INTERMEDIATE LABORATORY

Phys 252 Spring 2019

Instructor:	Professor David Collins
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Office Hours:	M 2 – 3pm, T 1 – 2pm, W 9 – 10am, F 10 – 11am, 1 – 2pm
Class Meetings:	TR 3:30 – 5:15pm, WS 218
Course Website:	http://www.coloradomesa.edu/~dacollin/teaching/2019Spring/Phys252/index.html
Required Text:	J. R. Taylor, *An Introduction to Error Analysis,* 2ed University Science (1997).
Prerequisites:	Phys 231 (co-requisite)

Overview

Physics is largely driven by experimental discoveries and observations. As physics has evolved, these experiments have become increasingly sophisticated in terms of the concepts involved, equipment used, measurement techniques and data analysis. Phys 252 aims to provide a first stepping stone between introductory level physics experiments and professional experimental physics. The course offers a variety of experiments from classical and modern physics. It also provides training in error analysis and presentation of experimental results via formal reports and presentations.

Course Structure

Phys 252 meets twice per week. The class will be divided into small groups with each working on one experiment. Groups will cycle through the available experiments; there will be seven or eight of these during the semester. The instructor will assign individual students to groups and these will change regularly.

Assignments, Quizzes and Exams

1. **Attendance:** You will also score 1 point for attending the each lab class meeting. Credit for this requires that you are present for the entire class period. Your total attendance, is obtained by adding all such points.

2. **Homework Assignments:** There will be assignments associated with the error analysis portion of the course. Some of these will be done during class and some

outside of class. These assignments will be graded for completeness and correctness with numerical grades in proportion to the amount of work required to complete the assignment.

3. **Lab Journal:** You will be required to keep a lab journal, in which you describe, in detail, your activities during the time in which you are in the lab. The purpose of the journal is to provide enough information about an experiment that have done so that someone else with the same equipment could recreate it. A detailed description of desired lab journal contents and grading rubric is provided later. Your lab journal will be graded once every two or three weeks according to the attached schedule.

4. **Lab Reports:** You will be expected to produce four formal lab reports. Lab reports will be written in the style of a professional scientific journal article. Examples of such articles are provided on the course website. For each of these reports you will produce two draft reports and a final report, which the instructor will critique. The two drafts will be graded according to the attached rubric and the grade for each will count for 15% of the grade for the report. You will produce a final report which addresses the points raised in the critiques of the draft reports. Typically there will be substantial revisions between draft and final reports. Final reports will be graded according to the attached rubric. The final report will count for 70% of the report grade. Lab reports must contain:

   a) a title,
   b) an abstract, in which the experiment and the results are described briefly in a couple of paragraphs,
   c) a description of the context of the experiment and the theory which underlies it,
   d) a description of the apparatus and the measurements performed,
   e) data, result of the data analysis including error estimates,
   f) a discussion of the implications of the experiment.

5. **Oral Presentations:** Each student will give two 10 – 15 minute presentations to the entire class during the semester; these must be aimed at an audience of peers. One will be done in the week before Spring break and the other during the final exam period. You will be required to do a practice presentation to the instructor during the week before your class presentation. Each will count for 5% of the course grade.

An undergraduate student should expect to spend on a minimum of two hours outside the classroom for every hour in the classroom. The outside hours may vary depending on the number of credit hours or type of course. More details are available from the faculty member or department office and in CMU's Curriculum Policies and Procedures Manual.

Grades

The numerical grades for each component will be totaled and a final numerical grade will be computed according to the following distribution.

Attendance	10%
Homework Assignments	10%
Lab Journal	30%
Lab Reports	40%
Oral Presentations	10%

The following letter grades will be *guaranteed*:

90%	A
80%	B
70%	C
60%	D

It is possible that letter grades will be attained at lower numerical scores than those above. The only exception is that an F will be given if your numerical score is less than 50%.

Grading Rubrics

1. **Lab Journal:**

   Lab journal entries will be assessed according to a rubric broken down into the following categories.

