UExcel® Official Content Guide

EXAM CODE **140** CATALOG NUMBER **PHYx140**

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Physics

CREDIT HOURS
6

LEVEL
LOWER

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SECTION ONE

Preparing for the Exam

Before You Choose This UExcel Exam

Uses for the Examination

- Excelsior College, the test developer, recommends granting six (6) semester hours of lower-level undergraduate credit to students who receive a letter grade of C or higher on this examination.
- Other colleges and universities also recognize this exam as a basis for granting credit or advanced standing.
- Individual institutions set their own policies for the amount of credit awarded and the minimum acceptable score.

Examinees who have applied to Excelsior College should ask their academic advisor where this exam fits within their degree program.

Examinees **not enrolled** in an Excelsior College degree program should check with the institution from which they wish to receive credit to determine whether credit will be granted and/or to find out the minimum grade required for credit. Those who intend to enroll at Excelsior College should ask an admissions counselor where this exam fits within their intended degree program.

For more information on exam availability and actual testing information, see the Exam Registration and Information Guide.

Examination Length and Scoring

This examination consists of 70 multiple choice and other type questions. You will have two (2) hours to complete the exam. Your score will be reported as a letter grade. Questions are scored either correct (1) or incorrect (0). There is no partial credit. Each credit-bearing exam contains pretest questions, which are embedded throughout the exam. They are indistinguishable from the scored questions. It is to your advantage to do your best on all the questions. Pretest questions are being tried out for use in future versions of the exam.

The UExcel exams do **not** have a fixed grading scale such as A = 90–100%, B = 80–90%, and so forth, as you might have seen on some exams in college courses. Each UExcel test has a scale that is set by a faculty committee and is different for each exam. The process, called standard setting, is described in more detail in the Technical Handbook. Excelsior puts each exam through a standard setting because different test questions have different levels of difficulty. To explain further, getting 70% of the questions right on the exam when the questions are easy does not show the same level of proficiency as getting 70% of questions correct when the questions are hard. Every form of a test (a form contains the test questions) has its own specific grading scale tailored to the particular questions on each exam form.

Please also note that on each form, some of the questions (referred to as pretest questions) count toward the score and some do not; the grading scale applies only to those questions that count toward the score. The area with percentage ratings on the second page of your score report is intended to help identify relative strengths and weaknesses and which content areas to emphasize, should you

decide to take the examination again. Your grade is **based on only the scored questions.** Therefore, the percentage ratings do not necessarily reflect the total percentage that counted toward your grade.

For the best view of the types of questions on this exam, see the sample questions in the back of this guide. Practice, practice, practice!

Score Reporting

For most of our examinations, based on performance, an examinee is awarded a letter grade of A, B, C, or F. A letter grade of D can be given, but credit is awarded for A, B, and C letter grades only. The letter grades reported to examinees indicate that their performance was equivalent to the performance of students who received the same letter grade in a comparable, on-campus course.

More specifically, the letter grade indicates the examinee's proficiency relative to the learning outcomes specified in the exam content guide. Following are general descriptions of examinee performance at each level:

Letter Grade Description

A Highly Competent: Examinee's performance demonstrates an advanced level of knowledge and skill relative to the learning outcomes.

B Competent: Examinee's performance demonstrates a good level of knowledge and skill relative to the learning outcomes.

C Marginally Competent: Examinee's performance demonstrates a satisfactory level of knowledge and skill relative to the learning outcomes.

D Not Competent (no credit recommended): Examinee's performance demonstrates weak knowledge of the content and minimal skill relative to the learning outcomes.[①]

F Fail (no credit recommended): Examinee's performance demonstrates no knowledge of the content and no skill in the subject relative to the learning outcomes.

Credit is transcripted by Excelsior College for examinees who achieve letter grades of C or higher.

We encourage colleges and universities to use the Excelsior College letter grades of A, B, and C as acceptable standards for awarding credit.

See page 30, at the back of this content guide, for a sample UExcel Grade Report for Examinations.

Excelsior College Bookstore

The Excelsior College Bookstore offers recommended textbooks and other resources to help you prepare for UExcel exams.

The bookstore is available online at (login required): www.excelsior.edu/bookstore

Excelsior College Library

Library services are available to students enrolled in a degree program at Excelsior College. Created through our partnership with the Sheridan Libraries of The Johns Hopkins University, the library provides access to journal articles, books, websites, databases, reference services, and many other resources. To access the Excelsior College Library, visit www.excelsior.edu/library (login is required). Access to the library is available 24/7.

Take Charge of Your Own Learning

At Excelsior College, independent, self-directed study supported by resources we help you find is not a new concept. We have always stressed to students who take exams that they are acting as their own teacher, and that they should spend as much time studying for an exam as they would spend in a classroom and on homework for a corresponding college course in the same subject area.

Begin by studying the content outline contained in this content guide, at its most detailed level. You will see exactly which topics are covered, and where chapters on those topics can be found in the Recommended Resources. You will see exactly where you might need to augment your knowledge or change your approach.

The content outline, along with the learning outcomes for this exam and recommended textbooks, will serve as your primary resources.

① In general, two-hour exams do not award a D letter grade.

How Long Will It Take Me to Study?

Study for a UExcel exam is comparable to an equivalent college-level course. As an independent learner, you should study and review as much as you would for the same subject in a campus-based college course. If you already have a background in the subject, you may be able to pass the exam successfully with fewer hours of study. It depends upon the learner as well as the subject, the number of credits (for example, a 6- or 8-credit exam will require more hours of study than a 3-credit exam), and the length of the exam. We strongly encourage you to create a long-term action or study plan, so that you have a systematic approach to prepare for the exam. We've included guidelines for creating such a plan.

How Can I Create an Effective Long-Term Study Plan?

1. **Determine the time you will require to complete your preparation for this exam.** If you have not studied the subject before, you should plan to budget approximately 45 hours of study time for every credit: 135 hours for 3 credits, 180 hours for 4 credits, 270 hours for 6 credits, and 360 hours for 8 credits. These hours are rules of thumb based on expectations for a student taking a course in the subject; it may take you more or less time, depending on how familiar you are with the material and how easily you absorb the information studying on your own. Aside from the content review, you should then factor in time to search for and use other resources, and to complete any projects and assignments in the study materials that will clarify your understanding of the topics in the content outline (that part in the content guide where the specific areas of study are spelled out). Spend more time on concepts and areas in which you feel you are weak. Totaled, this is approximately the amount of time you should expect to devote to a three-credit, campus-based course. The actual amount of time you require depends on many factors, and will be approximate. If your background is weak, you may need to set aside substantially more than 135–150 hours. If your background is strong, you may budget less time.

   Take a few minutes to review the content outline to assess your familiarity with the content. Then, in the space below, write the number of hours you will allocate to complete preparing for the exam.

   Hours Required = [ ]

2. **Determine the time you will have available for study.**

   In self-study, you need structure, as well as motivation and persistence, and a methodical approach to preparation. There is no set class to keep you on task. You have to do that yourself. Construct a time-use chart to record your daily activities over a one-week period. The most accurate way to do this is to complete the chart on a daily basis to record the actual amount of time you spend eating, sleeping, commuting, working, watching television, caring for others and yourself, reading, and everything else in an adult's life. However, if your schedule is regular, you might prefer to complete the chart in one sitting and, perhaps, by consulting your appointment book or planner.

   After you have recorded your activities, you will be ready to schedule study periods around these activities or, perhaps, instead of some of them. In the space below, write the number of hours you will be able to set aside for study each week.

   Hours Required = [ ]

3. **Divide the first number by the second number.**

   This will give you the number of weeks you will need to set aside for independent study. For example, if you think you will require 170 hours of study and you have 10 hours available to study each week, divide 170 hours by 10 hours and you will get 17. This means that you will need about 17 weeks to complete this course of study. However, you will also need to allow about a week for review and self-testing. Moreover, to be on the safe side, you should also add two weeks to allow for unforeseen obstacles and times when you know you will not be able to study (e.g., during family illnesses or holidays). So, in this case, you should allot a total of 18 to 19 weeks to complete your study.

4. **Schedule your examination to coincide with the end of your study period.**

   For example, if you plan to allow 18 weeks for study, identify a suitable examination date and begin study at least 18 weeks before that date. (The date you

begin study assumes that you will have received all of your study materials, particularly textbooks, by that time.)

5. **Format a long-term study plan.**

   You will need to use a calendar, planner, or some other tool to format and track your long-term study plan. Choose a method that is convenient and one that keeps you aware of your study habits on a daily basis. Identify the days and exact hours of each day that you will reserve for study throughout your whole independent study period. Check to see that the total number of hours you designate for study on your long-term study plan adds up to the number of hours you have determined you will need to complete this course of study (Step 1).

