

Physics 1: Space, Time and Motion (PHY 151/201) Wisconsin Lutheran College, Spring 2025

Overview : The world around us is in a state of constant change: the sun and moon rise and set, waves crash, rain falls, fires burn, and mountains crumble. Amidst all of these changes, there are certain patterns; there is a discernible order. In other words: the stars, the seas, the clouds, and the earth itself each seem to have a particular nature. Physics is the careful study of the natures of things. In fact, the word physics literally means "natures" in the Greek language.

In this course, we will study physics using some famous scientific works written by Galileo Galilei, Blaise Pascal, Isaac Newton and Albert Einstein. The required textbook is *A Student's Guide Through the Great Physics Texts, Volume 2: Space, Time and Motion*. You should purchase a hard-copy for use in the classroom, since there are no electronic devices permitted in the classroom.

Specific topics we will study include falling bodies and projectile motion, buoyancy and drag, hydrostatic pressure, the strength of materials, acoustics, Newton's laws of motion, conservation of momentum and energy, gravitation, and special relativity.

This course website: www.greatphysics.com/Volume2 is designed to lead you, week-by-week, through Volume 2 of *A Student's Guide* using short videos and homework assignments. Each video has a code (in parentheses) that indicates the book volume, chapter, and lecture number. Click is the link for Week 1 to get you started!

What are we learning in this course? This course will be divided into four units.

Unit 1: Galileo's Dialogues (about 6 weeks). In this unit, we will read selections from Galileo's famous *Dialogues Concerning Two New Sciences*, in which he discusses the sciences of (1) the strength of materials, and (2) projectile motion. We will also have the opportunity to discuss topics such as the law of the lever, dimensional analysis and scaling laws, pendulum motion, buoyancy, drag, sound, and even music theory.

Unit 2: Pascal's Treatise on the Equilibrium of Fluids (about 3 weeks). In this unit, we will take a closer look at buoyancy, hydrostatic pressure, Pascal's Principle, and at Pascal's solution to certain paradoxes that arise in the study of fluids.

Unit 3: Newton's Mathematical Principles of Natural Philosophy (about 5 weeks). In this unit, we will take a careful look at the development of Newton's theory of Universal Gravitation. Topics include: inertia, momentum, Newton's laws, force and acceleration, action-reaction pairs, free body diagrams, collisions,

centripetal force, conservation laws, and planetary motion.

Unit 4: Einstein's Relativity (about 2 weeks). In this final unit, we will explore Einstein's theory of space and time, focusing on the phenomena of time dilation, length contraction, and relativistic momentum and energy.

Course times and locations

PHY 151: General Physics 1 (Algebra-based) meets in Generac Hall on Monday, Wednesday and Friday from 8:00 - 8:50 (Dr. Ebeling) or from 10:30 - 11:20 a.m. (Dr. Brown)

PHY 201: Physics 1 (Calculus-based) In will also meet on Thursday from 11:30 - 12:20 (Dr. Brown).

Laboratory sections meet in Room S115 from 12:30 - 3:20 pm on the following days: Monday (Dr. Wagie), Tuesday (Dr. Ebeling), Wednesday (Dr. Wagie), Thursday (Dr. Wagie).

Course Instructors

- Daniel Ebeling, Ph.D, Professor of Chemistry
- Jeff Brown, Ph.D., Associate Professor of Computer Science
- Hannah Wagie, Ph.D., Associate Professor of Chemistry
- Kerry Kuehn, Ph.D., Professor of Physics (Course administrator)

Grade components

Final exam	30%
Weekly quizzes	30%
Laboratory notebook	20%
Homework assignments	10%
Laboratory oral presentation	10%

Required Textbook: You will need to obtain a physical copy of the required textbook for the course.

Kuehn, Kerry K., *A Student's Guide through the Great Physics Texts, Volume 2: Space, Time and Motion*. (New York: Springer, 2015).

Use of electronics in the lecture room is prohibited:

My goal is to maintain a high level of interaction in the classroom. To this end, the use of electronic devices (phones, laptops, etc.) during the lectures is forbidden. All such devices should be not brought to class or placed in a closed bag.

