Nanyang Technological University
Division of Physics and Applied Physics

Academic Year	2020	**Semester**	1
Course Coordinator	Fan Hongjin (Prof)		
Course Code	PH1198		
Course Title	Physics Laboratory Ia		
Pre-requisites	Physics at A or H2 level or equivalent		
No of AUs	2 AU		
Contact Hours	48 hours (1 hour lesson and 3 hours hands on laboratory work in Physics Year 1 Teaching Lab per Week, Week 2-13)		
Proposal Date	11 June 2020		

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.

Intended Learning Outcomes (ILO)

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

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

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.

Assessment (includes both continuous and summative assessment)

- You will be assessed by an online assignment system (NTULearn), Laboratory Teaching Assistant(s) and faculty member(s) from NTU.
- The shown weightage for Components 1. to 4. are the cumulative weightage over 4 different experiments.

Component	Course LO Tested (Pg 2)	Related Programme LO or Graduate Attributes (Pg 14-15)	Weighting	Team / Individual	Assessment Rubrics
1. Experiments Laboratory Half-Reports	LO 1-5 & 7	Competency (1,2,4,5,6,7) Creativity (2) Communication (1,2,3) Character (1,2)	24%	Individual	Rubrics marking - Appendix 1
2. Experiments Laboratory Notebook	LO 1-2, 4, 6	Competency (3,6,7) Creativity (2) Character (1)	12%	Individual	Rubrics marking - Appendix 2
3. Experiments in-Class Assessments	LO 2, 4-5, 7	Creativity (2) Communication (1,2,3) Character (1,2,3	15%	Individual	Rubrics marking - Appendix 3
4. Pre-Experiments Online Quiz	LO 1 & 7	Competency (2,4,5,6)	9%	Individual	Point-based marki (not rubric-based) using NTULearn
5a. Course Mini-Project – Project	LO 1-2, 4-5, 7-8	Competency (1,2,3,4,5,6,7) Creativity (2) Communication (1,2,3) Character (1,2,3)	24%	Team	Rubrics marking **Student Project** - Appendix 4
5b. Course Mini-Project – Presentation	LO 1-2, 4-5, 7-8	Competency (1,2,3,4,5,6,7) Creativity (1,2) Communication (1,2,3) Character (1,3)	16%	Individual	Rubrics marking **Presentation** - Appendix 5
Total			100%		

Formative feedback

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

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Experiments Laboratory Half-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.
Mini-Project	You would be required to design an experiment as a team to explore a physical phenomenon. You are also required to present the experiment's findings to your course-mates. You would be able to receive feedback via your presentation remarks.

Reading and References

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

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons

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.

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. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Fan Hongjin (Prof)	SPMS-PAP 04 06	+65 65137408	fanhj@ntu.edu.sg

Planned Weekly Schedule

Dependent on assigned experiment schedule as provided by the Physics Year 1 lab manager, Dr. Ranjani Narayanan.

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Appendix 1: Examiner's Assessment Rubrics for PH1198 Physics Laboratory Ia
Part 1: 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 required data plots were presented. Fitting results were presented. Choice of fitting function & fitting results were presented and explained.	The required data plots were presented. Fitting results were presented. Choice of fitting function & fitting results were presented.	The required data plots were presented. Fitting results were presented. Choice of fitting function & fitting results were not presented.	The required data plots were presented. No fitting results were presented.	No data plots nor fitting results were presented.	/ 15
Sections of the laboratory Half 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 *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..)?	Required quantifiers used. Well-reasoned attempts at benchmarking the experiment's accuracy & precision. Successful attempts at identifying error trends in presented results.	Required quantifiers used. Reasonable attempts at benchmarking the experiment's accuracy & precision. Determined attempts at identifying error trends in presented results.	Required quantifiers used. Some attempts at benchmarking the experiment's accuracy & precision Some attempts at identifying error trends in presented results.	Required quantifiers used. No attempts at benchmarking the experiment's accuracy & precision	Absence of any quantifiers used. Omission of any attempts 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
	Far Exceeds Expectations (9 - 10)	**Exceeds Expectations in some areas** (7 - 8)	**Meets Expectations** (5 - 6)	**Meets Expectations in some areas** (1 - 4)	**Below Expectations** (0)	**Score**
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%.

