to apply some new concepts to the experimental context.	Unable to understand any rudimentary physical concepts despite instruction.	/ 70
	(26 - 30)	(20 - 25)	(13 - 19)	(1 - 12)	(0)	
Soft Skills & Teamwork suggested consideration point(s); • Is the student able to work with their assigned teammate(s)? • Is the student able to take initiative and lead? • Is the student able to seek assistance with understanding the experiment, or conversely help their teammate(s) who are having difficulty with understanding the experiment's needs?	Present for all lab session in an active role. Completes assigned experimental tasks. Has a critical role by successfully leading the team to understand and complete the team's experiments.	Present for all lab session in an active role. Completes assigned experimental tasks. Has an initiative to assist other members to understand and complete the experiments.	Present for all lab session in a limited active role. Completes assigned experimental tasks. Has an initiative to ask for help if required.	Present for all lab sessions in a passive role. Mostly copies from other teammates. In a mostly administrative rather than experimental role. Lacks initiative to ask for help	Missing from all group sessions or did not assist with any tasks or team mates throughout the session. Disruptive behaviour.	/ 30
					[1]Total :	/ 100

[1]Normalised to 100%.

Appendix 3: Examiner's Assessment Rubrics for PH1198 Physics Lab Ia
Component 4: Laboratory Half-Report

Sections of the laboratory Half Report	Far Exceeds Expectations (14 - 15)	Exceeds Expectations in some areas (12 - 13)	Meets Expectations (9 - 11)	Meets Expectations in some areas (6 - 8)	Below Expectations (0 - 5)	Score
Results Section *Meeting Requirements & Presentation Clarity* suggested consideration Point(s); • Did the student present all the experimental results as required in that experiment's lab manual? • Did the student investigate certain physical aspects of the experiment outside the requirements of the lab manual? • Are the results presented in an organised and coherent style with named diagrams & tables for easy reference?	All of the required results were presented. Presented results were well-organised, tabulated. Appreciable initiative investigating phenomena outside the requirements.	All of the required results were presented. Presented results were well-organised and tabulated. Some initiative investigating phenomena outside the requirements.	Most of the required results were presented. Presented results were organised and tabulated.	Some of the required results were presented. Presented results were disorganised and not tabulated.	None of the required results were presented. Any presented results were messy and not tabulated.	/ 15
Presentation of Experimental Error suggested consideration point(s); • If an experiment requires so, is the student able to perform error propagation correctly? • Is the student able to obtain uncertainties within the reasonable bounds of the apparatus used or from calculations? • Has the student included experimentally obtained errors in their tabulated results in the form of uncertainties? If presenting graphical results, in the form of error bars?	All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Explanation was provided. Correct uncertainties from error propagation. Method was provided.	All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Correct uncertainties from error propagation.	Most of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic.	Some of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic.	No uncertainties were presented.	/ 15