This restriction should not pose a problem, since during the classroom, lectures we will be primarily aimed at discussing the assigned texts and working through example problems, many of which required drawing

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pictures. For such activities, hand-written lecture notes are far superior to an electronic keyboard.

If you have a special need for electronic devices in the lecture room, please talk to me in person. Since there are no electronic devices in class, if you have purchased an electronic copy of the textbook, then you will need to print out the relevant pages and bring these to class. To avoid having to do this, I would highly recommend purchasing a hard-copy of the textbook.

The use of electronics is permitted (in fact, often required) in the laboratory. So please bring your phone/computer/devices to lab.

Grading scale: The standard grading scale used at WLC is reproduced below. While I do *not* curve individual quiz or test scores, I *do* curve your overall midterm grades and the final semester grades. If you are concerned about your grade during the semester, please come by and talk to me and I'd be happy to talk about your progress.

A	100%	C	< 77%
AB	< 95%	CD	< 71%
B	< 89 %	D	< 65%
BC	< 83%	F	< 60%

General Education/ELO Component: This course is aimed at the "Inquiry and Analysis" Essential Learning Outcome (ELO), and fully satisfies the Laboratory Science general education requirement of Wisconsin Lutheran College. Your assigned *laboratory presentation*, and the associated *laboratory notebook* pages, constitute an artifact that can be submitted as evidence to your digital portfolio. Instructions for online submission are available from your academic advisor.

Course material and delivery Each week on my personal website, www.greatphysics.com/Volume2/, I will identify (i) which book chapter(s) you must read, (2) which video lectures you must watch, (3) which homework problems you must complete, (4) the week's laboratory exercise, and (5) any supplementary information that may be of interest.

Weekly quizzes Just about every Monday, we will have a short (about 20 minute) quiz. Immediately afterwards, we will review the answers and score the quiz. The quizzes are designed to ensure that you are keeping up with the weekly course material.

How to succeed on the quizzes: Each quiz will be approximately 10 points. Quiz questions will be drawn

(in approximately equally proportions) from (i) the assigned textbook readings, (ii) the online lecture videos, (iii) the in-class lecture material, (iv) the weekly homework assignments, and (v) the week's laboratory exercises.

What will we do during our classroom time?

Mondays, Wednesdays, and Fridays will be devoted primarily to discussion of the week's reading and lecture material. We will also spend considerable time working through example problems and the week's homework exercises. This is designed, at least in part, to prepare you for our in-class quizzes every Monday (see below).

Calculus component: Students who have previously taken (or are currently enrolled in), and who are enrolled in PHY 201 will have an additional class meeting on every Thursday. During this session, we will work through problems that require more mathematical sophistication and that will prepare students for upper-level physics courses.

Weekly homework assignments Every week, I will assign a few homework problems. These may be numerical, conceptual, or essay-style problems. You should complete the homework problems and upload your solution *via* the course management system (Canvas) by Saturday evening.

Usually, I will simply check that you have uploaded a file and assign a pass/fail grade. Occasionally during the semester, I will inspect homework problems for completeness and accuracy.

The homework problems are designed to encourage you to engage with the material and to prepare you for the weekly quizzes. Solutions will be available on the course website. Homework that is submitted late will be deducted 15% each day, with a minimum score of 40%.

Final exam There will be one comprehensive final examination given during the finals week. A practice exam will be made available on the course website.

Reading classic scientific texts In this course, we will be reading and discussing some of the classic scientific texts dealing with space, time and motion. The scientific texts we will read are considered classics because they address timeless questions in a particularly honest and convincing manner. This does not mean that everything they say is true. In fact many classic scientific texts contradict one another. But it is by the careful analysis of the most reputable observations and opinions that one may begin to discern truth from error.

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You will not understand everything you read; nobody does. The texts are challenging. Like great literature, these texts must be “grown into”, so to speak. (Remember: nobody understands all of Shakespeare or all of the Bible the first time they read it, either!) So think of this course as a “first dip” into the deep end of the pool. These texts are classics because both the beginner and the advanced scholar can profit by studying them.