6. **Record in your long-term study plan the content you plan to cover during each study period.**

   Enter the session numbers, review, and examination preparation activities you will complete during each study period. While it is suggested that approximately 160–170 hours of study is required for this exam, each and every student may require different timelines based on their comfort with, and comprehension of, the material.

   You now have a tentative personal long-term study plan. Keep in mind that you will have to adjust your study plan, perhaps several times, as you study. It is only by actually beginning to work systematically through the material, using the content outline, that you will be able to determine accurately how long you should allow for each unit.

What Learning Strategy Should I Use?

The following guidelines are intended to help you acquire the grounding in the knowledge and skills required for successful completion of this examination.

1. **Approach learning with a positive attitude.**

   Most students are capable of learning subject content if they devote enough time and effort to the task. This devotion will give you a positive edge and a feeling of control.

2. **Diligently complete the exact work you specified in your study plan.**

   Your study plan is being designed for the specific purpose of helping you achieve the learning outcomes for this exam.

3. **Be an active learner.**

   You should actively engage in the learning process. Read critically, take notes, and continuously monitor your comprehension. Keep a written record of your progress, highlight content you find difficult to grasp, and seek assistance from someone in your learning community who can help you if you have difficulty understanding a concept.

4. **Be patient: you may not understand everything immediately.**

   When encountering difficulty with new material, be patient with yourself and don't give up. Understanding will come with time and further study. Sometimes you may need to take a break and come back to difficult material. This is especially true for any primary source material (original letters, documents, and so forth) that you may be asked to read. The content outline will guide you through the material and help you focus on key points. You will find that many concepts introduced in earlier sessions will be explained in more detail in later sessions.

5. **Apply your learning to your daily life.**

   Use insights you gain from your study to better understand the world in which you live. Apply the learning whenever you can. Look for instances that support or contradict your reading on the subject.

6. **Accommodate your preferred way of learning.**

   How do you learn best? Common ways to learn are reading, taking notes and making diagrams, and by listening to someone (on video or live). Others learn by doing. Do any of these descriptions apply to you? Or does your learning style vary with the learning situation? Decide what works for you and try to create a learning environment to accommodate your preferences.

Study Tips

Become an active user of the resource materials. Aim for understanding rather than memorization. The more active you are when you study, the more likely you will be to retain, understand, and apply the information.

The following techniques are generally considered to be active learning:

- **preview or survey** each chapter
- **highlight or underline text** you believe is important
- **write questions or comments** in the margins
- **practice re-stating content** in your own words
- **relate what you are reading** to the chapter title, section headings, and other organizing elements of the textbook
- **find ways to engage** your eyes, your ears, and your muscles, as well as your brain, in your studies
- **study with a partner or a small group**
- **prepare your review notes** as flashcards or create recordings that you can use while commuting or exercising

When you feel confident that you understand a content area, review what you have learned. Take a second look at the material to evaluate your understanding. If you have a study partner, the two of you can review by explaining the content to each other or writing test questions for each other to answer. Review questions from textbook chapters may be helpful for partner or individual study, as well.

Study smart for your UExcel exam! Success starts with establishing a relationship with your advisor.

Using UExcel Practice Exams

The official UExcel practice exams are highly recommended as part of your study plan. They can be taken using any computer with a supported web browser such as Google Chrome.

The practice exam package comes with two sets of questions. Please be aware that there will be fewer questions on the practice exams than there will be on the exam you take for credit. Generally, the practice questions will not be the same as the ones you will see when you take the actual exam for credit. They are intended to expose you to the types of questions you'll encounter in the actual exam. Practice questions are a tool, and do not provide a full exam experience. For example, the practice question sets do not have time limitations. Begin with the Content Guide, especially the detailed content outline. Memorizing specific questions and answers on the practice sets is not as effective as using the questions to practice, along with the content outline, to see which concepts you may need to study further. To register for the practice exam, visit www.excelsior.edu and log into your MyExcelsior account. **Please note: You must be registered for the corresponding credit-bearing exam before you can register for the practice exam.**

Practice exams are not graded. Rather, they are intended to help you make sure you understand the subject and give you a sense of what the questions will be like on the exam for credit. Ideally, you would check any questions you got wrong, look at the explanations, and go back to the textbook to reinforce your understanding. After taking both forms of the practice exam, you should feel confident in your answers and confident that you know the material listed in the content outline.

Practice exams are one of the most popular study resources. Practice exams are typically shorter than the credit-bearing exam. Since the questions are drawn from the same pool of questions that appear on the credit-bearing exam, what you will see when you sit for the graded exam will be roughly the same. Used as intended, these practice exams will enable you to:

- Review the types of questions you may encounter on the actual exam.
- Practice testing on a computer in a timed environment.
- Practice whenever and wherever it is convenient for you.

Take two different forms of a practice exam within a 180-day period. (We highly recommend that you take the first form of the practice exam as a pretest, early in the study period. Use the results to identify areas to further study and carry out a plan. Then take the second form as a post-test and see how much you have improved.)

Although there is no guarantee, our research suggests that exam takers who do well on the practice exams are more likely to pass the actual exam than those who do not take advantage of the opportunity. Note that since the practice exams are not graded (calibrated) the same way as the scores on the credit-bearing exam, it will be hard for you to use the practice exams

as a way to predict your score on the credit-bearing exam. The main purpose of the practice exams is for you to check your knowledge and to become comfortable with the types of questions you are likely to see in the actual, credit-bearing exam.

About Test Preparation Services

Preparation for UExcel® exams and Excelsior College® Examinations, though based on independent study, is supported by Excelsior College with a comprehensive set of exam learning resources and services designed to help you succeed. These learning resources are prepared by Excelsior College so you can be assured that they are current and cover the content you are expected to master for the exams. These resources, and your desire to learn, are usually all that you will need to succeed.

There are test-preparation companies that will offer to help you study for our examinations. Some may imply a relationship with Excelsior College and/or make claims that their products and services are all that you need to prepare for our examinations.

Excelsior College does not endorse the products and services of any tutorial or test preparation firm. We do not review the materials provided by these firms for the content or compatibility of their material and resources with UExcel® exams or Excelsior College Examinations®. No test preparation vendor is authorized to provide admissions counseling or academic advising services, or to collect any payments, on behalf of Excelsior College. Excelsior College does not send authorized representatives to a student's home nor does it review the materials provided by test preparation companies for content or compatibility with Excelsior College examinations.

To help you become a well-informed consumer, we suggest that before you make any purchase decision regarding study materials provided by organizations other than Excelsior College, you consider the points outlined on our website at www.excelsior.edu/testprep.

Exam Preparation Strategies

Each learner is different. However, all learners should read the content outline in the exam's Content Guide and ensure that they have mastered the concepts. For someone with no prior knowledge of the subject, a rule of thumb is 135 hours of study for a 3-credit exam—this number is just to give you an idea of the level of effort you will need, more or less.

Content Guides

This content guide is the most important resource. It lists the outcomes, a detailed content outline of what is covered, and textbooks and other study resources. It also has sample questions and suggestions for how to study. Content guides are updated periodically to correspond with changes in particular examinations and in textbook editions. Examinees can download any of the latest free UExcel content guides by visiting the individual exam page or from the list at www.excelsior.edu/contentguides.

Using the Content Outline

Each content area in the content outline includes the most important sections of the recommended resources for that area. These annotations are not intended to be comprehensive. You may need to refer to other chapters in the recommended textbooks. Chapter numbers and titles may differ among textbook editions.

This content outline contains examples of the types of information you should study. Although these examples are many, do not assume that everything on the exam will come from these examples. Conversely, do not expect that every detail you study will appear on the exam. Any exam is only a broad sample of all the questions that could be asked about the subject matter.

Using the Sample Questions and Rationales

Each content guide provides sample questions to illustrate those typically found on the exam. These questions are intended to give you an idea of the level of knowledge expected and the way questions are typically phrased. The sample questions do not sample the entire content of the exam and are not intended to serve as an entire practice test.

Recommended Resources for the UExcel Exam in Physics

The resources listed below were selected by the faculty members on the examination committee for use in developing this exam.

Resources listed under "Strongly Recommended" were used by the committee to verify all the questions on the exam. Please refer to the Content Outline to see which parts of the exam are cross-referenced to these resources.

Resources listed under "Optional" provide additional material that may deepen or broaden your understanding of the subject, or that may provide an additional perspective on the exam content. Textbook resources, both Strongly Recommended and Optional, may be purchased from the Excelsior College Bookstore.

You should allow ample time to obtain the necessary resources and to study sufficiently before taking the exam, so plan appropriately, with an eye towards your own personal learning needs. See the sections in this guide on the Excelsior College Bookstore and the Excelsior College Library, and under Reducing Textbook Costs, to help you secure the Strongly Recommended resources successfully.

