Physics 105 Class Schedule – Fall 2008

	Monday	Tuesday	Wednesday	Thursday	Friday
September	1 **Holiday** ***Before first day:*** Study units (chapter 1) Read syllabus	2 **First Day of Class** Velocity Reading: 2.1-2.3 (7/8 edition: 2.1-2.2)	3	4 lecture 2 Acceleration Reading: 2.4-2.7 (7/8: 2.3-2.6)	5 Homework 1
	8	9 lecture 3 Vectors, trigonometry Reading: 1.7-8, 3.1-3, 3.6 (5: 1.8-1.9, 3.1-3.3, 3.6) (7/8: 1.7-1.8, 3.1-3.2, 3.5)	10 Homework 2	11 lecture 4 2-D motion Reading: 3.4-3.5 (7/8: 3.3-3.4)	12 Homework 3
	15 Add/drop deadline	16 lecture 5 Exam 1 Review (Ch. 2-3) No reading assignment **Begin Exam 1 10:15 AM**	17	18 lecture 6 Newton's Laws of Motion Reading: 4.1-4.4	19 Homework 4
	22 **End Exam 1** (late fee after 5 pm)	23 lecture 7 Using Newton's Laws: ropes, pulleys and planes Reading: 4.5	24 Homework 5	25 lecture 8 More using Newt's Laws: friction Reading: 4.6	26 Homework 6
October	29	30 lecture 9 Energy Reading: 5.1-5.4 (7/8: 5.1-5.3)	1 Homework 7	2 lecture 10 Energy, Power Reading: 5.5-5.8 (7/8: 5.4-5.7)	3 Homework 8
	6 Withdraw deadline	7 lecture 11 Exam 2 Review (Ch. 4-5) No reading assignment **Begin Exam 2 10:15 AM**	8	9 lecture 12 Momentum Reading: 6.1-6.4	10 Homework 9
	13 **End Exam 2** (late fee after 5 pm)	14 lecture 13 Circular motion Reading: 7.1-7.6 (7/8: 7.1-7.4)	15 Homework 10	16 lecture 14 Forces & rotation, gravity Reading: 7.7-end (7/8: 7.5-end)	17 Homework 11
	20	21 lecture 15 Torque and equilibrium Reading: 8.1-8.4	22 Homework 12	23 lecture 16 Torque and rotation Reading: 8.5-8.6	24 Homework 13
	27	28 lecture 17 Torque and angular momentum Reading: 8.7	29 Homework 14	30 lecture 18 Exam 3 Review (Ch. 6-8) No reading assignment **Begin Exam 3 10:15 AM**	31
November	3	4 lecture 19 Fluids, solids, pressure Reading: 9.1-9.6	5 **End Exam 3** (late fee after 5 pm) Homework 15	6 lecture 20 Fluid motion Reading 9.7-9.8	7 Homework 16
	10	11 lecture 21 Temperature, gases Reading: chapter 10	12 Homework 17	13 lecture 22 Specific heat & heat flow Reading: 11.1-11.8 (7/8: 11.1-11.5)	14 Homework 18
	17	18 lecture 23 Thermo laws, engines Reading: chapter 12	19 Homework 19	20 lecture 24 Exam 4 Review (Ch9-12) No reading assignment **Begin Exam 4 10:15 AM**	21
	24	25 Discontinuance deadline **No class** (Friday instruction)	26 **End Exam 4** (late fee after 5 pm)	27 **Thanksgiving Holiday**	28
December	1	2 lecture 25 Vibrations, waves Reading: chapter 13	3 Homework 20	4 lecture 26 Sound waves, Doppler Reading: 14.1-14.6	5 Homework 21
	8	9 lecture 27 Interference Reading: 14.7-14.13	10 Homework 22	11 lecture 28 **Semester Review** No reading assignment.	12 **Reading Day**
	15 **Final exam opens**	16 **…**	17 **…**	18 **…**	19 **End Final** (late fee after 5 pm) All late HW must be submitted by 11:59 pm