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Appendix 2: Examiner's Assessment Rubrics for PH1198 Physics Laboratory Ia
Part 2: Laboratory Notebook

	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%.

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Appendix 3: Examiner's Assessment Rubrics for PH1198 Physics Laboratory Ia
Part 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%.

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Appendix 4: Examiner's Assessment Rubrics for PH1198 Physics Laboratory Ia
Part 5a: Course Mini-Projects (Student Project)

	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**
Originality of Project Idea suggested consideration point(s); • Did the students came up with a novel experiment? • Was their experiment a modification of an existing one? • Were the laboratory equipment provided used in a new and novel way? • Did the students design and make their own equipment for this project?	Experiment designed was completely different from existing experiments.	Experiment designed was a modification of existing experiments with several distinct differing feature.	Experiment designed was a modification of existing experiments with a distinct differing feature.	Experiment designed was a slight modification of existing experiments with little differing features.	Experiment designed was a direct copy of existing experiments.	/ 25
Design of the Experiment & Apparatus suggested consideration point(s); • Are the procedures laid out by the students able to test their intended phenomena? • Was their range of provided laboratory equipment adequate for the experimental task(s)? • Did the students have to design and create new working apparatus to supplement their existing equipment?	The designed procedures, provided and/or designed apparatus were able to fulfil all of the experiment's goals and be useful potentially in future expansions of the experiment's goals.	The designed procedures, provided and/or designed apparatus were able to fulfil all of the experiment's goals.	The designed procedures, provided and/or designed apparatus were able to fulfil most of the experiment's goals.	The designed procedures, provided and/or designed apparatus were able to fulfil a few of the experiment's goals.	The designed procedures, provided and/or designed apparatus were not able to fulfil the experiment's goals.	/ 25
Experimentally Obtained Data suggested consideration point(s); • Did the students record all relevant data as required by their experiment's goals? • Were the students' data processing methods effective at supporting their investigations? • Did the students presented their data clearly?	Relevant data was presented very clearly. No errors in how the students handled their data.	Relevant data was presented clearly. Few or no minor errors in how the students handled their data.	Data was presented some-what clearly. Some minor errors in how the students handled their data.	Data was presented mostly unclearly. Few major errors in how the students handled their data.	Data was not presented clearly. Lots of major errors in how the students handled their data.	/ 25

	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**
Error analysis suggested consideration point(s); • Are the students able to obtain uncertainties within the reasonable bounds of the apparatus used or from calculations? • Were the students able to identify errors in their designed experiment? • Were the students able to suggest improvements to their designed experiment?	Able to obtain and propagate uncertainties, aware that errors exist in their design, able to determine the extent of the errors' impact and suggest good improvements to their design.	Able to obtain and propagate uncertainties, aware that errors exist in their design, somewhat able to determine the extent of the errors' impact and suggest some improvements to their design.	Able to obtain & propagate some basic uncertainties, aware that errors exist in their design but unable to determine the extent of the errors' impact, suggests simple improvements to their design.	Able to obtain some basic uncertainties, somewhat aware that errors exist in their design but not aware of the errors' impact.	Unable to obtain uncertainties, unaware that errors exist in their design.	/ 25
Please note that all members are expected to actively participate in the project. If any member is unable to do so due to valid reason (e.g., medical/family issue), we provide half score; If absent without valid reason, zero score. If there is contribution by providing ideas that are accepted by other team members, but the member is unable to physically participate in the project, also half score. In all such cases, there will be an interview with the course coordinator to ascertain the circumstances resulting in the student's lack of participation before their final grade is decided.					[1]Total :	/ 100

[1]Normalised to 100%.