Classroom discussion Much of the time that we spend in the classroom will be devoted to discussion of the reading selections. As the discussion leader, I will typically ask questions regarding specific ideas which are found in the texts. For instance, I may ask, “What does the author mean by the term “mass,” or “do all objects have mass” And if so, “How do you know?” The task will then be to try, as a group, to answer these questions.

It is critical that participants carefully read the assigned selections before engaging in classroom discussion. This will help participants to make relevant comments and to cite textual evidence to support or contradict assertions made during the course of the discussion. In this way, many assertions will be revealed as problematic, in which case they must then be refined or rejected altogether. This is precisely the method used by scientists themselves in order to discover and evaluate competing ideas or theories.

During our discussion, you may speak with complete freedom. There is only one rule: *any comment or question you make must be made publicly so that all others can hear and respond*. Most students are initially apprehensive about speaking up in class. This is natural. If you find yourself to be one of these it is important to realize that you do not need to make an elaborate point in order to engage in classroom discussion. Often, a short question can provide a simple avenue. For example, “I am unclear what the author means by the term *energy*. Can someone please clarify?” Write down questions like these in the margins while reading the text. Start like this. Pretty soon, you may find yourself joining gamely in classroom discussion.

Laboratory exercises Many reputable opinions regarding how nature works are wrong. In many cases, this is because these opinions do not conform to the way nature actually behaves. How can one determine how nature actually behaves? During our weekly laboratory session, we will carry out experimental investigations which attempt to reveal how nature works under controlled conditions. You will be provided with equipment and some general questions or suggestions related to the assigned reading for the week. It will be your responsibility to devise

experimental techniques and procedures so as to clarify your understanding of nature.

Laboratory equipment You will be assigned a laboratory partner with whom you will carry out the various laboratory exercises. There are to be no more than two students in any laboratory group. Each group will be assigned a column of shelves containing a host of laboratory equipment. Your group is responsible for all of the equipment in this column. You may not use equipment from any other column of shelves. During the final laboratory session, the laboratory instructor will inspect your column of shelves and will assign a final laboratory grade based on the orderliness of your column.

Laboratory notebook You must keep a record of your work during the laboratory sessions. To this end, you will need to purchase a lab notebook which must be brought to lab on your first laboratory session. Your lab notebook must be sturdy, must be at least 8.5 x 11 inches and must be quad-ruled (graph paper). You must allow the first few pages in your lab book to serve as a table of contents. The purpose of the lab book is to serve as a single source which contains all of the information relevant to your experiments. In particular, during each laboratory session, you should record the following information in your laboratory notebook:

- Your name and your laboratory partner’s name, the date and a title for the experiment.
- A neat sketch of any experimental apparatus you use, along with labels (make and model).
- A clear description of your experimental procedure(s), including difficulties which you experienced in carrying out your experiments.
- Tables containing any data which you collect. You must never write data anywhere else: not on scrap paper, not on the back of your hand, nowhere. Also, you must write down an estimated uncertainty in any measurement which you perform. For instance, if you use a stop watch to time a falling ball, you should estimate the precision with which you were able to record the time. This is always slightly larger than the resolution of the device being used.

Your lab report must be written in blue or black ink. It must be written in chronological order. That is, you might first describe some of your procedure, then record some data, then describe some more of your procedure, then some more data, and finally do some analysis. The important thing is that you write clearly and that you spread out your writing so that the reader of your notebook can easily ascertain what you did, and reproduce it if necessary. If it contains computer printouts of data tables or plots, these must be trimmed to fit neatly on a page and secured with tape. Do not fold or stack your plots. All plots must occupy at least

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half of a laboratory book page (*i.e.* don't make tiny plots).

Before leaving the lab, your instructor will assign you a grade based on the neatness, clarity and completeness of your laboratory notebook.

Laboratory grading Laboratory notebook pages must be scanned and uploaded using the course management software by the date assigned by your laboratory instructor. The scanned pages must be assembled into a single file. Each student will receive a weekly laboratory grade which will range from 0% to 100%, based on their laboratory notebook. What follows are a few example students and the grade each received for one particular week.