   (a) **Format and organization:** Journal entry formatting must reflect:

      i. *Title and date:* New experiments must be given a title. The date must appear for each lab day.

      ii. *Organization:* Delineation of procedure, equipment, theory, data, data analysis, error analysis.

      iii. *Data, graphs:* Data must be labeled clearly, location of data stored in computer files must be identified, graphs must be attached in the logical location.

   (b) **Procedure:** The procedure description must be sufficiently detailed that an outsider could replicate the experiment:

      i. *Set-up:* The experimental situation must be clearly described.

      ii. *Equipment:* Equipment must be identified.

      iii. *Measurement techniques:* Measurement techniques must be clearly described. Measured quantities must be clearly described.

      iv. *Procedures:* If the procedure is the same as that done on a previous day a reference to that day must be given.

   (c) **Data and Analysis:** All data acquired during the experiment should be recorded.

      i. *Data:* Data must be labeled with units provided.

      ii. *Data analysis:* Data analysis steps must be provided or, if software was used, printouts must be included.

      iii. *Graphs:* Graphs must be titled, axes must be labeled and units indicated.

      iv. *Error analysis:* All steps of the error analysis must be included.

   (d) **Narrative:** Each lab journal entry must contain a narrative description that includes.

      i. *Overview:* describes the issue that the experiment investigates.

      ii. *Data analysis:* A brief narrative description of major steps in data analysis.

      iii. *Reflection/conclusion:* A conclusion and reflection of the experiment or the day's activity.

The categories will be assessed according to:

Score	0	1	2	3	4
Format and organization (10%)	Between 0 – 29% of title/date, delineation, labeling correct.	Between 30 – 49% of title/date, delineation, labeling correct.	Between 50 – 69% of title/date, delineation, labeling correct.	Between 70 – 89% of title/date, delineation, labeling correct.	Between 90 – 100% of title/date, delineation, labeling correct.
Procedure (30%)	Between 0 – 29% of procedure descriptions sufficient to replicate experiments/equipment identified.	Between 30 – 49% of procedure descriptions sufficient to replicate experiments/equipment identified.	Between 50 – 69% of procedure descriptions sufficient to replicate experiments/equipment identified.	Between 70 – 89% of procedure descriptions sufficient to replicate experiments/equipment identified.	Between 90 – 100% of procedure descriptions sufficient to replicate experiments, all equipment identified.
Data and Analysis (20%)	Between 0 – 29% of data, results, data analysis, calculations and error analysis are present.	Between 30 – 49% of data, results, data analysis, calculations and error analysis are present.	Between 50 – 69% of data, results, data analysis, calculations and error analysis are present.	Between 70 – 89% of data, results, data analysis, calculations and error analysis are present.	Between 90 – 100% of data, results, data analysis, calculations and error analysis are present.
Narrative (40%)	Between 0 – 29% of narrative, description of modifications, reflections are present.	Between 30 – 49% of narrative, description of modifications, reflections are present.	Between 50 – 69% of narrative, description of modifications, reflections are present.	Between 70 – 89% of narrative, description of modifications, reflections are present.	Between 90 – 100% of narrative, description of modifications, reflections are present.

2. **Lab Report:**

The first and second drafts of each lab report will be assessed according to the following rubric, broken down into the following categories.

(a) **Concept Map:** There should be a bubble or concept map that describes the major questions and issues that the lab addresses and which contains the major conceptual pieces that describe how the lab exercise addresses the questions.

(b) **Scientific Outline and Details:** The draft must contain:

i. a description of the basic physical situation that the lab addresses,

ii. the theory needed to understand the situation and an elaboration of how the theory predicts the outcomes of measurements performed in the lab, and

iii. details of the procedure followed in the lab.

(c) **Data and Analysis:** The draft must contain:

i. the data gathered in the lab, including plots,

ii. the analysis of the data, and

iii. error analysis.