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Appendix 5: Examiner's Assessment Rubrics for PH1198 Physics Laboratory Ia
Part 5b: Course Mini-Projects (Presentation)

	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**
Visual Presentation suggested consideration point(s); • Are the slides informative? • Are the slides too cluttered or too sparse? • Did the students include visualisations of their set-up? Were the slides well animated?	The visuals were very helpful to the audience.	The visuals were helpful to the audience.	The visuals were somewhat helpful to the audience.	The visuals were mostly helpful to the audience.	The visuals were not helpful to the audience.	/ 25
Oral Presentation suggested consideration point(s); • Was the presentation audible? • Did the students vary their tone to emphases on key issues? • Was the physical concepts delivered in a clear and concise manner? • Was time managed well? Did the students have equal speaking time?	Ideas were presented very clearly. Provided more than the required info about the project. Accurate concepts delivered. Excellent time management. Engaging presentation.	Ideas were presented clearly. Provided the required info about the project. Mostly accurate concepts delivered. Excellent time management.	Ideas were presented some-what clearly. Provided most of the required info about the project. Mostly accurate concepts delivered.	Ideas were mostly unclear. Provided some of the required info about the project. Some major errors in concepts delivered.	Ideas were not presented clearly. Provided little to none of the required info about the project. Major errors in concepts delivered.	/ 25
	(46 - 50)	(36 - 45)	(21 - 35)	(11 - 20)	(0 - 10)	
Q&A Session 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 audience?	Very Productive discussions and deep analyses. Critiques extends beyond the requirements of the project into new scenarios.	Productive discussions and analyses. Critiques involved different aspects of the project, how the different aspects interact with each other and corresponding impacts.	Some discussions and analyses. Critiques involved more than a single aspect of the project. Unable to debate relationships between the project's aspects.	Little discussions and analyses. Critiques involved only a single aspect of the project.	Absence of a response, discussions, analyses or critique.	/ 50
Please note that all group members are expected to actively participate in the presentation. We will be assessing each student individually for the presentation. In specific cases (e.g., medical/family issue) where a member is absent for a valid reason, there will be an interview with the course coordinator to ascertain the circumstances for the student's lack of participation before their final grade is decided.					[1]Total :	/ 100

[1]Normalised to 100%

Graduate Attributes

What we want our graduates from Physics and Applied Physics to be able to do:

Upon the successful completion of the PHY, APHY and PHMA programs, graduates should be able to:

Competency	1	demonstrate a rigorous understanding of the core theories and principles of physics involving (but not limited to) areas such as classical mechanics, electromagnetism, thermal physics and quantum mechanics;
		[PHMA only] demonstrate a rigorous understanding of the core theories and principles of mathematical sciences involving (but not limited to) areas such as analysis, algebra and statistical analysis;
	2	read and understand undergraduate level physics content independently;
	3	make educated guesses / estimations of physical quantities in general;
	4	apply fundamental physics knowledge, logical reasoning, mathematical and computational skills to analyse, model and solve problems;
	5	develop theoretical descriptions of physical phenomena with an understanding of the underlying assumptions and limitations;
	6	critically evaluate and distinguish sources of scientific/non-scientific information and to recommend appropriate decisions and choices when needed;
	7	demonstrate the ability to design and conduct experiments in a Physics laboratory, to make measurements, analyse and interpret data to draw valid conclusions.

Creativity	1	propose valid approaches to tackle open-ended problems in unexplored domains;
	2	offer valid alternative perspectives/approaches to a given situation or problem.

Communication	1	describe physical phenomena with scientifically sound principles;
	2	communicate (in writing and speaking) scientific and non-scientific ideas effectively to professional scientists and to the general public;
	3	communicate effectively with team members when working in a group.

Character	1	uphold absolute integrity when conducting scientific experiments, reporting and using the scientific results;
	2	readily pick up new skills, particularly technology related ones, to tackle new problems;
	3	contribute as a valued team member when working in a group.

Civic Mindedness	1	put together the skills and knowledge into their work in an effective, responsible and ethical manner for the benefits of society.