- The 100% student conceived of an appropriate experimental program and has systematically executed it. When he or she ran into difficulties, he was able to arrive at a reasonable solution or work-around. His data is of good quality, and his analysis involves a reasonable assessment of sources of systematic error.
- The 80% student conceived of an appropriate experimental program and has systematically executed it. Although he or she was able to complete his experiments, either his data was inconclusive, or his analysis involved a significant systematic error which for which he was unable to account.
- The 60% student conceived of an appropriate experimental program, but was unable to complete significant portions of the laboratory assignment.
- The 0% student completed little or none of the laboratory assignment.

Laboratory presentations After collecting your data and performing some preliminary analysis, you will be prepared to share your experiments and your results with your classmates. Therefore, each week at the beginning of the lab section we will spend 15 minutes discussing the previous week's laboratory experiment. Each individual will be assigned a week during the semester on which to do a formal presentation. The formal presentations must include:

- acknowledgement of the collaborators on your experiment
- description of the problem you were trying to solve, and how this relates to the week's lecture,
- a description of how you attempted to solve the problem, including a detailed description of your experimental apparatus and procedure,
- plots or tables of your data, along with a description of how you analyzed your data, and
- a summary of the significance of your laboratory work. It is not good enough to simply state your results without any analysis of their meaning. If your

results are different than you had expected, then you must address this issue directly. This should include an analysis of any systematic errors. Be sure to distinguish between systematic and random errors.

The presentation should last no more than ten minutes, and will be followed by a short question and answer session. Be sure to bring visual aides that will allow others to get a clear look at you experimental setup and any data or plots you have prepared. The grade you receive will depend upon both the quality of your data and the extent to which you address the points mentioned in the previous section.

The laboratory discussion time will be aimed at understanding the meaning and significance of the experiments performed during lab sessions, and at discussing ways in which the experiments might have been performed so as to achieve the most meaningful results.

Final thoughts I want to encourage you to come to me with any concerns you may have during the course of the semester, whether they be physics questions or difficulties with reading or discussion. This course is designed to stretch your mind, but not to "break" you. Reading the classics in any field is challenging, but very rewarding. I would very much like to help you succeed and to enjoy this class! My contact information is listed at the beginning of this syllabus, so please feel free to contact me!

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Supplementary information: Follow the links below for the College's current policies regarding

- **Equal opportunity, Harassment and Nondiscrimination**
- **Americans with Disabilities Act and Support Services**
- **Student Health and Well Being**
- **Copyright Policy**
- **Academic Integrity, Cheating and Plagiarism**

Assessment compliance information:

College-level academic goals (AG)

1. Articulate a world-view based on Holy Scripture, as interpreted by the Lutheran Confessions.
2. Think critically, clearly, and accurately in the pursuit of Truth.
3. Express themselves with grace and precision in a variety of contexts.

College-level Essential Learning outcomes (ELO)

1. Creative Thinking
2. Critical Thinking
3. Effective Communication
4. Ethical Reasoning
5. Inquiry & Analysis
6. Intercultural Knowledge and Competence

Departmental Learning Outcomes (DLO): *What are WLC physics students expected to learn? There are six student learning outcomes (DLOs) that are emphasized in the physics curriculum at WLC. What are they? And how are they related to the ELOs of the College?*

1. *improve scientific reading comprehension:* physics students will engage in the careful reading, analysis and discussion of the most important scientific texts and ideas. DLO1 can be mapped most directly to ELOs 2, 3, 4, and 5.
2. *articulate scientific ideas:* physics students will learn to speak and write on scientific topics using correct grammar, rational argumentation, and convincing style. DLO 2 can be mapped most directly to ELOs 1, 2, 3.
3. *solve problems:* physics students will learn to work out clear, correct, and creative solutions to both written and laboratory exercises. DLO 3 can be mapped most directly to ELOs 1, 2, 3 and 4.
4. *analyze and understand nature:* students will learn to grasp and to intuitively understand the workings of nature; this objective implies more than merely memorizing strategies and formulae used to solve technical problems. DLO 4 can be mapped most directly to ELOs 2, 3, 4 and 5.
5. *discern truth from error:* physics students will aim not merely to learn scientific ideas, but to evaluate

and judge them, and to recognize their philosophical and even theological implications. DLO 5 can be mapped most directly to ELOs 2, 3, 4 and 5.