Sections of the laboratory Half Report	Far Exceeds Expectations (14 - 15)	Exceeds Expectations in some areas (12 - 13)	Meets Expectations (9 - 11)	Meets Expectations in some areas (6 - 8)	Below Expectations (0 - 5)	Score
Results Section *Presentation of fitting results* suggested consideration point(s); • If an experiment requires so, is the student able to perform curve fitting using the recommended software? • Has the student utilised the correct fitting function & results based on the experiment's theoretical considerations? • Has the student provided the fitting results? (Score to be merged with **Results Section** *Meeting Requirements & Presentation Clarity* should graphical fitting be not required in a particular experiment.)	The <u>required data plots</u> were presented. <u>Fitting results</u> were presented. Choice of fitting function & fitting results were <u>presented and explained</u>.	The <u>required data plots</u> were presented. <u>Fitting results</u> were presented. Choice of fitting function & fitting results were <u>presented</u>.	The <u>required data plots</u> were presented. <u>Fitting results</u> were presented. Choice of fitting function & fitting results were <u>not presented</u>.	The <u>required data plots</u> were presented. <u>No fitting results</u> were presented.	<u>No data plots nor fitting results</u> were presented.	/ 15
	(18 - 20)	(15 - 17)	(12 - 14)	(9 - 11)	(0 - 8)	
Discussion Section *Obtaining Error Trends from Experimental Results* suggested consideration point(s); • Is the student able to relate their obtained experimental results with the experiment's theoretical predication through the use of an appropriate quantifier (e.g. % differences, p-values, etc.)? • Is the student able to explain and make educated benchmarks of the experiment's accuracy and precision from the provided apparatus? • Is the student able to compare their obtained experimental results against the benchmarks of accuracy and precision? • Is the student able to identify trends in their results or data (e.g. asymmetry, skewed results towards a particular value, etc.) through suitable quantifiers of errors (e.g. % differences, uncertainties, etc..)?	<u>Required quantifiers</u> used. <u>Well-reasoned attempts</u> at benchmarking the experiment's accuracy & precision. <u>Successful attempts</u> at identifying error trends in presented results.	<u>Required quantifiers</u> used. <u>Reasonable attempts</u> at benchmarking the experiment's accuracy & precision. <u>Determined attempts</u> at identifying error trends in presented results.	<u>Required quantifiers</u> used. <u>Some attempts</u> at benchmarking the experiment's accuracy & precision <u>Some attempts</u> at identifying error trends in presented results.	<u>Required quantifiers</u> used. <u>No attempts</u> at benchmarking the experiment's accuracy & precision	<u>Absence of any quantifiers</u> used. <u>Omission of any attempts</u> at determining the apparatus accuracy & precision.	/ 20

Sections of the laboratory Half Report	Far Exceeds Expectations (23 - 25)	Exceeds Expectations in some areas (20 - 22)	Meets Expectations (16 - 19)	Meets Expectations in some areas (11 - 15)	Below Expectations (0 - 10)	Score
Discussion Section *Evaluation of Errors' Impact on Experimental Results* suggested consideration point(s); • Has the student done only a qualitative analysis of the identified errors? • Has the student identified possible errors from observing the trend of errors? • Is the student able to identify one or two major causes of error in this experiment? • Has the student made an attempt at quantifying the impact of possible errors after identifying them? • Has the student suggested improvements to experimental procedure to reduce said identified errors? Or has the student supported current procedures as superior at reducing experimental errors?	Appreciable attempts at quantifiable error analysis. In-Depth qualitative error analysis. Well-reasoned discussion on the experimental impact of errors.	Some attempts at quantifiable error analysis. Considerable qualitative error analysis. Considerable discussion on the experimental impact of errors.	Considerable qualitative error analysis. Some discussion on the experimental impact of errors.	Brief and short qualitative error analysis. Brief discussion on the experimental impact of errors.	Error analysis was completely omitted.	/ 25
	(9 - 10)	(7 - 8)	(5 - 6)	(1 - 4)	(0)	
Conclusion Section suggested consideration point(s); • Has the student evaluated the success of their experiment via obtained experimental goals and suitable quantifiers? • Has the student identified the most prominent source of error and had given suggestions to improve the experiment? Conclusion Section is at most 2 paragraphs.	Experiment's goals are fully met. Detailed mention of any concluding evaluations, has interesting observations.	Experiment's goals are fully met. Some mention of any concluding evaluations.	Brief. Experiment's goals are fully met Little mention of any concluding evaluations.	Very brief. Experiment's goals are not fully met. Absence of any concluding evaluations.	The conclusion section was completely omitted.	/ 10
					[1]Total :	/ 100

[1]Normalised to 100%.

