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

Course Overview

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Yijie Shen
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Course Title	Physics Laboratory IIb
Course Code	PH2199
Academic Units	2
Contact Hours	49
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	PH1199 or CY1400
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to:
a. build understanding of experimentation in key topics of physics.
b. provide foundation knowledge for experimental physics
c. begin building observational skills of physical phenomena.
d. 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	Write a lab report with appropriate figures, captions, and references
ILO 2	Perform error analysis and understand the propagation of errors
ILO 3	Perform curve fitting by doing weighted or unweighted linear or nonlinear regression using softwares like Origin, Matlab or Python
ILO 4	Keep a proper lab notebook, and exercise basic scientific data management
ILO 5	Discuss deviations between theory and experiment
ILO 6	Use various experimental techniques, e.g. lock-in amplification, to reduce measurement errors
ILO 7	Use various statistical procedures to reduce irremovable sources of error, e.g. radioactive decay
ILO 8	Perform moderately sophisticated optical system assembly and alignment
ILO 9	Use certain programming languages at an introductory level to process or obtain data.

Course Content

The students will understand the fundamentals of proper experimentation and its importance to discovery and knowledge of physics. The students will acquire skills and knowledge related to the key areas of physics.

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
3. Various reference notes provided on NTULearn during the course.

NOTE: 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 Introduction Lecture			In-person	General briefing of the course structure, requirement, assessment components and lab safety related matters.
2	week 2-11: Lab Sessions (based on assignment by Year 2 Lab manager)	1-9		In-person	Hands-on experiments, report writing and Viva with lab TAs and faculty.
3	Week 12, 13 & revision week: Make-up lab sessions (as applicable)	1-9		In-person	Hands-on experiments, report writing and Viva with lab TAs and faculty.

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Experiments Laboratory 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.
Experiment(s)' Viva Voce & Discussion	You would be asked warm-up and in-depth questions by the teaching assistant or faculty member conducting the viva. You would be tested on their depth of understanding of the various experimental aspects. You receive feedback through interactions with the teaching assistant.
Pre-Experiment Online Quiz	Before your hands-on lab session, you will complete a short quiz via the online assignment system. The quiz serves to introduce the experiment you will be working on, and to encourage you to review the relevant lab manual and supporting materials in advance. It is designed to help you gauge your understanding of key concepts and procedures, and to ensure you are adequately prepared for the upcoming experiment. Immediate feedback will be provided through your quiz scores on NTULearn.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Report/Case study(Experiments Laboratory Full-Reports)	LO 1-9		55		Individual	Analytic	Relational
2	Continuous Assessment (CA): Others(Experiment(s)' Viva Voce & Discussion (Faculty Member viva is experiment specific))	LO 1-9		35		Individual	Analytic	Relational
3	Continuous Assessment (CA): Test/Quiz(Pre-Experiment Online Quiz)	LO 2, 4, 6-8		10		Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

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

Formative Feedback

Formative feedback is given through multiple discussion sessions with the various experiments' teaching assistants as well as through the reports with comments.

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 lab session is mandatory. Students are expected to read the lab manual and related materials before attending each session. A pre-lab quiz is administered online to assess readiness and reinforce key concepts. Safety protocols must be strictly followed at all times. Proper attire is mandatory; no food and drinks are allowed in the lab.
All data must be recorded honestly and accurately. Plagiarism, fabrication or sharing of results without permission constitutes academic misconduct.
Lab reports must be submitted by the stated deadlines. Late submission may be penalized unless prior approval has been granted.

Policy (Absenteeism)

If you are sick and unable to attend your laboratory or viva sessions, you have to:
1. Send an email to the lab manager regarding the absence and request for a replacement / make-up laboratory or viva 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.

Appendix 1: Examiner's Assessment Rubrics for PH2199 Physics Laboratory IIb
Part 1: Laboratory Full-Report

Sections of the Laboratory Full Report	**Far Exceeds Expectations** (22 - 25)	**Exceeds Expectations in some areas** (16 - 21)	**Meets Expectations** (11 - 15)	**Meets Expectations in some areas** (6 - 10)	**Below Expectations** (0 - 5)	**Score**
Introduction, Theory & Procedure Section suggested consideration point(s); • Did the student state the explicit, and any implicit, goals of their experiment? • 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?	All of the experiment goal(s) were stated. Extensive procedural details provided, referenced the lab manual's procedure steps specifically as needed. Appreciable attempts to reduce or deduce experimental error.	All of the experiment goal(s) were stated. Lots of procedural details provided, referenced the lab manual procedures. Appreciable attempts to reduce or deduce experimental error.	Most of the experiment goal(s) were stated. Some procedural details provided, copied directly from the lab manual. Some attempts to reduce or deduce experimental error.	Some of the experiment goal(s) were stated. Few procedural details provided, copied directly from the lab manual. Some attempts to reduce or deduce experimental error.	None of the experiment goal(s) were stated. Little or no procedural details provided. Absence of attempts to reduce or deduce experimental error.	/ 25
	(26 - 30)	(21 - 25)	(14 - 20)	(6 - 13)	(0 - 5)	
Results Section 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	All of the required results were presented. Presented results were	All of the required results were presented. Presented results were	Most of the required results were presented. Presented results were	Some of the required results were presented. Presented results were disorganised	None of the required results were presented. Any presented results were	/ 30