Textbook Editions

Textbook editions listed in the UExcel content guides may not be the same as those listed in the bookstore. Textbook editions may not exactly match up in terms of table of contents and organization, depending upon the edition. However, our team of exam developers checks exam content against every new textbook edition to verify that all subject areas tested in the exam are still adequately available in the study materials. If needed, exam developers will list additional Strongly Recommended resources to ensure that all topics in the exam are still sufficiently covered. Public libraries may have the textbooks you need, or may be able to obtain them for you through interlibrary loan to reduce textbook costs. You may also consider financial aid, if you qualify, to further help defray the steep cost of textbooks. A section on open educational resources (OER) has been included in this guide to help you locate additional, possibly free resources to augment your study.

Strongly Recommended

Young, H.D. (2020). *College physics* (11th ed.). San Francisco: Pearson Addison-Wesley.

The study materials may be purchased from the Excelsior College Bookstore.

Optional Resources

The examination development committee did not identify any specific Optional resources for this exam. If you would like to explore topics in more depth, we encourage you to refer to available Open Educational Resources (OER).

Reducing Textbook Costs

Many students know it is less expensive to buy a used textbook, and buying a previous edition is also an option. The Excelsior College bookstore includes a buyback feature and a used book marketplace, as well as the ability to rent digital versions of textbooks for as long as students need them. Students are encouraged to explore these and the many other opportunities available online to help defray textbook costs.

Open Educational Resources

There are many resources available online free of charge that may further enhance your study for the exam. Known as Open Educational Resources (OER), these may be textbooks, courses, tutorials, or encyclopedias. Any additional OER that you find independently should be used to augment study—not as replacements for the Strongly Recommended resources.

Most sites for university-based OER can be searched through www.ocwconsortium.org and/or www.oercommons.org.

Sites that specialize in web courses designed by college professors under contract with the website sponsor, rather than in web versions of existing college courses, include:

www.education-portal.com

www.opencourselibrary.org (abbreviated as OCL)

We have included specific courses that cover material for one or more UExcel® exams from the sites in the listings above. It's worth checking these sites frequently to see if new courses have been added that may be more appropriate or may cover an exam topic not currently listed.

Sites like Khan Academy (www.khanacademy.com) and iTunes U feature relatively brief lessons on very specific topics rather than full courses. Full courses are also available on iTunes U (http://www.apple.com/education/ipad/itunes-u/). We have chosen a few courses and collections for this listing.

Open Online Textbooks

BookBoon
http://bookboon.com/en/textbooks-ebooks

Flatworld Knowledge
http://catalog.flatworldknowledge.com/#our-catalog

College Readiness

Khan Academy
http://www.khanacademy.org/

Hippocampus
http://www.hippocampus.org/

Open Course Library
http://opencourselibrary.org/collg-110-college-success-course/

Study Aids

Education Portal
http://education-portal.com/

Khan Academy
http://www.khanacademy.org/

Annenberg Learner
http://www.learner.org/

OpenCourseWare
http://ocwconsortium.org/en/courses/search

OER Commons
http://www.oercommons.org/

Open Course Library
http://www.opencourselibrary.org/

To achieve academic success, rate yourself at Excelsior College's Self-Regulated Learning Lab. Visit the Diagnostic Assessment & Achievement of College Skills site at https://srl.daacs.net/

It's free!

SECTION TWO

Content Outline

General Description of the Examination

The UExcel Physics examination is based on material typically taught in a two-semester (lecture-only) algebra/trigonometry-based course sequence in physics. The content of the examination corresponds to course offerings such as Physics I & II.

The examination measures comprehensive knowledge of facts and terminology, an understanding of physical concepts and theories in mechanics, thermal physics, electromagnetism, light and optics, and nuclear physics, and the ability to apply this knowledge and understanding to analyze and solve a variety of problems.

Those beginning to study for this exam should be familiar with concepts generally covered in college-level algebra courses, trigonometry, graphing techniques, units and conversion, scientific notation, and orders of magnitude.

Learning Outcomes

After you have successfully worked your way through the recommended study materials, you should be able to demonstrate the following learning outcomes:

1. Demonstrate knowledge and comprehension of the fundamental principles of physics (for example, conservation laws, mass, energy, charge, momentum). (Aligns to GECC 2.1)
2. Select appropriate physical principles that apply to a given situation, represent a situation as a mathematical problem, and solve the problem. (Aligns to GECC 2.2)
3. Model physical situations with diagrams, graphs, and equations. (Aligns to GECC 2.1)
4. Use mathematical tools of algebra and trigonometry to solve physical problems. (Aligns to GECC 2.2)

General Education Career Competencies Addressed in this Exam

GECC-2: Mathematical and Scientific Problem Solving: Apply scientific knowledge and reasoning to make evidence-based decisions. Apply mathematical concepts and reasoning to solve problems that involve quantitative information.

Content Outline

The content outline describes the various areas of the test, similar to the way a syllabus outlines a course. To fully prepare requires self-direction and discipline. Study involves careful reading, reflection, and systematic review.

The major content areas on the Physics examination, the percent of the examination, and the hours to devote to each content area are listed below.

Content Area	Percent of the Examination	Hours of Study*
I. Mechanics	30%	81
II. Thermal Physics	20%	54
III. Electromagnetism	25%	68
IV. Light and Optics	15%	41
V. Modern Physics	10%	27
Total	**100%**	

*Approximate: For those examinees who know the topic well, less time may be needed to learn the subject matter. For those who are new to the subject matter, more time may be required for study.

NOTE: Occasionally, examples will be listed for a content topic to help clarify that topic. However, the content of the examination is not limited to the specific examples given.

I. Mechanics

30 PERCENT OF EXAM

Chapter 2, Motion along a Straight Line

Chapter 3, Motion in a Plane

Chapter 4, Newton's Law of Motion

Chapter 5, Applications of Newton's Laws

Chapter 6, Circular Motion and Gravitation

Chapter 7, Work and Energy

Chapter 8, Momentum

Chapter 9, Rotational Motion

Chapter 10, Dynamics of Rotational Motion

Chapter 11, Elasticity and Periodic Motion

Chapter 12, Mechanical Waves and Sound

Chapter 13, Fluid Mechanics

A. One-dimensional kinematics

1. Position and displacement
2. Speed and velocity
3. Acceleration
4. Straight line motion with constant acceleration

B. Two-dimensional kinematics

1. Vectors and coordinate systems
2. Projectile motion
3. Uniform circular motion

C. Force and the laws of motion

1. The force concept and free body diagrams

2. Types of force
    a. Gravitation
    b. Friction
    c. Elastic
3. The First Law of Motion
4. The Second Law of Motion
5. The Third Law of Motion
6. Applications of the laws of motion

D. Momentum

1. Impulse and momentum
2. Conservation of momentum
3. Collisions

E. Work and energy

1. Work
2. Dissipation
3. Types of energy
    a. Kinetic and potential energy of ordinary objects
    b. Thermal, nuclear, chemical, and electromagnetic energy
4. Conservation of energy
5. Power

F. Rotational motion

1. Angular position, velocity, and acceleration
2. Moment of inertia
3. Torque
4. Angular momentum
5. Rotational kinetic energy

G. Static equilibrium

1. Conditions for static equilibrium
2. Elasticity
    a. Stress and strain
    b. Hooke's Law

H. Waves

1. Oscillations and simple harmonic motion
2. Resonance
3. Transverse and longitudinal traveling waves
4. Superposition and interference
    a. Standing waves
    b. Beats
5. Energy transport
6. Sound
    a. Doppler effect
    b. Human hearing

I. Fluids

1. Density
2. Pressure
3. Pascal's principle
4. Archimedes' principle
5. Continuity equation
6. Bernoulli's equation

II. Thermal Physics

20 PERCENT OF EXAM

Chapter 14, Temperature and Heat

Chapter 15, Thermal Properties of Matter

Chapter 16, The Second Law of Thermodynamics

A. Temperature

B. Heat and thermal energy

1. Mechanisms of heat transfer
2. First Law of Thermodynamics

C. Thermal properties of materials

1. Ideal gases
2. Heat capacity and specific heat
3. Phase changes and latent heat
4. Thermal expansion
5. Thermal conduction

D. Second Law of Thermodynamics

1. Engines and efficiency
2. Entropy

III. Electromagnetism

25 PERCENT OF EXAM

Chapter 17, Electric Charge and Electric Field

Chapter 18, Electric Potential and Capacitance

Chapter 19, Current, Resistance, and Direct-Current Circuits

Chapter 20, Magnetic Field and Magnetic Forces

Chapter 21, Electromagnetic Induction

Chapter 22, Alternating Current (Sections 1, 2, and 4)