Sections of the Laboratory Full Report	**Far Exceeds Expectations** (5)	**Exceeds Expectations in some areas** (4)	**Meets Expectations** (2 - 3)	**Meets Expectations in some areas** (1)	**Below Expectations** (0)	**Score**
Introduction & Theory Section suggested consideration point(s); • Did the student state the explicit, and any implicit, goals of their experiment? • Did the student use relevant theories to predict the experiment's outcome? • Are there additional concepts outside those provided in the lab manual presented in depth to aid in the experiment's investigations?	All of the experiment goal(s) were stated. Presented relevant theories were accurate together with more complex theories.	All of the experiment goal(s) were stated. Presented relevant theories were accurate.	Most of the experiment goal(s) were stated. Presented relevant theories had minor errors.	Some of the experiment goal(s) were stated. Presented theories had some errors or were irrelevant.	None of the experiment goal(s) were stated. Presented theories had major errors or were irrelevant.	/ 5
	Far Exceeds Expectations (18 - 20)	**Exceeds Expectations in some areas** (15 - 17)	**Meets Expectations** (12 - 14)	**Meets Expectations in some areas** (9 - 11)	**Below Expectations** (0 - 8)	**Score**
Procedure Section suggested consideration point(s); • Did the student have additional experimental procedures aside from those provided in the lab manual? • Is the student able to provide a pictorial overview of their experiment for the ease of understanding? • How did the student process their data with methods based on fore-mentioned theoretical expressions? • Did the student state how they evaluated their experimental set-up or apparatus to determine quantifiable errors?	Extensive procedural details provided, referenced the lab manual's procedure steps specifically as needed. Annotated diagram(s) of the experiment set-up provided. Appreciable attempts to reduce or deduce experimental error.	Lots of procedural details provided, referenced the lab manual procedures. Annotated diagram(s) of the experiment set-up provided. Appreciable attempts to reduce or deduce experimental error.	Some procedural details provided, copied directly from the lab manual. Simple annotated diagram(s) of the experiment set-up provided. Some attempts to reduce or deduce experimental error.	Few procedural details provided, copied directly from the lab manual. Simple diagram(s) of the experiment set-up provided. Some attempts to reduce or deduce experimental error.	Little or no procedural details provided. No diagram(s) of the experiment set-up provided. Absence of attempts to reduce or deduce experimental error.	/ 20

Sections of the Laboratory Full Report	Far Exceeds Expectations (10)	Exceeds Expectations in some areas (7 - 9)	Meets Expectations (6 - 8)	Meets Expectations in some areas (4 - 5)	Below Expectations (0 - 3)	Score
Results Section *Meeting Requirements & Presentation Clarity* suggested consideration Point(s); • Did the student present all the experimental results as required in that experiment's lab manual? • Did the student investigate certain physical aspects of the experiment outside the requirements of the lab manual? • Are the results presented in an organised and coherent style with named diagrams & tables for easy reference?	All of the required results were presented. Presented results were well-organised, tabulated. Appreciable initiative investigating phenomena outside the requirements.	All of the required results were presented. Presented results were well-organised and tabulated. Some initiative investigating phenomena outside the requirements.	Most of the required results were presented. Presented results were organised and tabulated.	Some of the required results were presented. Presented results were disorganised and not tabulated.	None of the required results were presented. Any presented results were messy and not tabulated.	/ 10
Presentation of Experimental Error suggested consideration point(s); • If an experiment requires so, is the student able to perform error propagation correctly? • Is the student able to obtain uncertainties within the reasonable bounds of the apparatus used or from calculations? • Has the student included experimentally obtained errors in their tabulated results in the form of uncertainties? If presenting graphical results, in the form of error bars?	All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Explanation was provided. Correct uncertainties from error propagation. Method was provided.	All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Correct uncertainties from error propagation.	Most of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic.	Some of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic.	No uncertainties were presented.	/ 10

Sections of the Laboratory Full Report	Far Exceeds Expectations (10)	Exceeds Expectations in some areas (7 - 9)	Meets Expectations (6 - 8)	Meets Expectations in some areas (4 - 5)	Below Expectations (0 - 3)	Score
Results Section *Presentation of fitting results* suggested consideration point(s); • If an experiment requires so, is the student able to perform curve fitting using the recommended software? • Has the student utilised the correct fitting function & results based on the experiment's theoretical considerations? • Has the student provided the fitting results? (Score to be merged with **Results Section** *Meeting Requirements & Presentation Clarity* should graphical fitting be not required in a particular experiment.)	The <u>required data plots</u> were presented. <u>Fitting results</u> were presented. Choice of fitting function & fitting results were <u>presented and explained</u>.	The <u>required data plots</u> were presented. <u>Fitting results</u> were presented. Choice of fitting function & fitting results were <u>presented</u>.	The <u>required data plots</u> were presented. <u>Fitting results</u> were presented. Choice of fitting function & fitting results were <u>not presented</u>.	The <u>required data plots</u> were presented. <u>No fitting results</u> were presented.	<u>No data plots nor fitting results</u> were presented.	/ 10

