Fall 2017: Fundamentals of Physics

- SYLLABUS -

PHY 2002L: BTRA, X — TR 9:05 a.m. – 10:20 a.m. Lecture Room: 1311, 17 Lexington

Contact Info

Professor Richford

drichford@gradcenter.cuny.edu

Rm. 938, 17 Lexington; Mailbox in Rm. 506, 17 Lexington

Office Hours: Tuesdays, 8 a.m. – 9 a.m.

Textbook

Recommended: "The Physics of Everyday Phenomena," W. Thomas Griffith Additional practice problems and resources: "Physics," Giancoli:

http://wps.prenhall.com/esm_giancoli_physicsppa_6/16/4350/1113788.cw/ index.html

Grading

Exams 100%

(consisting of three exams: best exam score 50%, second best 40%, lowest 10%)

Problems & Homework

Problems are key. It is very important to regularly work out and solve problems given throughout the course—this practice is the best way to learn the process and concepts of this class. Submissions must be neat and hand-written. Homework will be assigned and corrected; however, it will not count towards your grade.

Learning **Objectives**

Understanding basic physics and gaining insight into fundamental physical principles; development of quantitative skills and critical thinking through problem solving; development of scientific and experimental skills using the scientific method in laboratory experiments; appreciation of the power and beauty of modern science and its central role in civilization and culture.

Attendance Absence from 5 (five) or more lecture sessions draws a WU grade for the course.

Academic dishonesty is unacceptable and will not be tolerated. Cheating, forgery,

Baruch's Policy on Academic Honesty states, in part—

plagiarism and collusion in dishonest acts undermine the college's educational mission and the students' personal and intellectual growth. Baruch students are expected to bear individual responsibility for their work, to learn the rules and definitions that underlie the practice of academic integrity, and to uphold its ideals. Ignorance of the rules is not an acceptable excuse for disobeying them. Any student who attempts to compromise or devalue the academic process will be sanctioned.

Academic Honesty

Academic dishonesty in this will not be tolerated and automatically results in an F for the course. A report of suspected academic dishonesty will be sent to the Office of the Dean of Students. Additional information and definitions can be found at www.baruch.cuny.edu/academic/academic_honesty.html.

Disability Accommodation

Students with disabilities may be eligible for a reasonable accommodation to enable them to participate fully in courses at Baruch. If you feel you may be in need of an accommodation, please contact the Office of Services for Students with Disabilities at (646) 312-4590.

	1	
Lecture		
Schedule	Tuesday, August 29	Introduction
Course topics, session topics, dates, assignments, and pacing all subject to change	Thursday, August 31	Unit Conversions; Algebra/Trig primer; Position
	Tuesday, September 12	Distance vs. Displacement
	Tuesday, September 5	Velocity & Speed
	Thursday, September 7	Acceleration & Mass & Newton's Laws (Ch 2, 3, 4)
	Tuesday, September 12	Homework 1 assigned
	Thursday, September 14,	Homework 2 assigned
	Tuesday, September 19	Circular Motion (Ch. 5); Thursday Schedule
	Tuesday, September 26	Momentum & Impulse (Ch. 7) Homework 3 assigned
	Thursday, September 28	
	Tuesday, October 3	Review 1
	Thursday, October 5	Exam 1
	Tuesday, October 10	Rotation & Angular Momentum (Ch. 8)
	Thursday, October 12	Homework 5 assigned
	Tuesday, October 17	Energy & Work & Gravitation
	Thursday, October 19	Homework 6 assigned
	Tuesday, October 24	
	Thursday, October 26	Special Relativity Intro (Ch. 20)
	Tuesday, October 31	Fluids & Drag (Ch. 9)
	Thursday, November 2	Homework 7 assigned
	Tuesday, November 7	Review 2
	Thursday, November 9	Exam 2
	Tuesday, November 14	Heat and Thermodynamics (Ch. 10, 11)
	Thursday, November 16	Homework 8 assigned
	Tuesday, November 28	
	Thursday, November 30	Advanced Topics (T.B.D.)
	Tuesday, December 5	
	Thursday, December 7	Review 3

Final Exam (Cumulative)

Tuesday, December 12

Fall 2017: Lab

PHY 2003: ETRL — TR 4:10 p.m. – 5:25 p.m.