Chapter 23, Electromagnetic Waves (Sections 1–5)

A. Electrostatics

1. Electric charge
2. Conservation of charge
3. Coulomb's Law
4. Electric field
5. Electric potential
6. Capacitance
7. Energy in electric fields

B. Circuits

1. Conductors and insulators
2. Current
3. Resistance
4. Ohm's Law
5. Electric power
6. Kirchhoff's current and voltage laws
7. Reactance-capacitance circuits

C. Magnetism

1. Magnetic phenomena
2. Magnetic force on moving charges
3. Magnetic field due to moving charges
4. Faraday's Law and inductance
5. Energy in magnetic fields
6. *R-L* and *L-C* circuits

D. AC circuits

1. Impedance
2. AC power

E. Electromagnetic waves

1. Production and propagation
2. Electromagnetic spectrum
3. Intensity

IV. Light and Optics

15 PERCENT OF EXAM

Chapter 23, Electromagnetic Waves (Sections 6–8, 10)

Chapter 24, Geometric Optics

Chapter 25, Optical Instruments

Chapter 26, Interference and Diffraction

A. Geometric optics

1. Reflection
2. Refraction
3. Imaging with mirrors and thin lenses
4. Simple optical instruments (for example: eye, magnifying glass, microscope, telescope)

B. Wave optics

1. Polarization
   a. Polarizers (including Malus's Law)
   b. Polarization by reflection (including Brewster's angle)
2. Interference
   a. Double-slit
   b. Thin films
   c. Interferometer
3. Diffraction
   a. Single-slit
   b. Around obstacles

V. Modern Physics

10 PERCENT OF EXAM

Chapter 27, Relativity (Section 7)

Chapter 28, Photons, Electrons, and Atoms (Sections 1, 2, 3, and 6)

Chapter 30, Nuclear and High-Energy Physics (Sections 2, 3, 5, 6, and 7)

A. **Photoelectric effect**

B. **Particle nature of light (photons)**

C. **Wave nature of matter (DeBroglie relation)**

D. **Bohr model of hydrogen**

E. **Mass energy relation**

F. **Radioactivity**

1. Half life
2. Fission and fusion

SECTION THREE

Sample Questions

The sample questions give you an idea of the level of knowledge expected in the exam and how questions are typically phrased. They are not representative of the entire content of the exam and are not intended to serve as a practice test.

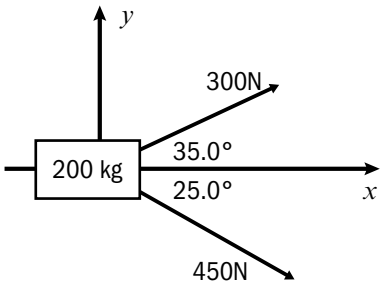
Rationales for the questions can be found on pages 18–21 of this guide. In that section, the correct answer is identified and each answer is explained. The number in parentheses at the beginning of each rationale refers to the corresponding section of the content outline. For any questions you answer incorrectly, return to that section of the content outline for further study.

During your exam, tables of essential formulas, values, and constants will be available for your reference, and you will have access to a scientific calculator. The calculator button is in the top left hand corner of the page as each question is presented and the tables and formulas are in the Formulas button located in the lower left hand corner as each question is presented. Copies of the tables and a picture of a typical scientific (non-graphing) calculator are provided at the back of this content guide.

1. A truck moving along a straight, flat road at a speed of 20 m/s slows down at a constant rate for 3 s until it reaches a speed of 5 m/s. What is the distance the truck traveled during this 3 s time period?
   1) 15.0 m
   2) 22.5 m
   3) 37.5 m
   4) 82.5 m

2. Three laboratory carts slide without friction on an air track. The left cart has a 1-kg mass and an initial velocity of 4 m/s to the right. The middle cart has a 1-kg mass and an initial velocity of 1 m/s to the right. The right cart has a 2-kg mass and an initial velocity of 2 m/s to the left. The three carts collide and stick together, moving away from the collision region as a combined object. Neglecting air resistance, what will be the speed of the combined object?
   1) 0.25 m/s
   2) 0.33 m/s
   3) 1.5 m/s
   4) 2.5 m/s

3. Base your answer to the following question on the figure below:



Two people are pulling a 200 kg object along the x axis. One person pulls with a force of 300 N at an angle of 35.0° with respect to the x axis. The other person pulls with a force of 450 N at an angle of 25.0°. The mass was moved a total distance of 5.00 m. Which value is closest to the work done on the mass by the two people?
   1) 654 J
   2) 1810 J
   3) 3270 J
   4) 3750 J

4. A small block with a 1-kg mass starts from rest and slides down a ramp from an initial height of 2 m above the ground. The block is moving with a speed of 6 m/s when it reaches the ground. What is the amount of mechanical energy dissipated in the sliding process?

   1) 0 J
   2) 1.6 J
   3) 18 J
   4) 19.6 J

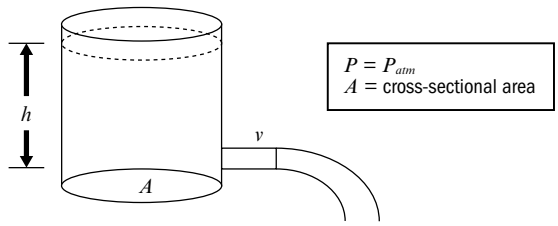
5. The following four objects are resting on top of a platform:

   1 a small marble
   2 a metal pipe
   3 a solid metal bar
   4 a bicycle wheel

   They all start to roll at the same time, without slipping, down an inclined plane. By determining the fastest to slowest time, what is the most likely order in which each object will reach the bottom of the incline?

   (Place the numbers in the correct order in the space below. Do not separate them with commas, spaces, or dashes.)

6. Base your answer to the following question on the figure below:



   A large cylindrical container of water is opened to the atmosphere and allowed to drain. What is the best estimate of the speed of water as it exits the base?

   1) $v = \sqrt{2gh}$

   2) $v = \dfrac{(hg)^{\frac{1}{2}}}{rA}$

   3) $v = \sqrt{\dfrac{2P}{m}}$

   4) $v = \dfrac{h}{t}$

7. A bathtub is filled with 55.0 L of water at 48.0°C. An additional 15.0 L of water are added so that the final temperature of all the water is 39.0°C. What was the initial temperature of the 15.0 L of water?

   1) 0.125°C
   2) 6.00°C
   3) 30.0°C
   4) 33.0°C

8. A rigid, sealed container is filled with 0.3 mols of helium gas at 20°C and atmospheric pressure (P_{atm} = 1.013 × 105 Pa). The container is placed in a storage shed where the gas is warmed to 40°C. What is the final pressure (P_f) inside the container, assuming ideal gas behavior?

   1) 1.013 × 105 Pa
   2) 1.082 × 105 Pa
   3) 2.026 × 105 Pa
   4) 6.078 × 105 Pa

9. Which statement predicts what will happen when a copper hoop with an inner radius r_1 and an outer radius r_2 is heated uniformly?
   1) r_1 and r_2 both decrease.
   2) r_1 decreases and r_2 increases.
   3) r_1 increases and r_2 decreases.
   4) r_1 and r_2 both increase.

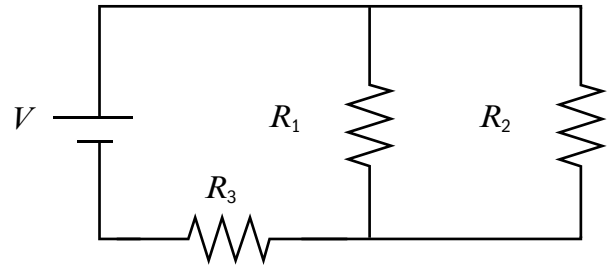
10. Two identical cubes of brass, each with a mass of 1 kg, have temperatures of 15°C and 35°C respectively. They are placed in contact within a perfectly insulating container. Assume the specific heat capacity of brass is 380 $J \cdot kg^{-1} \cdot K^{-1}$. What is the approximate change in entropy of the system?
   1) -0.5 J/K
   2) 0 J/K
   3) 0.5 J/K
   4) 361.9 J/K

11. Two identical point charges are 0.1 m apart. The force between them is 1 N. What charge is closest to the magnitude of one of these charges?
   1) 1.11×10^{11} C
   2) 0.95×10^{5} C
   3) 1.05×10^{-5} C
   4) 3.30×10^{-11} C

12. The potential at the point (0, 0) due to a charge +Q placed at point (-1, 0) is 2 V. What value is closest to the potential when a second charge +Q is added at point (0, 1)?
   1) 0 V
   2) 2 V
   3) $2\sqrt{2}$ V
   4) 4 V