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? • 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? • If an experiment requires so, o is the student able to perform curve fitting using the recommended software? o Has the student utilised the correct fitting function & results based on the experiment's theoretical considerations? o Has the student provided the fitting results?	well-organised , tabulated. Considerable initiative investigating phenomena outside the requirements. --- All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Explanation was provided. Correct uncertainties from error propagation. Method was provided. --- The required data plots were presented. Fitting results were presented.	well-organised and tabulated. Appreciable initiative investigating phenomena outside the requirements. --- All of the required uncertainties were presented. Uncertainties obtained were contextually realistic. Correct uncertainties from error propagation. --- The required data plots were presented. Fitting results were presented. Choice of fitting function & fitting results were presented.	organised and tabulated. Some initiative investigating phenomena outside the requirements. --- Most of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic. --- The required data plots were presented. Fitting results were presented. Choice of fitting function & fitting results were not presented.	and not tabulated. Some of the required uncertainties were presented. Uncertainties obtained were contextually unrealistic. The required data plots were presented. No fitting results were presented.	messy and not tabulated. No uncertainties were presented. No data plots nor fitting results were presented.	

	Choice of fitting function & fitting results were presented and explained.					

Sections of the Laboratory Full Report	**Far Exceeds Expectations** (35 - 40)	**Exceeds Expectations in some areas** (30 - 34)	**Meets Expectations** (16 - 29)	**Meets Expectations in some areas** (6 - 15)	**Below Expectations** (0 - 5)	**Score**
Discussion Section 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?	Required quantifiers used. Well-reasoned attempts at benchmarking the experiment's accuracy & precision. Successful attempts at identifying error trends in presented results. Excellent attempts at quantifiable error analysis. In-Depth qualitative error analysis. Well-reasoned discussion on the experimental impact of errors.	Required quantifiers used. Reasonable attempts at benchmarking the experiment's accuracy & precision. Determined attempts at identifying error trends in presented results. Appreciable attempts at quantifiable error analysis. Considerable qualitative error analysis.	Required quantifiers used. Some attempts at benchmarking the experiment's accuracy & precision Some attempts at identifying error trends in presented results. Some attempts at quantifiable error analysis. Considerable qualitative error analysis. Some discussion on the experimental impact of errors.	Required quantifiers used. No attempts at benchmarking the experiment's accuracy & precision Brief and short qualitative error analysis. Brief discussion on the experimental impact of errors.	Absence of any quantifiers used. Omission of any attempts at determining the apparatus accuracy & precision. Error analysis was completely omitted.	/ 40

• 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.)? • 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 supported current procedures?		<u>Considerable discussion</u> on the experimental impact of errors.				
	(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%.

Appendix 2: Examiner's Assessment Rubrics for PH2199 Physics Laboratory IIb
Part 2: Experiment(s)' Viva Voce & Discussion

	Far Exceeds Expectations (21 - 25)	**Exceeds Expectations in some areas** (16 - 20)	**Meets Expectations** (11 - 15)	**Meets Expectations in some areas** (6 - 10)	**Below Expectations** (0 - 5)	**Score**
Experiment Theoretical Understanding suggested consideration point(s);	Demonstrated <u>extremely thorough understanding</u> of the	Demonstrated <u>thorough understanding</u> of	Demonstrated <u>considerable understanding</u> of	Demonstrated <u>limited understanding</u> of	Demonstrated <u>completely no understanding</u> of	/ 25

• Did the student have a firm grasp of the physical theories behind the experiment? • Does the student understand the scientific significance of their experiment?	experiment's physics.	the experiment's physics.	the experiment's physics.	the experiment's physics.	the experiment's physics.	
Understanding of Experimental Methodology suggested consideration point(s); • Did the student have a good understanding of the experimental design, instrumentation and data acquisition? • Did the student explain and perform any additional procedures outside of the lab manual's instructions?	Demonstrated an expert understanding of the experiment's methodology. Significant number of additional procedures, supported with detailed explanations	Demonstrated through understanding of the experiment's methodology. Appreciable number of additional procedures, supported with simple explanations	Demonstrated considerable understanding of the experiment's methodology. Limited number of additional procedures, supported with simple explanations	Demonstrated limited understanding of the experiment's methodology.	Demonstrated completely no understanding of the experiment's methodology.	/ 25
Analysis of Experimental Data suggested consideration point(s); • Is the student able to support their analysis from their obtained data or observed data trends? • Is the student able to use their analysis to support their experimental deductions (e.g.	Able to extensively support their analysis through use of appropriate data. Deduced aspects are strongly supported by their analysis.	Able to support their analysis through use of appropriate data. Deduced aspects are somehow supported by their analysis.	Able to support their analysis through use of reasonably appropriate data. Deduced aspects are weakly supported by their analysis.	Able to weakly support their analysis through use of reasonably appropriate data. Few to none deduced aspects. Deduced aspects are	No Analysis. Unable to support their analysis through use of data. Absence of any deduced aspects.	/ 25

errors of significance, prove of existence, etc..) ?				weakly supported by their analysis.		
Communication Skills suggested consideration point(s); • Did the students understand the questions and answer to the point? • Were the students confident of their answer? • Were the students able to engage in a meaningful & civil discussion with the faculty member?	Very productive discussions and deep analyses. Ideas were presented very clearly.	Productive discussions and analyses. Ideas were presented clearly.	Some discussions and analyses. Ideas were presented some-what clearly.	Little discussions and analyses. Ideas were mostly unclear.	Absence of a response, discussions or analyses Ideas were not presented clearly.	/ 25
					[1]Total :	/ 100

[1]Normalised to 100%.