Contact Info

Lab Details

Professor Richford

drichford@gradcenter.cuny.edu

Rm. 939, 17 Lexington; Mailbox in Rm. 506, 17 Lexington

Office Hours: Tuesdays, 8 a.m. - 9 a.m.

The lab schedule has yet to be determined; however, there will be at least 4 recitation sessions quiz will be given at the beginning of each recitation, after which, problems from lecture and homework will be solved on the board.

All lab reports must be submitted no later than one week after the experiment is completed; these will be graded on a scale of o-18. No credit will be given for a report submitted without completion of the experiment. Late lab reports will be penalized 4 (two) points (out of 18 [eighteen]) for each academic day of lateness. No reports will be accepted one week after the due date.

Although the experiment may be done in groups, each student must submit an individual lab report.

Lateness to lab sessions is penalized 1 (one) point (out of 18 [eighteen]) for each five-minute block of lateness off that session's corresponding lab report or quiz grade (for example, five minutes' lateness-one point deducted, six minutes' lateness-two points deducted). If you are more than 30 (thirty) minutes late, you will be considered absent from that session.

Required Materials A notebook, a ruler, a protractor, and a scientific calculator

A lab report must consist of the following, in the following order:

- 1. Name, names of lab partners, title, introduction
- 2. Procedure of experiment, including diagram and description of any apparatus, and journal of the experiment
- Theory of underlying physics being tested
- 4. Experimental data
- 5. Calculations and error analysis
- Conclusions and sources of error
- Solutions to problems posed in the lab manual

Margins: 1-inch top and bottom, 1.5-inch left and right (drawings and tables may exceed margins)

Lab Report Formatting

Lab Report

Structure

Font: any roman font, 12-point size, 15-point spacing

Paragraph: fully justified text, right-ragged data; no space between paragraphs in the same section; do not indent first line of first paragraph in each section; indent first line of succeeding paragraphs by half an inch

Header/Footer: name, current page, and total number of pages on each page

Laboratory		
Schedule	Thursday, August 25	Introduction
Experiments, session		Experiment 1: Measurements and Unit Conversions
topics, dates, and quizzes subject to		Experiment 2: Gravitational Acceleration
change		Experiment 3: 2D Vectors, Force Table
		Experiment 4: Newton's Second Law
	To Be Determined	Recitation Session 1, Quiz 1
		Experiment 5: Momentum Conservation
		Experiment 6: Simple Pendulum
		Recitation Session 2, Quiz 2
		Experiment 7: Torque and Angular Acceleration
		Experiment 8: Specific Heat of Metals
		Recitation Session 3, Quiz 3
		Experiment 9: Ohm's Law
		Experiment 10: Reflection and Refraction of Light
		Recitation Session 4, Quiz 4

unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Section missing (if required by lab manual)	Global Comments	Total: 3 point
Report is readable and near, yet inconsistent with the formatting requirements	0	
Name/Title/Introduction Section Name/Title/Introduction Section Name/Title/Introduction Section Name/Title/Introduction Section Name/Title/Introduction Section Name/Title/Introduction Section Missing any one of the following: name, names of lab partners, title, introduction Total: 2 points Section missing: copy lab manual verbatim Interpretation Seminarizing the lab manual and what you did in your own words—no move than a paragraphy present and adequact, diagram unclear, journal absent Theory Section Theory Section missing Section missing A brief description, journal, and diagram present and clear Theory Section missing A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, at the own to demonstrate that the student fully understands the details or significance Data Section missing Section missing Data are present, et organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, conclusions are absent, or intervening sleps are absent; error unclead/ressed; sentences used instead of algebraic equations Formulas used are absent, conclusions are absent, or intervening sleps are absent; error unclead/ressed; sentences used instead of algebraic equations Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error augue or incomplete unclear, not fitting the data and calculations; sources of error orgue or incomplete in unclear, not fitting the data and calculations; sources of error orgue or incomplete or inculations and determinent; sources of error orgue or incomplete in unclear, not fitting the data and calculations; sources of error orgue or incomplete or inculations and determinent; sources of error orgue or incomplete in inclear, and fitting the data and calculations; sources of error orgue or incomplete or incurplete	1	
Name/Title/Introduction Section Missing any one of the following: name, names of lab partners, title, introduction Contains all of the above Procedure and Journal Section Section missing; copy lab manual verbatim Brief description (summarizing the lab manual and what you did in your own words—no more than a paragraph) present and adequate, diagram unclear; journal absent Brief description, journal, and diagram present and celear Theory Section Section missing A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section Section missing Complete, yet it does not demonstrate that the student fully understands the details or significance Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas and conclusions, and steps are present, error adequately accounted for Total: 3 points Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately acquested or unclear, on the fitting with the experiment Conclusions address the fit between theory and experiment inadequately acquested or unclear, on the fitting with the experiment Conclusions address the fit between theory and experiment inadequately acquested inadequately acquested in unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment; sources of error acquested in the process of the	2	
Procedure and Journal Section O Section missing; capy lab manual verbatim Drief description (summarizing the lab manual and what you did in your own words—no more than a paragraph) present and adequate, diagram unclear; journal absent Brief description, journal, and diagram present and adequate, diagram unclear; journal absent Theory Section O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section O Section missing 1 Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. 2 Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulae used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations 2 Formulae used are doculations present, steps absent; error analysis inadequate 3 Formulae, conclusions, and steps are present, error analysis inadequate 3 Formulaes, conclusions, and steps are present, error analysis inadequate Conclusions unclear, not fitting the data and calculations; sources of error augue or incomplete Conclusions address the fit between theory and experiment inadequately sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment inadequated such analysis analysis in adequate C	3	Report is neat and consistent with the formatting requirements
Procedure and Journal Section O Section missing; capy lab manual verbatim Drief description (summarizing the lab manual and what you did in your own words—no more than a paragraph) present and adequate, diagram unclear; journal absent Brief description, journal, and diagram present and adequate, diagram unclear; journal absent Theory Section O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section O Section missing 1 Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. 2 Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulae used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations 2 Formulae used are doculations present, steps absent; error analysis inadequate 3 Formulae, conclusions, and steps are present, error analysis inadequate 3 Formulaes, conclusions, and steps are present, error analysis inadequate Conclusions unclear, not fitting the data and calculations; sources of error augue or incomplete Conclusions address the fit between theory and experiment inadequately sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment; sources of error sugue or incomplete Conclusions address the fit between theory and experiment inadequated such analysis analysis in adequate C	Name / Title / Indus dueties Continu	
Procedure and Journal Section Section missing; copy lab manual verb above more than a paragraph) present and adequate; diagram unclear; journal absent brief description, journal, and diagram present and clear Theory Section Theory Section Section missing A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas, conclusions, and steps are present, error adequately accounted for unclear, or not filting with the experiment Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not filting with the experiment Conclusions addressed the fit between theory and experiment; sources of error ague or incomplete Conclusions addressed the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error ague or inc		•