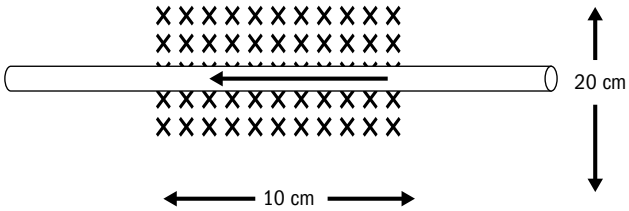
13. A heater draws a current of 5 A from a 120-V source. What value is closest to the resistance of the heater?
   1) 0.042 Ω
   2) 0.2 Ω
   3) 24 Ω
   4) 600 Ω

14. Base your answer to the following question on the figure below:



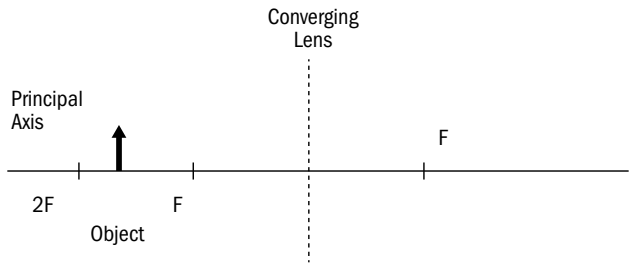
In the circuit, V = 100 V, R_1 = 10 Ω, R_2 = 5 Ω, and R3 = 5 Ω. What value is closest to the power dissipated in R_3?
   1) 225 W
   2) 500 W
   3) 720 W
   4) 2000 W

15. A wire carries a current of 1.5 A to the left through a region of magnetic field as shown below. Dimensions are given in the figure. The field strength is 4 T.



What magnitude and direction best describes the force on the wire?
   1) 0.60 N, down
   2) 0.60 N, up
   3) 1.20 N, down
   4) 1.20 N, up

16. Base your answer to the following question on the figure below:



The figure shows an object positioned near a converging lens and the focal points of the lens. Which statement best describes the character of the image?

1) real and upright
2) real and inverted
3) virtual and upright
4) virtual and inverted

17. Which statement describes the character of images produced by a convex mirror?

The image is

1) inverted and larger than the object.
2) inverted and smaller than the object.
3) upright and larger than the object.
4) upright and smaller than the object.

18. A double-slit experiment is performed in air and in water. The experiment consists of two slits 0.0420 mm apart. A coherent source of light with frequency 6.74×10^{14} Hz passes through the slits and projects on a screen 1.20 m away. The whole experiment is then immersed in water (index of refraction $n = 1.33$). By how much is the third order bright fringe displaced?

1) 0.945 cm
2) 1.10 cm
3) 1.68 cm
4) 1.88 cm

19. When blue light hits a photoelectric plate, an electrical current is produced. Which statement predicts the current produced if violet light with the same intensity hits the same photoelectric plate?

The current

1) will be lower.
2) will be higher.
3) will be the same.
4) cannot be determined.

20. A sample is found to be emitting radiation at a rate of 48 counts per minute at noon. Six hours later, the rate has decreased to 24 counts per minute. What is the counts-per-minute emission rate of the sample at noon the previous day?

1) 144
2) 288
3) 384
4) 768

SECTION FOUR

Rationales

1.(I.A.4)

1) This answer is obtained by incorrectly multiplying the final speed 5 m/s by 3 seconds.

2) This answer is obtained from (1/2) at^2 using the correct values a = 5 m/s^2 and t = 3 seconds.

*3) Solution:

$$x_f - x_i = v_{0x}t + \frac{1}{2}a_x t^2$$

$$v_{0x} = 20\frac{m}{s}$$

$$t = 3s$$

$$a_x = \frac{v_{fx} - v_{ix}}{t} = \frac{5\frac{m}{s} - 20\frac{m}{s}}{3s} = -5\frac{m}{s^2}$$

$$x_f - x_i = 20(3) + \left(\frac{1}{2}\right)(-5)\left(3^2\right) = 37.5m$$

4) This answer is obtained by using the positive value +5 m/s^2 for the acceleration instead of the correct value -5 m/s^2.

2.(I.D.2)

*1) Solution:
Momentum conservation says (1kg)(+4 m/s) + (1 kg)(+1 m/s) + (2 kg)(-2 m/s) = (4 kg)v_{fx}. Solve to find v_{fx} = +0.25 m/s, that is, 0.25 m/s to the right.

2) You used momentum conservation, but mistakenly used 3 kg for the mass of the combined object.

3) You used an energy strategy: (1/2)(1kg)(4 m/s)^2 + (1/2)(1kg)(1 m/s)^2 – (1/2)(2 kg)(2 m/s)^2 = (1/2)(4 kg)v_f^2 but mechanical energy is not conserved in this collision. (Any collision in which objects deform or stick together is necessarily dissipative.) Also, kinetic energy is never negative, even when the objects are moving in opposite directions.

4) You used an energy strategy: (1/2)(1kg)(4 m/s)^2 + (1/2)(1kg)(1 m/s)^2 + (1/2)(2 kg)(2 m/s)^2 = (1/2)(4 kg)v_f^2 but mechanical energy is not conserved in this collision. (Any collision in which objects deform or stick together is necessarily dissipative.)

3.(I.E.1)

1) This is the result if you do not multiply by the distance.

2) This is the result if you use sine instead of cosine.

*3) Solution:
$W = W_1 + W_2$ = 300 N × 5 m * cos 35° + 450 × 5 m × cos 25° = 3268 J

4) This is the result if you do not calculate work with the components of the force parallel to the displacement, but using the magnitude.

*correct answer

4.(I.E.4)

1) You assume mistakenly that mechanical energy is conserved here.

*2) Solution:
The initial energy in the system was mgh = (1 kg)(9.8 m/s^2)(2 m) = 19.6 J. The final energy in the system was (1/2)(1 kg)(6 $m/s)^2$ = 18 J. Therefore, the energy dissipated was 19.6 J - 18 J = 1.6 J

3) The answer is the final kinetic energy, not the energy dissipated.

4) The answer is the initial gravitational potential energy, not the energy dissipated.

5.(I.F.2)

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The objects need to be sorted according to their moments of inertia I.

$I_{\text{pipe}} > I_{\text{wheel}} > I_{\text{bar}} > I_{\text{marble}}$, therefore,
$V_{\text{marble}} > V_{\text{bar}} > V_{\text{wheel}} > V_{\text{pipe}}$

6.(I.I.6)

*1) Solution using Bernoulli's equation:

$$P_1 + \frac{1}{2}mv_1^2 + mgh_1 = P_2 + \frac{1}{2}mv_2^2 + mgh_2$$

$$v = v_2 = \sqrt{2gh}$$

2) This is only dimensionally correct.

3) You assumed $P_{atm} = P_1$ and $P_2 = 0$.

4) You assumed that it is height over time.

7.(II.A)

1) You used the ratio of Celsius temperatures as follows:

$$\frac{39}{48} = 0.8125 = \frac{55}{70} + \frac{15x}{70}$$

$$x = 0.125^\circ\text{C}$$

*2) Solution:
Use volume ratios and temperatures of initial volume and final volume to calculate temperature of added volume:

$$\left(\frac{55}{70}\right)48 + \left(\frac{15}{70}\right)x = 39$$

$$x = 6$$

3) You ignored that volumes are different, saw temperature drop of 9°C, so made second volume temperature 9° cooler than final volume, i.e. 30°C.

4) You took temperature drop of 9°, divided by volume ratio (9/(15/55)) to arrive at 33°C.

8.(II.C.1)

1) You thought that there are no changes.

*2) Solution:

$$P_f = P_{atm}\left(\frac{T_f}{T_i}\right) = 1.013 \times 10^5\,\text{Pa} \times \left(\frac{313K}{293K}\right) = 1.082 \times 10^5\,\text{Pa}$$

3) You forgot to convert Celsius to Kelvin.

4) You multiplied number of moles with change in temperature.

9.(II.C.4)

1) You assumed that there is length contraction.

2) You assumed that as the outer rim expands, the inner one must be compressed.

3) You assumed that the inner rim expands and causes the outer one to compress.

*4) Solution:
In thermal expansion, both dimensions will increase as temperature increases.

*correct answer

10.(II.D.2)

1) You reversed order of terms and found a decrease in entropy.

2) You thought final temperature was to be used and since they are the negative of each other, this led to a cancellation.

*3) Solution:

$S_h = -Q_h/T$ and $S_c = Q_c/T$, $-Q_h = Q_c = Q = mc(T_h - T_{eq})$

T_{eq} = 298 K since m and c are the same for both pieces of brass.