Physics 105 – Fall 2008 – Sections 1 and 2
Dr John S. Colton

General Information

Instructor: Dr. John S. Colton, john_colton@byu.edu, N335 ESC, 422-3669.
Lectures: Section 1 is 9:00-10:15 am; section 2 is 12:30-1:45 pm; T Th, 377 CB.
Instructor Office Hours: 4-5 pm WF, generally to be held in the Physics Tutorial Lab in N304 ESC. Private meetings are available by appointment.
Weekly Problem Solving Session: Time/place TBA.
Textbook: *College Physics*, by Serway & Faughn (5^{th}, 6^{th}, 7^{th} editions) or by Serway & Vuille (8^{th} edition). Only volume 1 is needed for Physics 105; but volume 2 is used in Physics 106, so if you're planning to take that course too it may be cheaper to get a book with both volumes combined. Feel free to obtain an inexpensive used copy.
Website: http://www.physics.byu.edu/faculty/colton/courses/phy105-fall08. You can easily navigate to the course website from the Physics Dept homepage: choose "Courses" then "Class Web Pages" and then Physics 105 (Colton).
Blackboard: The course will *not* use Blackboard at all. There is no Blackboard site.
Google group: The following Google group is available for you to discuss physics concepts, HW problems, etc., with other students: http://groups.google.com/group/physics-105-fall-2008

Student Email Addresses: I will often send class information via email to your Route-Y address. If you do not use that address, please set it to forward to the email account you do use.

Course Content: In this class you will learn about the physics of motion, with an emphasis on mechanical and thermodynamic systems. You will learn and apply mathematical methods, reasoning, and general problem solving skills. These new concepts and skills should enhance your experience of the physical world and prepare you to use physical concepts, devices and instruments.

Students who successfully complete this course will be able to:

- Solve introductory physics problems involving fundamental physics equations and laws
- Answer qualitative questions involving physics concepts
- Recognize physics principles at work in the world around them

I also hope that as you learn more about the physical laws governing the universe, your appreciation for the order, simplicity and complexity of God's creations will increase. I sincerely believe that one can come to know the Creator better by studying His creations.

Brigham Young:

> Man is organized and brought forth as the king of the earth, to understand, to criticize, examine, improve, manufacture, arrange and organize the crude matter and honor and glorify the work of God's hands. This is a wide field for the operation of man, that reaches into eternity; and it is good for mortals to search out the things of this earth.

Steve Turley (former BYU Physics Department chair):

> My faith and scholarship also find a unity when I look beneath the surface in my discipline to discover the Lord's hand in all things (see D&C 59:21). It is His creations I study in physics. With thoughtful meditation, I have found striking parallels between His ways that I see in the scriptures and His ways that I see in the physical world. In the scriptures I see a God who delights in beauty and symmetry, who is a God of order, who develops things by gradual progression, and who establishes underlying principles that can be relied on to infer broad generalizations. I see His physical creations following the same pattern. Just as numerous gospel ordinances and practices serve as types of Christ, His creations are full of types we can use to strengthen our faith, teach us valuable spiritual lessons, and bring us to Christ. These types are so strong that Alma invokes them as a proof to Korihor of the existence of God. In Alma 30:44 we read, "even the earth, and all things that are upon the face of it, year, and its motions, yea and also all the planets which move in their regular form do witness that there is a Supreme Creator."

Class Identification Number: Each of you will receive a personal identification number for this course, called a "Class ID" (CID). The purpose of this number is to protect your privacy. Most of you will receive your CID by e-mail before the first day of classes. If you have not received it by then, you can obtain it over the internet—go to the course website and click on the relevant link.

Lecture Notes: The evening before each lecture, or earlier, I will post the overhead transparencies that I will use for that lecture on the course website. You may find it helpful to print them out and use them for taking notes on during class.