Procedure and Journal Section O Section missing; copy lab manual verbatim Brief description (summarizing the lab manual and what you did in your own words—no more than a paragraph) present and adequate; diagram unclear; journal absent Brief description, journal, and diagram present and clear Theory Section Total: 2 points O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section Data Section missing 1 Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. 2 Data are present, organized logically, clearly Calculations and Error Analysis Section Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas used are absent and sent or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Conclusions unclear, not fitting with the experiment Conclusions unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment in adequately aspective in adequate Conclusions in the proper		
O Section missing: copy lab manual verbatim Prief description (summarizing the lab manual and whal you did in your own words—no more than a paragraphy present and adequate; diagram unclear, journal absent Brief description, journal, and diagram present and clear Theory Section O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section O Section missing Data are present yel organized haphazardly or in sentences, or are incomplete, unclear, etc. 2 Data are present, organized logically, clearly Calculations and Error Analysis Section Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas used are absent, conclusions are absent, error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Formulas, conclusions unclear, not filting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error organized inadequate Posed-Questions Section O Section missing (if required by lab manual) Section present (if required by lab manual) Section missing (if not required by lab manual)	ľ	Contains an of the above
Section missing; copy lab manual verbatim First description (summarizing the lab manual and what you did in your own words — no more than a paragraph) present and adequate; diagram unclear, journal absent Brief description, journal, and diagram present and clear Theory Section	Procedure and Journal Section	Total: 2 points
more than a paragraph) present and adequate; diagram unclear; journal absent Theory Section Total: 2 points Section missing A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, uncleur, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Total: 3 points Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, on to fitting thing the data and calculations; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Section missing (if required by lab manual) Section present (if required by lab manual) Section present (if required by lab manual)	0	Section missing; copy lab manual verbatim
more than a paragraph) present and adequate, diagram unclear; journal absent Theory Section Theory Section Total: 2 points Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas, conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Conclusions unclear, not fitting with the experiment Conclusions address the fit between theory and experiment; sources of error wague or incomplete Conclusions address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Section missing (if required by lab manual) Section present (if required by lab manual) Section present (if required by lab manual)	1	Brief description (summarizing the lab manual and what you did in your own words—no
Theory Section O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section O Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas and conclusions, and steps are present, error analysis inadequate Formulas unclear, not fitting with the experiment Conclusions unclear, not fitting with the experiment Conclusions unclear, or not fitting with the experiment Conclusions adaptees the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment; sources of error appear or incomplete Conclusions adequately address the fit between theory and experiment inadequately Conclusions adequately Conclusions adequately by lab manual) Conclusions adequately Conclusions adequately Conclusi	ľ	more than a paragraph) present and adequate; diagram unclear; journal absent
O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section O Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Conclusions unclear, not fitting with the experiment Conclusions unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions adjuted by address the fit between theory and experiment; sources of error vague or incomplete Conclusions adjuted by address the fit between theory and experiment; sources	2	Brief description, journal, and diagram present and clear
O Section missing 1 A brief description of the underlying theory being tested is incomplete or unclear A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section O Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Conclusions unclear, not fitting with the experiment Conclusions unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions adjuted by address the fit between theory and experiment; sources of error vague or incomplete Conclusions adjuted by address the fit between theory and experiment; sources	Theory Section	Total: 2 points
A brief description of the underlying theory being tested is present and reasonably complete, yet it does not demonstrate that the student fully understands the details or significance Data Section Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas used are not instead of algebraic equations Formulas, conclusions, and steps are present, error analysis inadequate Formulas, conclusions present, steps absent, error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error wage or incomplete Conclusions address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate inadequate Section missing (if not required by lab manual)	0	Section missing
Data Section Data Section Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas one districtions and seps are present, and steps are present, error analysis inadequate Total: 3 points Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions adequately address the fit between theory and experiment inadequately; sources of error aspect for an appropriate Posed-Questions Section Section missing (if required by lab manual) Section present (if required by lab manual) Section missing (if not required by lab manual)	1	A brief description of the underlying theory being tested is incomplete or unclear
Data Section Total: 2 points Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Calculations and Error Analysis Section Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas und conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error ague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate inadequate Section missing (if not required by lab manual)		A brief description of the underlying theory being tested is present and reasonably