Q=(1kg)*(380 J/kg K)*(308K - 298K)=3800 J.

S_h= -3800J/308K = -12.3 J/K, S_c=3800J/298K = 12.8J/K.

Therefore, $S_{tot} = S_h + S_c$ = 0.5 J/K

4) You were able to recall that the change in entropy was positive but forgot to use absolute temperature. Instead, you used 35 K and 15 K.

11.(III.A.3)

1) This is the result if you do not take the square root of q^2.

2) This is the result if you multiply, rather than divide by 9 × 1011.

*3) Solution:

$$F = \frac{1}{4pe_0}\frac{q^2}{r^2} \cong \frac{9\times10^9}{0.1^2}q^2 = 9\times10^{11}q^2$$

$$q = \sqrt{\frac{1}{9\times10^{11}}} = \sqrt{\frac{1}{90\times10^{10}}} \cong 0.105\times10^{-5}C$$

4) This is the result if you divide by r, rather than r^2.

12.(III.A.5)

1) This is the result if you use the sign of the distance, rather than just the magnitude.

2) This is the result if you think the second charge has no effect.

3) This the result of adding the potentials as though they were vectors.

*4) Solution:
Potentials simply add. Potential due to each charge depends only on charge and distance, not direction. If the potential due to the first charge is 2V, then the potential due to the second is also 2V.

13.(III.B.4)

1) This is the result if you invert the solution, using $R = I/V$.

2) This is the result if you use $R = 1/I$.

*3) Solution:

$$R = \frac{V}{I} = \frac{120}{5} = 24\Omega$$

4) This is the result if you use $P = IV$.

14.(III.B.6)

1) This is the result if one neglects to include current through R_2.

2) This is the result if one uses P = 100 × 5.

*3) Solution:

$V_1 = V_2$, so $I_1R_1 = I_2R_2$ and $I_2 = I_1\frac{R_1}{R_2} = 2I_1$

Using Kirchhoff's current rule, $I^3 = I^1 + I^2 = 3I_1$.
Using Kirchhoff's voltage rule,

$$V = 100V = V_1 + V_3 = I_1R_1 + 3I_1R_3 = 10I_1 + 15I_1 = 25I_1$$

So I_1 = 4 A, and therefore I_2 = 8 A and I_3 = 12 A.

$$P_3 = I_3^2R_3 = 12^2 \times 5 = 720W$$

4) This is the result if you use $P = V^2/R$ with V = 100V and R = 5 Ω.

15.(III.C.2)

*1) Solution:
$F = iLB$ using the right hand rule to determine direction.

2) This is a result of misusing the right hand rule.

3) This is a result of using the height of the field region instead of the width.

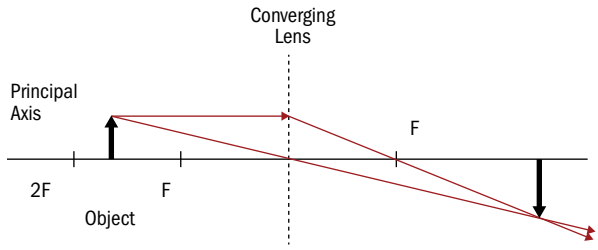
4) This is a combination of the errors in 2) and 3).

*correct answer

16.(IV.A.3)

1) Real and upright images cannot be produced using converging lenses.

*2) Solution:
If $S_1 > F$, then the image will be real and inverted.



3) For converging lenses, virtual and upright images will appear only if $S_1 < F$.

4) Virtual and inverted images cannot be produced using converging lenses.

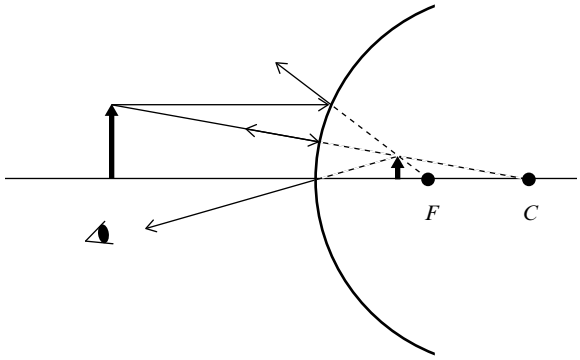
17.(IV.A.3)

1) Convex mirrors do not produce magnifications.

2) This is true for images produced by a concave mirror where S > F.

3) This is true for images produced by a concave mirror where S < F.

*4) Solution:
It should be upright and smaller than the object.



18.(IV.B.2)

*1) Solution:

$$\lambda_{air} = \frac{c}{nf} = \frac{3*10^8 \text{m/s}}{1*6.74 \text{ Hz}} = 445\text{nm}$$

$$y_{4,air} = R\frac{m\lambda_{air}}{d} = 1.2\text{m}\frac{3*445*10^{-9}\text{m}}{0.042*10^{-3}\text{m}} = 0.03814\text{m}$$

$$\lambda_{water} = \frac{c}{nf} = \frac{3*10^8 \text{m/s}}{1.33*6.74 \text{ Hz}} = 334.66\text{nm}$$

$$y_{4,air} = R\frac{m\lambda_{water}}{d} = 1.2\text{m}\frac{3*334.66*10^{-9}\text{m}}{0.042*10^{-3}\text{m}} = 0.0287\text{m}$$

$$\Delta y = 0.03814\text{m} - 0.0287\text{m} = 0.00945\text{m} = 9.45\text{m}$$

2) You used m = 3.5.

3) You used m = 4.

4) You used (m +1)/2 = 4.5.

19.(V.A)

*1) Solution:
The same intensity of violet light requires a smaller number of photons, resulting in fewer ejected electrons.

2) Current depends on number of incident photons, not total incident energy.

3) Current depends on number of incident photons, not total incident energy.

4) Current depends on number of incident photons with minimum energy.

20.(V.F.1)

1) You considered only two half lives.

2) You considered only three half lives.

3) You incorrectly computed four half lives.

*4) Solution:
There are four half lives.

$$T_{1/2} = 6h$$

$$number\ of\ half\ lives\ in\ 24\ hours = \frac{24}{6} = 4$$

$$Rate = 48 \times 2^4 = 768$$

*correct answer

Tables of Essential Formulas, Values, and Constants

Mechanics

$$v_x = v_{0x} + a_x t$$

$$x = x_0 + v_{0x} + \tfrac{1}{2} a_x t$$

$$v_x^{\,2} = v_{0x}^{\,2} + 2a_x(x - x_0)$$

$$a_{\text{rad}} = \frac{v^2}{R}$$

$$f_{\text{k}} = \mu_{\text{k}} n$$

$$f_{\text{s}} \le \mu_{\text{s}} n$$

$$F_{\text{spr}} = -kx$$

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$W = F\Delta r \cos\theta$$

$$K = \tfrac{1}{2} mv^2$$

$$U_{\text{grav}} = mgy$$

$$U_{\text{el}} = \tfrac{1}{2} kx^2$$

$$P_{\text{av}} = \frac{\Delta W}{\Delta t}$$

$$P = Fv\cos\theta$$

$$\sum \vec{F} = \lim_{\Delta t \to 0} \frac{\Delta \vec{p}}{\Delta t}$$

$$\Delta \vec{p} = \vec{F}\,\Delta t = \vec{F}(t_{\text{f}} - t_{\text{i}}) = \vec{J}$$

$$\omega = \omega_0 + \alpha t$$

$$\theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2$$

$$v = r\omega$$

$$K = \tfrac{1}{2} I\omega^2$$

$$\tau = Fr\sin\theta$$

$$L = I\omega$$

$$Y = \frac{l_0 F_\perp}{A\,\Delta\ell} = \frac{\text{stress}}{\text{strain}}$$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

$$T_{\text{s}} = 2\pi\sqrt{\frac{m}{k}}$$

$$T_{\text{p}} = 2\pi\sqrt{\frac{\ell}{g}}$$

$$x = A\cos\omega t$$

$$v_x - \omega A\sin\omega t$$

$$a_x = -\omega^2 A\cos\omega t$$

$$v = \lambda f$$

$$\beta = (10\,\text{dB})\log\frac{I}{10^{-12}\ \text{W/m}^2}$$

$$I = \frac{P}{4\pi r^2}$$

$$f_{\text{L}} = \frac{v + v_{\text{L}}}{v + v_{\text{s}}} f_{\text{s}}$$

$$p = p_0 + \rho gh$$

$$F_{\text{buoy}} = \rho Vg$$

$$\frac{\Delta V}{\Delta t} = A_1 v_1 = A_2 v_2$$

$$p + \rho gy + \tfrac{1}{2}\rho v^2 = \text{constant}$$

a = acceleration
A = area
F = force
f = frequency
h = depth
I = rotational inertia or intensity
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
P = power
p = momentum or pressure
r = radius or distance
s = displacement
T = period
t = time
U = potential energy
v = velocity or speed
V = volume
W = work done on a system
x = position
y = height
Y = Young's Modulus
μ = coefficient of friction
θ = angle
τ = torque
ω = angular speed
α = angular acceleration
ρ = density