Grading: Letter grades will be assigned according to this scale. If you hit these grade boundaries, you are guaranteed to get the grade shown. At the end of the semester, I may adjust the boundaries slightly to help you a bit, but there is no guarantee this will occur.

A	93%	B+	84%	C+	71%	D+	48%
A-	88%	B	79%	C	60%	D	44%
		B-	75%	C-	52%	D-	40%

Please note that these boundaries have *already* been substantially curved from the standard 90-80-70-60-50 scale. In particular, if you get e.g. a 62% on an exam, it is not a D-; rather, it is solidly in the C range. For reference: last year, using a similar grading scale, the final grades were such that 33% of class got A's and A-'s; 32% of the class got B+'s, B's and B-'s; 27% of the class got C+'s, C's, and C-'s; 8% of the class got D+'s or below.

You will be graded on homework, pre-class quizzes, class participation, and midterm & final exams. The percentage contribution to your final grade will be like this:

- HW: 30%
- Pre-class quizzes: 3%
- Class participation: 3%
- 4 Midterm Exams: 44%
- Final Exam: 20%

You can check your grade at any time through the link on the course website.

Homework: Please **carefully read the detailed description of online homework submission** which is a separate document, *Homework Submission and Grading*, found later in this packet.

In short: All homework is due at 11:59 pm on the day marked on the schedule. We will use a computerized grading system developed by the Physics Department specifically for the introductory classes. This system has both plusses and minuses. The biggest minus is that you just type your answer into the computer, rather than turning in the work that you did to obtain the answer. That means that there is no traditional partial credit, which can be frustrating to students.

Instead of the traditional way of assigning partial credit, we give partial credit a different way: we let you submit a problem multiple times if you get it wrong. If you get the problem right on the first try, you get full credit. If you need a second or third try to get the problem right, then you only get partial credit. Up to five attempts may be made on a given problem before all points are lost. These resubmissions must be made within a few days of the original deadline. All retries are due before the next HW due-date to avoid being counted as late. To allow for emergencies or adding the class late, you will get three free late assignments; after that late work only counts for half credit.

This system offers several major advantages to students:

- Students get instant feedback as to whether they did the problem correctly.
- Each student gets a slightly different—but closely related—problem to work; this makes copying off of other students nearly impossible. (Yes, sadly even at BYU this is a problem.)
- Because the HW problems are not assigned directly from the textbook, students can purchase cheap older editions instead of all being forced to use the same, newest edition.
- By not needing to use TAs to *grade* the homework, the Physics Department can afford to employ more TAs in the Tutorial Lab to help you understand how to *do* the homework.

I encourage you to work with other students to figure out the problems, but of course the answers you submit must be based on your own work. Also, even though you only submit the numerical answers, you should keep your work in some sort of organized homework notebook. Many exam questions will be similar to homework problems, so you need to know what you did to solve the HW problems in order to study for the exams. Practice good problem solving skills: draw pictures of the problems, write neatly, and use plenty of space. Substitute units with your numbers into your algebra, and check to see that the units work out right on your final answer.

Homework solutions will be posted, most likely in the glass cases outside N361 ESC.

Additional Thoughts: In a recent BYU seminar for new faculty, experts on student learning taught that **most student learning is done outside of the classroom**. I expect this class to follow that same trend. This will likely be a very homework-intensive class for you. The BYU Undergraduate Catalog states that "The expectation for undergraduate courses is three hours of work per week per credit hour for the average student who is appropriately prepared; much more time may be required to achieve excellence" (pg 57; underline added). For this particular three credit hour class that means **an average student should spend about six hours per week on homework** outside of class, in order to achieve an average grade. I surveyed my class at the end of last year and found that most students were indeed putting in 5-6 hours of work per week outside of class. Some were putting in much more than that in order to get good grades. Unfortunately, while spending extra time will certainly help, it is not a guarantee of a great grade; I know some students get frustrated by this. Perhaps that's just the "nature of the beast"—some students grasp the material more easily than others and some students have a more extensive background in the subject already. I suppose a lot of subjects are like that. At any rate, I will do everything I can within reason to help you personally succeed in this course.