Lab Report Rubric: First and Second Drafts

Score	0	1	2	3	4
Concept Map (20%)	Concept map is absent.	Concept map is present and contains between 20% and 40% of relevant concepts.	Concept map is present and contains between 40% and 60% of relevant concepts.	Concept map is present and contains between 60% and 80% of relevant concepts.	Concept map is present and contains between 80% and 100% of relevant concepts.
Scientific Outline and Details (40%)	Less than 20% of is present.	Between 20% and 40% is present.	Between 40% and 60% is present.	Between 60% and 80% is present.	At least 80% is present.
Data and Analysis (40%)	Less than 20% of essential data and analysis is present.	Between 20% and 40% of essential data and analysis is present.	Between 40% and 60% of essential data and analysis is present.	Between 60% and 80% of essential data and analysis is present.	At least 80% of essential data and analysis is present.

The final version of each lab report will be assessed according to the following rubric, broken down into the following categories. Within each category, there are several subcategories and the relative weight of each toward the grade for the report is indicated.

(a) **Formatting:** The report must be written in the style of a scientific journal article. Examples can be found in the *American Journal of Physics* or the *Physical Review* journal series. The following components are essential:

   i. *Title, . . . :* The title must reflect the work accurately. An author name and affiliation are required.

   ii. *Abstract:* The abstract must briefly summarize the issue investigated, the means of investigation and the main findings of the work.

   iii. *Sections:* The report must be divided into sections that accurately delineate and reflect the main pieces of the work.

   iv. *References:* References must be cited within the text and listed at the end of the report using the style of one of the journals listed above.

   v. *Figures and tables:* Figures, diagrams, pictures and tables must be "floating," be numbered in order of appearance and captioned meaningfully. There must be at least one reference to each figure and table within the text.

(b) **Scientific Content and Exposition:** The bulk of the grade for each lab report considers whether the report clearly describes the work in a logical order. Considerations are:

   i. *Introduction:* The body of the report must begin with an introduction that briefly describes the issue or question investigated. The introduction must describe the broader context of the work, why the issue is interesting or important and what other investigations into the issue have found.

   ii. *Major ideas:* Every scientific work is built on a small number of major ideas; if one of these is missing then the report will make no sense or be unconvincing to an outside reader. In the report, the major ideas must appear in a logical order and each must be introduced with a brief motivation.

   iii. *Minor ideas:* Within and amongst the major ideas that sustain the work, there will be numerous smaller ideas and details; if one of these is missing an outside reader will be able to understand the general idea of the work but may have to fill in some details to render it convincing. In the report, such minor ideas must appear in a logical order and each must be connected to its predecessor or else introduced with a brief motivation.

   iv. *Scientific exposition and clarity:* The work will probably rely on features specific to scientific disciplines; these include mathematical derivations, experimental details (e.g. circuit descriptions), information processing algorithms, and data analysis. These must be described clearly at a level appropriate for sophomore division level physics courses.

v. *Scientific details:* The physics and mathematics that supports the findings of the experiment must be correct. The details of the experiment must be correct.

(c) **Writing:** A portion of the grade for each lab report considers the quality of the writing and whether suggested revisions were done.

i. *Grammar, spelling, . . . :* The report must use standard English grammar, spelling, usage rules and punctuation.

ii. *Mathematical grammar:* Equations and mathematical entities must fit within the standard grammatical rules and must appear as part of a sentence (although they may be typeset on new lines).

iii. *Writing style:* Writing should be done in a professional style with a neutral tone. Colloquial or conversational style of language must not appear in the report. Repeated statements and other forms of verbosity must not appear in the report.

iv. *Revisions:* Revisions will be suggested after each version of the report is submitted; these must be addressed.