Electromagnetism

$$F = k\frac{q_1 q_2}{r^2}$$

$$E = \frac{F}{q}$$

$$U = qV$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$E = -\frac{\Delta V}{\Delta s}$$

$$C = \frac{Q}{V}$$

$$C = \varepsilon_0 \frac{A}{d}$$

$$C_{\text{eq}} = C_1 + C_2 + C_3 + \cdots$$

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

$$U = \frac{1}{2}CV^2$$

$$u = \frac{1}{2}\varepsilon_0 E^2$$

$$R = \frac{V}{I}$$

$$R = \rho\frac{\ell}{A}$$

$$P = VI = I^2 R$$

$$R_{\text{eq}} = R_1 + R_2 + R_3 + \cdots$$

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

$$F = q v_\perp B = q vB\sin\theta$$

$$F = I\ell B\sin\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{2R}$$

$$B = \mu_0 nI$$

$$\Phi_B = BA\cos\theta$$

$$|\varepsilon| = \left|\frac{\Delta\Phi_B}{\Delta t}\right|$$

$$|\varepsilon| = L\left|\frac{\Delta i}{\Delta t}\right|$$

$$U = \frac{1}{2}LI^2$$

$$u = \frac{B^2}{2\mu_0}$$

$$\omega = \sqrt{\frac{1}{LC}}$$

$$X_L = \omega L$$

$$X_C = \frac{1}{\omega C}$$

$$E = cB$$

$$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}}$$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
ε = emf
F = force
I = current
J = current density
L = inductance
ℓ = length
P = power
Q = charge
q = point charge
R = resistance
r = distance
s = distance
t = time
u = field energy density
U = potential energy
V = electric potential
X = reactance
v = velocity or speed
ρ = resistivity
θ = angle
Φ_m = magnetic flux
ω = angular frequency

Thermal Physics

$$T_C = \frac{5}{9}\left(T_F - 32^\circ\right)$$

$$\Delta L = \alpha L_0 \Delta T$$

$$Q = mc\Delta T$$

$$Q_{f,v} = mL_{f,v}$$

$$H = kA\frac{T_H - T_C}{L}$$

$$PV = nRT$$

$$W = -P\Delta V$$

$$\Delta U = Q - W$$

$$e = \left|\frac{W}{Q_{\mathrm{H}}}\right|$$

$$e_{\mathrm{Carnot}} = \frac{T_{\mathrm{H}} - T_{\mathrm{C}}}{T_{\mathrm{H}}}$$

$$\Delta S = \frac{Q}{T}$$

e = efficiency
H = heat transfer rate
k = thermal conductivity
L = length
$L_{\mathrm{f,v}}$ = latent heats
n = number of moles
Q = heat
S = entropy
T = temperature
Q = charge
U = internal energy
W = work done
α = coefficient of linear expansion

Light and Optics

$$v = f\lambda$$

$$n = \frac{c}{v}$$

$$n_a \sin\theta_a = n_b \sin\theta_b$$

$$\sin\theta_{\mathrm{crit}} = \frac{n_b}{n_a}$$

$$I = I_{\max}\cos^2\theta$$

$$f = \frac{R}{2}$$

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$m = \frac{y'}{y} = -\frac{s'}{s}$$

$$d\sin\theta = m\lambda$$

$$\sin\theta = \frac{m\lambda}{a}$$

$$\tan\theta_B = \frac{n_2}{n_1}$$

a = slit width
d = separation
f = frequency or focal length
d = distance
I = intensity
L = distance
m = magnification or an integer
n = index of refraction
R = radius of curvature
s = distance
v = speed
x = position
y = height
λ = wavelength
θ = angle

Modern Physics

$$E_{\mathrm{rest}} = mc^2$$

$$\frac{1}{2}mv_{\max}^{\ 2} = hf - \phi$$

$$E = hf$$

$$E_n = -\frac{1}{\varepsilon_0^{\ 2}}\frac{me^4}{8n^2h^2}$$

$$\lambda = \frac{h}{p}$$

$$N = N_0 e^{-\lambda t}$$

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

E = energy
f = frequency
K = kinetic energy
m = mass
N = number of nuclei
p = momentum
λ = wavelength or decay function
ϕ = work function
t = time
$T_{1/2}$ = half life

Fundamental Physical Constants

Name	Symbol	Value
Speed of the light in vacuum	c	2.998×10^{8} m/s
Magnitude of charge of electron	e	1.602×10^{-19} C
Gravitational constant	G	6.674×10^{-11} N·M^2/kg^2
Planck's constant	h	6.626×10^{-34} J·s
Boltzmann constant	k	1.381×10^{-23} J/K
Stefan-Boltzmann constant	σ	5.671×10^{-8} W/(m^2·K^4)
Avogadro's number	N_A	6.022×10^{23} molecules/mol
Gas constant	R	8.314 J/(mol·K)
Mass of electron	m_e	9.109×10^{-31} kg
Mass of proton	m_p	1.673×10^{-27} kg
Mass of neutron	m_n	1.675×10^{-27} kg
Permeability of vacuum	μ_0	$4\pi \times$ 10-7 Wb/T·m/A
Permittivity of vacuum	$\varepsilon_0 = 1/\mu 0\ c^2$ $1/4\pi\varepsilon_0$	8.854×10^{-12} C^2/(N·m^2) 8.988×10^{9} n·m^2/C^2

Other Useful Constants

Name	Symbol	Value
Mechanical equivalent of heat		4.186 J/cal (15°C)
Standard atmospheric pressure	1 atm	1.013×10^{5} Pa
Absolute zero	0 K	-723.15°C
Electron volt	1 eV	1.602×10^{-19} J
Unified atomic mass unit	1 u	1.661×10^{-27} kg
Electron rest energy	$m_e c^2$	0.5110 MeV
Volume of ideal gas (0°C and 1 atm)		22.41 liter/mol
Acceleration due to gravity (standard)	g	9.80 m/s^2

Unit Conversion

Length

1 m = 100cm = 1000 mm = 10^6 μm = 10^9 nm
1 km = 1000 m = 0.6214 mi
1 m = 3.281 ft = 39.37 in.
1 cm = 0.3937 in.
1 in. = 2.540 cm
1 ft = 30.48 cm
1 yd = 91.44 cm
1 mi = 5280 ft = 1.609 km
1 Å = 10^{-10} m = 10^{-8} cm = 10^{-1} nm
1 nautical mile = 6080 ft
1 light year = 9.461×10^{15} m

Area

1 cm^2 = 0.155 $in.^2$
1 m^2 = 104 cm^2 = 10.76 $in.^2$
1 $in.^2$ = 6.452 cm^2
1 ft^2 = 144 $in.^2$ = 0.0929 m^2

Volume

1 liter = 1000 cm^3 = 10^{-3} m^3
= 0.03531 ft^2 = 61.02 $in.^3$
1 ft^3 = 0.02832 m^3 = 28.32 liters = 7.477 gallons
1 gallon = 3.788 liters

Time

1 min = 60 s
1 h = 3600 s
1 d = 86,400 s
1 y = 365.24 d = 3.156×10^7 s

Angle

1 rad = 57.30° = 180°/π
1° = 0.01745 rad = π/180 rad
1 revolution – 360° = 2π rad
1 rev/min (rpm) = 0.1047 rad/s

Speed

1 m/s = 3.281 ft/s
1 ft/s = 0.3048 m/s
1 mi/min = 60 mi/h = 88 ft/s
1 km/h = 0.2778 m/s = 0.6214 mi/h
1 mi/h = 1.466 ft/s = 0.4470 m/s = 1.609 km/h
1 furlong/fortnight = 1.662×10^{-4} m/s

Acceleration

1 m/s^2 = 100 cm/s^2 = 3.281 ft/s^2
1 cm/s^2 = 0.01 m/s^2 = 0.03281 ft/s^2
1 ft/s^2 = 0.3048 m/s^2 = 30.48 cm/s^2
1 mi/h•s = 1.467 ft/s^2

Mass

1 kg = 10^3 g = 0.0685 slug
1 g = 6.85×10^{-5} slug
1 slug = 14.59 kg
1 u = 1.661×10^{-27} kg
1 kg has a weight of 2.205 lb when g = 9.80 m/s^2

Force

1 N = 10^5 dyn = 0.2248 lb
1 lb = 4.448 N = 4.448×10^5 dyn

Pressure

1 Pa = 1 N/m^2 = 1.450×10^{-4} $lb/in.^2$
= 0.209 lb/ft^2
1 bar = 10^5 Pa
1 $lb/in.^2$ = 6895 Pa
1 lb/ft^2 = 47.88 Pa
1 atm = 1.013×10^5 Pa = 1.013 bar
= 14.7 $lb/in.^2$ = 2117 lb/ft^2
1 mm Hg = 1 torr = 133.3 Pa

Energy

1 J = 10^7 ergs = 0.239 cal
1 cal = 4.186 J (based on 15°C)
1 ft·lb = 1.356 J
1 Btu = 1055 J = 252 cal = 778 ft·lb
1 eV = 1.602×10^{-19} J
1 kWh = 3.60×10^6 J

Mass-Energy Equivalence

1 kg ↔ 8.988×10^{16} J
1 u ↔ 931.5 MeV
1 eV ↔ 1.074×10^{-9} u

Power

1 W = 1 J/s
1 hp = 746 W = 550 ft·lb/s
1 Btu/h = 0.293 W

SECTION FIVE

Taking the Exam

Registering for Your Exam

Register Online

www.excelsior.edu/examregistration
Follow the instructions and pay by Visa, MasterCard, American Express, or Discover Card.