	Far Exceeds Expectations (18 - 20)	Exceeds Expectations in some areas (15 - 17)	Meets Expectations (12 - 14)	Meets Expectations in some areas (9 - 11)	Below Expectations (0 - 8)	Score
Discussion Section *Obtaining Error Trends from Experimental Results* suggested consideration point(s); • Is the student able to relate their obtained experimental results with the experiment's theoretical predication through the use of an appropriate quantifier (e.g. % differences, p-values, etc.)? • Is the student able to explain and make educated benchmarks of the experiment's accuracy and precision from the provided apparatus? • Is the student able to compare their obtained experimental results against the benchmarks of accuracy and precision? • Is the student able to identify trends in their results or data (e.g. asymmetry, skewed results towards a particular value, etc.) through suitable quantifiers of errors (e.g. % differences, uncertainties, etc..)?	<u>Required quantifiers</u> used. <u>Well-reasoned attempts</u> at benchmarking the experiment's accuracy & precision. <u>Successful attempts</u> at identifying error trends in presented results.	<u>Required quantifiers</u> used. <u>Reasonable attempts</u> at benchmarking the experiment's accuracy & precision. <u>Determined attempts</u> at identifying error trends in presented results.	<u>Required quantifiers</u> used. <u>Some attempts</u> at benchmarking the experiment's accuracy & precision <u>Some attempts</u> at identifying error trends in presented results.	<u>Required quantifiers</u> used. <u>No attempts</u> at benchmarking the experiment's accuracy & precision	<u>Absence of any quantifiers</u> used. <u>Omission of any attempts</u> at determining the apparatus accuracy & precision.	/ 20

Sections of the Laboratory Full Report	Far Exceeds Expectations (18 - 20)	Exceeds Expectations in some areas (15 - 17)	Meets Expectations (12 - 14)	Meets Expectations in some areas (9 - 11)	Below Expectations (0 - 8)	Score
Discussion Section *Evaluation of Errors' Impact on Experimental Results* suggested consideration point(s); • Has the student done only a qualitative analysis of the identified errors? • Has the student identified possible errors from observing the trend of errors? • Is the student able to identify one or two major causes of error in this experiment? • Has the student made an attempt at quantifying the impact of possible errors after identifying them? • Has the student suggested improvements to experimental procedure to reduce said identified errors? Or has the student supported current procedures as superior at reducing experimental errors?	<u>Appreciable attempts at quantifiable</u> error analysis. <u>In-Depth qualitative</u> error analysis. <u>Well-reasoned discussion</u> on the experimental impact of errors.	<u>Some attempts at quantifiable</u> error analysis. <u>Considerable qualitative</u> error analysis. <u>Considerable discussion</u> on the experimental impact of errors.	<u>Considerable qualitative</u> error analysis. <u>Some discussion</u> on the experimental impact of errors.	<u>Brief and short qualitative</u> error analysis. <u>Brief discussion</u> on the experimental impact of errors.	Error analysis was <u>completely omitted</u>.	/ 20
	(5)	(4)	(2 - 3)	(1)	(0)	
Conclusion Section suggested consideration point(s); • Has the student evaluated the success of their experiment via obtained experimental goals and suitable quantifiers? • Has the student identified the most prominent source of error and had given suggestions to improve the experiment? Conclusion Section is at most 2 paragraphs.	Experiment's goals are <u>fully</u> met. <u>Detailed mention</u> of any concluding evaluations, has interesting observations.	Experiment's goals are <u>fully</u> met. <u>Some mention</u> of any concluding evaluations.	Brief. Experiment's goals are <u>fully</u> met <u>Little mention</u> of any concluding evaluations.	Very brief. Experiment's goals are <u>not fully</u> met. <u>Absence</u> of any concluding evaluations.	The conclusion section was <u>completely omitted</u>.	/ 5
					[1]Total :	/ 100

[1]Normalised to 100%.