Lab Report Rubric: Formatting Category

Score	0	1	2	3	4
Title, author affiliation (1%)	None	No title present. Other information supplied.	Two of title, author, or affiliation is missing.	One of title, author, or affiliation is missing or the language is incorrect.	All appears with appropriate language and information.
Abstract (6%)	None present.	Abstract exists but fails to clearly describe any of: primary issue, method of investigation, and results.	Abstract clearly describes only one of: primary issue, method of investigation, and results.	Abstract clearly describes only two of: primary issue, method of investigation, and results or it contains excessive information.	Abstract clearly describes all of: primary issue, method of investigation, and results. Abstract does not contain excessive information.
Sections (5%)	Not delineated.	Number of missing or excessive sections is between 50% and 100% of total number of sections (for correctly section document).	Number of missing or excessive sections is between 25% and 50% of total number of sections (for correctly section document).	Number of missing or excessive sections is less than 25% of total number of sections (for correctly section document).	Sectioning is complete with no appearance of unnecessary sections or no need for additional sections. Section titles are clear and appropriate.
References (2%)	None present.	Between 75% and 100% of the author, journal/text, page, year in all references are absent.	Between 50% and 75% of the author, journal/text, page, year in all references are absent.	Between 25% and 50% of the author, journal/text, page, year in all references are absent.	Less than 25% of the author, journal/text, page, year in all references are absent.
Figures and Tables (if applicable) (1%)	Less than 20% of figures and tables have captions and a text reference.	Between 20% and 40% of figures and tables have meaningful captions and a text reference. Or most tabular material appears in the text.	Between 40% and 60% of figures and tables have meaningful captions and a text reference. Or most tabular material appears in the text.	Between 60% and 80% of figures and tables have meaningful captions and a text reference. Or some tabular material appears in the text.	At least 80% of figures and tables have meaningful captions and a text reference. No tabular material appears in the text.

Lab Report Rubric: Scientific Content and Exposition Category

Major ideas refer to the major points of the work. Minor ideas refer to sub-ideas within these major ideas. Scientific details refers to uncertainties, significant figures, graph axes labels, etc ....

Score	0	1	2	3	4
Introduction (5%)	None present.	Misses at least two of: a clear description of the issue under investigation, why it is interesting and prior investigations have found.	Misses one of: a clear description of the issue under investigation, why it is interesting and prior investigations have found.	Includes all of: a clear description of the issue under investigation, why it is interesting and prior investigations have found. There is some superfluous content, or ordering is inappropriate.	Includes all of: a clear description of the issue under investigation, why it is interesting and prior investigations have found. There is no superfluous content.
Order of Major Ideas. (20%)	More than 75% of the major ideas need to be moved, added or removed.	Between 50% and 75% of the major ideas need to be moved, added, removed or appear without any motivation.	Between one and 50% of the major ideas need to be moved, added, removed or appear without any motivation.	Only one of the major ideas needs to be moved, added, removed or appears without any motivation.	No major ideas need to be rearranged.
Order of Minor Ideas (15%)	More than 75% of the minor ideas need to be moved, added or removed.	Between 50% and 75% of the minor ideas need to be moved, added, removed or appear without any motivation.	Between 25% and 50% of the minor ideas need to be moved, added, removed or appear without any motivation.	Between 5% and 25% of the minor ideas need to be moved, added, removed or appear without any motivation.	Fewer than 5% of minor ideas need to be moved, added, removed or appear without any motivation.
Scientific Exposition and Clarity (10%)	More than 75% of the crucial scientific concepts or techniques are unclear.	Between 50% and 75% of the crucial scientific concepts or techniques are unclear.	Between 25% and 50% of the crucial scientific concepts or techniques are unclear.	Less than 25% of the crucial scientific concepts or techniques are unclear.	All scientific concepts or techniques are explained clearly.
Scientific Details (10%)	More than 75% are incorrect.	Between 75% and 20% are incorrect.	Between 50% and 20% are incorrect.	Between 20% and 5% are incorrect.	Fewer than 5% are incorrect.