6. *prepare for the future:* physics students will be ready for the next step—whether it is moving on to upper-level coursework at the undergraduate level, enrolling in graduate studies in physics, or applying for a job in industry that requires understanding physics methods and concepts. DLO 6 can be mapped most directly to ELOs 1 and 4.

General (and Specific) Student Activities: How are the six learning outcomes (DLOs) achieved? There are four general categories of student activities that have been designed so as to meet the six learning outcomes. These activities provide the “scaffolding,” as it were, for achieving the learning outcomes. Here we describe the four general categories of activities—along with a few specific activities for each general activity category—that are carried out in WLC physics courses. Next to each of the four general student activities we identify the student learning outcomes to which they are connected.

1. reading, analysis and discussion of scientific texts (designed to meet DLOs 1, 2, 4, 5, & 6)
 - a. close reading of scientific texts
 - b. classroom discussion
 - c. reaction papers or essays
2. formal scientific communication (designed to meet DLOs 1, 2, 4, 5, & 6)
 - a. conference style oral presentations
 - b. publication quality journal articles
3. theoretical analysis and problem solving (designed to meet DLOs 2, 3, 4, & 6)
 - a. analytical problem solving
 - b. advanced mathematical methods
 - c. computer analysis and modeling
4. experimental methods and techniques (designed to meet DLOs 2, 3, 4, & 6)
 - a. formal laboratory notebook
 - b. data acquisition methods
 - c. data analysis and uncertainty propagation
 - d. scientific instrument design

Which activities are done in this course? And which assignments can be submitted for evidence?

- 1a)** weekly assigned readings
- 1b)** classroom discussion of assigned readings
- 1c)** essays assigned for homework (when feasible)
- 2a)** oral laboratory presentation
- 3a)** weekly homework exercises
- 3b)** exercises involving algebra, geometry, calculus
- 4a)** weekly laboratory notebook assignments
- 4b)** data collection in notebooks
- 4c)** laboratory equipment setup

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Wk.	Topics	Text
1	Dimensional analysis, units, scaling	<i>Galileo's Dialogues Concerning Two New Sciences</i>
2	Early modern views of matter; Archimedes' principle; the effect of buoyancy and drag on falling bodies;	
3	pendular and periodic motion; sound waves, vibrations, frequency & pitch, consonance & dissonance,	
4	torque, static equilibrium; the law of the lever; strength of materials; longitudinal and transverse forces; beam breaking	
5	position, velocity and acceleration; falling bodies; the mean speed theorem; kinematic equations	
6	early modern views on force and acceleration; two-dimensional kinematics, projectile motion	
7	deductive and inductive reasoning; causality; final causes, science, and teleology; hydrostatic paradox; pascal's principle	<i>Pascal's Treatise on the Equilibrium of Fluids</i>
8	Hydrostatic pressure; siphons; barometric formula	
9	Spring break (no classes); Does nature abhor a vacuum?	
10	Mass, momentum, inertia, force, centripetal force, absolute and relative motion	<i>Newton's Mathematical Principles of Natural Philosophy</i>
11	newton's laws of motion, force addition, action-reaction pairs, force diagrams	
12	Holy Week (no class Thurs/Fri.) conservation of momentum, center of mass position and velocity, elastic and inelastic collisions	
13	Easter Monday (no class Mon.) rotational motion, centripetal force and acceleration, principle of parsimony, principle of induction, philosophy of nature	
14	Kepler's laws of motion, Newton's universal law of gravitation, natural theology and Newton's argument from design	
15	Principle of relativity, speed of light postulate, relativistic time dilation and length contraction	<i>Einstein's Relativity</i>
16	Relativistic energy and momentum	
17	Final exams	