Examination Administration

Pearson Testing Centers serve as the administrator for all Excelsior College computer-delivered exams.

Accessibility Services

Excelsior College is committed to the principle that every individual should have an equal opportunity to enroll in an Excelsior College degree program, to register for courses or examinations in order to demonstrate their knowledge and skills under appropriate conditions, and to complete a degree.

The Accessibility Services Office at Excelsior College is responsible for considering requests for reasonable accommodations for individuals with verifiable, documented disabilities. If you are requesting an accommodation due to a disability/condition, complete a Request for Accommodation form.

Computer-Delivered Testing

The UExcel exams are delivered by computer. You can take this exam either in a Pearson VUE testing center or at your home or office with an online proctor. If you are interested in remote proctoring, visit PearsonVUE OnVUE online proctoring.

The system is designed to be as user-friendly as possible, even for those with little or no computer experience. On-screen instructions are similar to those you would see in a paper examination booklet. You will use either the keyboard or the mouse to submit your answers, depending upon the type of question.

Before taking your exam, we strongly encourage you to go on a virtual tour of the testing center. To access this tour, click the What to Expect in a Pearson VUE test center at the following link: home.pearsonvue.com/test-taker/security.aspx

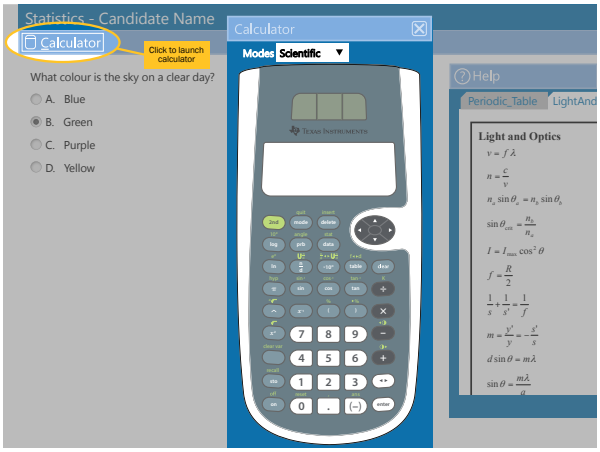
You also will receive a small, erasable whiteboard if you need one.

Whiteboards

Examinees cannot bring scratch paper to the exam. Instead, one will be provided for you to write notes or calculations on: a small whiteboard if you are testing at a Pearson Testing Center, and an on-screen "whiteboard" if you are testing online. You can see what the on-screen "whiteboard" looks like, and even try it out.

Calculator

You may not take your own calculator, if the exam calls for it. One will be provided on the testing screen. See example below.



Breaks

Breaks are only permitted for exams taken at Pearson VUE Testing Centers, and are not permitted during exams delivered via online proctoring.

Online Proctoring

As of spring 2021, Excelsior is offering an online delivery option for UExcel exams, using OnVUE, Pearson VUE's online delivery and proctoring service.

You must use a personal (vs. an employer's) computer if you want to take the exam online and not in a testing center, so the exam can be effectively delivered to you.

Breaks are not allowed during an exam taken online from home. You may not leave your seat during an online-proctored exam, so be prepared to sit for two or three hours. If you need extra time, the exam will have to be taken at a PearsonVUE Testing Center, and an accommodation formally requested.

NOTE: English Composition, Spanish, Music, and College Writing will NOT be available for online proctoring.

On the Day of Your Exam

Important Reminders

On the day of your exam, remember to:

- dress comfortably: the computer will not mind that you're wearing your favorite relaxation outfit
- arrive at the test site rested and prepared to concentrate for an extended period
- allow sufficient time to travel, park, and locate the test center
- be prepared for possible variations in temperature at the test center due to weather changes or energy conservation measures
- bring your ID, but otherwise, don't weigh yourself down with belongings that will have to be kept in a locker during the test.

Academic Integrity Nondisclosure Statement

- All examinees must agree to the terms of the Excelsior College Academic Integrity Policy before taking an examination. The agreement will be presented on screen at the Pearson VUE Testing Center before the start of your exam.
- Once the examinee agrees to the terms of the Academic Integrity Nondisclosure Agreement (NDA), the exam will begin.

If you choose not to accept the terms of the agreement

- your exam will be terminated
- you will be required to leave the testing center
- you will not be eligible for a refund. For more information, review the Student Policy Handbook at www.excelsior.edu/studentpolicyhandbook.

Student behavior is monitored during and after the exam. Electronic measures are used to monitor the security of test items and scan for illegal use of intellectual property. This monitoring includes surveillance of Internet chat rooms, websites, and other public forums.

UExcel Grade Report

After you complete the exam, you will be issued a UExcel Grade Report for Examinations. See the sample UExcel Grade Report in this content guide.

Grade Appeals

If you believe that your score grade is incorrect, you may appeal your grade to examcredit@excelsior.edu. Details about the appeals process are in the Student Handbook.

What If I Miss My Appointment?

If you don't cancel or reschedule your testing appointment 24 hours before your test appointment, you will have to pay the full fee of the exam, even if you don't show up.

Late Arrivals

You will also forfeit the exam fee if you arrive to the test center more than 15 minutes late.

Information About UExcel Exams for Colleges and Universities

A committee of teaching faculty and practicing professionals determines the learning outcomes to be tested on each exam. Excelsior College Center for Educational Measurement staff oversee the technical aspects of test construction in accordance with current professional standards. To promote fairness in testing, we take special care to ensure that the language used in the exams and related materials is consistent, professional, and user friendly. Editorial staff perform systematic quantitative and qualitative reviews to ensure accuracy, clarity, and compliance with conventions of bias-free language usage.

Excelsior College, the test developer, recommends granting six (6) semester hours of lower-level undergraduate credit to students who receive a letter grade of C or higher on this examination. Other colleges and universities also recognize this exam as a basis for granting credit or advanced standing. Individual institutions set their own policies for the amount of credit awarded and the minimum acceptable score.

Physics Exam Development Committee

Jerry O'Connor, MS
(Murray State University, 1978)
Associate Professor, San Antonio College

Peter Persans, PhD
(University of Chicago, 1982)
Professor, Rensselaer Polytechnic Institute

Eric Peterson, PhD
(Lamar University, 2008)
Instructor, Highland Community College

Jason Zimba, PhD
(University of California at Berkeley, 2001)
Assistant Professor, Bennington College

Sample Grade Report

Excelsior College
GRADE REPORT FOR EXAMINATIONS

Contact ID:

Test Date: 11/21/2020

Letter Grade: C

Examination Code and Title: 210 Statistics

Recommended Credit:
3 Lower Level

Your examination results are expressed as a Letter Grade of A, B, C, or F. Your results are automatically verified when they are received at Excelsior College. If an error is detected, you will be notified immediately.

Recommended Credit is the number of semester hours credit that Excelsior College awards and recommends for your grade. Excelsior College awards and recommends credit for letter grades of C or better.

If you plan to take another examination, you may download free content guides and the User's Guide by visiting our website at www.excelsior.edu/exams/content-guides/.

If you need an Excelsior College Official Examinations Transcript to document the credit you have earned for this examination for another institution, the request can be made online by accessing the Excelsior College website (www.excelsior.edu), logging into your MyExcelsior account, and scrolling down to the For Exams Takers box and clicking on the Request transcripts link. If you do not already have a MyExcelsior username and password, you can obtain one at no cost by accessing the Excelsior College website, clicking the Log In to MyExcelsior button, and then clicking the link "Create a MyExcelsior User Account."

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