Data Section Total: 2 points	2	complete, yet it does not demonstrate that the student fully understands the details or
O Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. 2 Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations 2 Formulas and conclusions present, steps absent; error analysis inadequate 3 Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error sequice or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Total: 2 points Total: 2 points Section present (if required by lab manual); not all questions answered or answers inadequate 1 Section missing (if not required by lab manual)		significance
O Section missing Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. 2 Data are present, organized logically, clearly Calculations and Error Analysis Section O Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations 2 Formulas and conclusions present, steps absent; error analysis inadequate 3 Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error sequice or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Total: 2 points Total: 2 points Section present (if required by lab manual); not all questions answered or answers inadequate 1 Section missing (if not required by lab manual)	Data Section	Total: 2 points
Data are present yet organized haphazardly or in sentences, or are incomplete, unclear, etc. Data are present, organized logically, clearly Total: 3 points Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas, conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions address the fit between theory and experiment; sources of error ague or incomplete Conclusions in adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions in adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions in adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions in adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error ague or incomplete Conclusions adequately address the fit between theory and experiment inadequately ague or incomplete. Conclusions adequately address the fit between theory and experiment inadequately address the fit between theory and experiment.		•
Calculations and Error Analysis Section Conclusions and Sources of Error Section Total: 3 points Conclusions and steps are present, error analysis inadequate Formulas used are absent, conclusions present, steps absent; error analysis inadequate Formulas used are absent, conclusions present, steps absent; error analysis inadequate Formulas used are absent, conclusions and esperint; error analysis inadequate Total: 3 points Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	_	0
Calculations and Error Analysis Section Calculations and Error Analysis Section Conclusions and Sources of Error Section Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error wague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Conclusions adequately by lab manual) Section missing (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	1	, , , , , , , , , , , , , , , , , , , ,
O Section missing Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Conclusions and Sources of Error Section O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate inadequate Section missing (if not required by lab manual)	2	Data are present, organized logically, clearly
Formulas used are absent, conclusions are absent, or intervening steps are absent; error not addressed; sentences used instead of algebraic equations Formulas, conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Total: 3 points O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate 1 Section missing (if not required by lab manual)	Calculations and Error Analysis Section	Total: 3 points
not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Total: 3 points O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	0	Section missing
not addressed; sentences used instead of algebraic equations Formulas and conclusions present, steps absent; error analysis inadequate Formulas, conclusions, and steps are present, error adequately accounted for Total: 3 points Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Posed-Questions Section Total: 2 points Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate inadequate Section missing (if not required by lab manual)	1	
Conclusions and Sources of Error Section Conclusions and Sources of Error Section O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate 1 Section missing (if not required by lab manual)	'	, , ,
Conclusions and Sources of Error Section O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate 1 Section missing (if not required by lab manual) Section missing (if not required by lab manual)	2	, , ,
O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	3	Formulas, conclusions, and steps are present, error adequately accounted for
O Section missing Conclusions unclear, not fitting the data and calculations; sources of error absent or unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points O Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	Conclusions and Sources of Error Section	Total: 3 points
unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	0	
unclear, or not fitting with the experiment Conclusions address the fit between theory and experiment inadequately; sources of error vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	1	Conclusions unclear, not fitting the data and calculations; sources of error absent or
vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	'	unclear, or not fitting with the experiment
vague or incomplete Conclusions adequately address the fit between theory and experiment; sources of error specific and appropriate Posed-Questions Section Total: 2 points Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	2	Conclusions address the fit between theory and experiment inadequately; sources of error
Posed-Questions Section Total: 2 points Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	_	vague or incomplete
Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	3	
Section missing (if required by lab manual) Section present (if required by lab manual); not all questions answered or answers inadequate Section missing (if not required by lab manual)	Posed-Questions Section	Total: 2 points
Section present (if required by lab manual); not all questions answered or answers inadequate 2 Section missing (if not required by lab manual)		1
inadequate 2 Section missing (if not required by lab manual)		Section present (if required by lab manual): not all questions answered or answers
	1	· · · · · · · · · · · · · · · · · · ·
	2	Section missing (if not required by lab manual)
	2	Section present (if required by lab manual); all questions answered adequately