Lab Report Rubric: Writing Category

Score	0	1	2	3	4
Conventional grammar, spelling and punctuation. (9%)	More than 50% of sentences require correction.	Between 50% and 10% of sentences require correction.	Between 10% and 5% of sentences require correction.	Between 5% and 1% of sentences require correction.	Less than 1% of sentences require correction.
Mathematical grammar. (1%)	More than 75% of the mathematics requires grammatical correction.	Between 75% and 50% of the mathematics requires grammatical correction.	Between 50% and 25% of the mathematics requires grammatical correction.	Between 25% and 5% of the mathematics requires grammatical correction.	Less than 5% of the mathematics requires grammatical correction.
Writing style (10%)	Writing always displays stylistic issues such as use of colloquial language or verbosity.	Writing usually displays stylistic issues such as use of colloquial language or verbosity.	Writing often displays stylistic issues such as use of colloquial language or verbosity.	Writing sometimes displays stylistic issues such as use of colloquial language or verbosity.	Writing needs little modification.
Revisions (5%)	Less than 25% of revisions have been addressed.	Between 25% and 50% of revisions have been addressed.	Between 50% and 75% of revisions have been addressed.	Between 75% and 100% of revisions have been addressed.	All revisions have been addressed.

Policies

1. The Tutorial Learning Center (TLC) is a *free* academic service for all CMU students. Tutors are available in Houston Hall 113 on a walk-in basis for many courses. More information is available at www.coloradomesa.edu/tutoring or 248-1392.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students must register with the EAS office to receive assistance. Please meet with the instructor the first week of class for information and/or contact Dana VandeBurgt, the Coordinator of Educational Access Services, directly by phone at 248-1801, or in person in Houston Hall, Suite 108.

   Helpful advice on student success can be found at: http://www.coloradomesa.edu/academics/documents/StudentSuccessatCMU_WCCC.pdf

2. **Attendance:** Attendance policies are described in the CMU catalog. You are expected to attend all the class meetings and attendance will be recorded. In case of illness or other emergencies you must be able to produce the appropriate documentation. There are other circumstances under which you can be excused but you must discuss these with me in advance. If you miss a class or lab for a valid reason, turn in any assignments due before the start of the next class. Assignments turned in beyond your return to class will not be accepted.

3. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **6 February 2019.** Please consult the CMU academic calendar and catalog for more details about adding and dropping courses.

4. **Academic Integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from anyone else, particularly in closed book exams, are serious violation of academic norms. CMU has extensive policies on these matters and penalties for infringement can be severe. For more details, consult the academic integrity policies in the CMU catalog.

Student Learning Outcomes

The learning outcomes for this course are as follows. A student who has taken this course will demonstrate the ability to:

1. set up and troubleshoot laboratory apparatus,
2. keep a laboratory notebook,
3. analyze data and perform error analysis using standard statistically meaningful techniques,
4. produce laboratory reports in the style of scientific journal articles, and
5. present findings of experiments orally.

This course contributes to the fulfillment of the following program learning outcomes for the BS in Physics degree. A student will have demonstrated the ability to:

1. show fluency with the major fields of physics (classical mechanics, electromagnetism, statistical physics and quantum theory),
2. use laboratory techniques to investigate experimentally physical phenomena, and
3. communicate effectively about topics in physics.

Schedule

The following schedule is tentative.

Week	Dates	Topic
1	1/22 – 1/24	Internal resistance of a battery. Error analysis (Ch 1 – 2).
2	1/29 – 1/31	Error analysis (Ch 3). Simple pendulum.
3	2/5 – 2/7	Simple pendulum cont. Error analysis (Ch 4).
4	2/12 – 2/14	Numerical solution for pendulum period. Error analysis (Ch. 5).
5	2/19 – 2/22	Speed of sound.
6	2/26 – 2/28	Calorimetry.
7	3/5 – 3/7	Atomic Spectroscopy. Practice presentations.
8	3/12 – 3/14	Lab stations. Class presentations.
9	3/19 – 3/21	Spring break (no classes).
10	3/26 – 3/28	Lab stations.
11	4/2 – 4/4	Lab stations.
12	4/9 – 4/11	Lab stations.
13	4/16 – 4/18	Lab stations.
14	4/23 – 4/25	Lab stations.
15	4/30 – 5/2	Lab stations.
16	5/7 – 5/9	Lab stations. Practice presentations.