Help On The Homework: There are multiple ways for you to get help solving homework problems.

Other Students. Your first line of defense should be other students in the class. Introduce yourself to people you sit next to. Form study groups. Visit and post to the Google group at http://groups.google.com/group/physics-105-fall-2008. Help others understand things you have figured out. You are not graded on a curve, so helping others does not hurt yourself. In fact, explaining things to others helps to cement the concepts in your own mind.

Tutorial Lab. A physics tutorial lab is provided in N304 and N362 ESC. Teaching assistants will be available roughly 9 am to 9 pm every weekday and several hours on Saturday. The TA schedule will be finalized during the first week of classes and can be found via a link found on the course website. You can get help from any of the TAs, but some are specifically associated with Physics 105 and will work through the Physics 105 problem sets themselves each week. I believe those TAs will be wearing "Physics 105" on their nametags.

Last year, a common complaint was that the Tutorial Lab was understaffed at peak times. If you discover this to be the case, or if you discover times when it is *over*staffed, please let the Tutorial Lab coordinator know. He will try to shuffle around the TAs, or possibly hire new TAs, in order to run an efficient operation. The coordinator is Dr. Richard Vanfleet, and may be contacted via the feedback form, here: http://gardner.byu.edu/tas/feedback_tutorial_lab.html
Please also let him know if you have especially good or bad experiences with any specific TAs.

Tutors. The Physics Department also keeps a list of physics majors willing to be personal tutors (for a fee). A message board related to this may be found here:
http://groups.google.com/group/byu_physics_tutors

Weekly Problem-solving Session. Because class time is limited, we will need to spend most of the lectures discussing physical laws and general concepts, instead of working out specific problems (although we will do some of that, too). For those who feel like they need more experience solving problems, I will run an optional problem-solving session every week. I will concentrate on how to visualize the situation a problem describes, what to think about before attempting to write down equations, and how to do the algebraic manipulation once you know which equations are relevant.

Dr. Colton's Office Hours. By all means talk to me during my office hours! I will generally hold these in the Tutorial Lab.

Textbook: Your textbook has a slew of worked example problems. Take advantage of it—don't just read the worked problems, but try to work them out yourself before looking at the book's solutions. Then try to understand the general principles involved in how the book's author approached the problem, not just the specific solution for the specific problem.

Additional books. One of these books may prove helpful to give you more experience in solving homework problems. There are likely other similar books that I haven't listed here.

- *3,000 Solved Problems in Physics (Schaum's Solved Problems)*, by Alvin Halpern
- *Schaum's Outline of Beginning Physics I: Mechanics and Heat*, by Alvin Halpern
- *Schaum's Outline of College Physics*, by Frederick Bueche and Eugene Hecht
- *How to Solve Physics Problems*, by Robert Oman and Daniel Oman
- (mentioned in the preface to your textbook) *Student Solutions Manual and Study Guide*, by Gordon, Teague, and Serway.

I will likely use the second Halpern book as the basis for problems at the weekly problem-solving session.

Warm-up Exercises: You will have a reading assignment for each class; the specific assignments are shown on the course schedule at the end of this syllabus. After reading the assignment, you will need to complete a short "warm-up exercise". You access these exercises via the course website. Your grade will be based solely on your answer to the question, "Did you do the reading assignment?"—2 points if yes, 1 point if no. You get 0 points if you don't bother to visit the website to answer the question. There will be additional (non-graded) questions on the reading assignment, and you will be given a chance to say which topic(s) you would like me to emphasize during the class discussion. These warm-up exercises will be <u>due at 8:00 am each class day</u>, to give me some time to look them over before the morning class.

You will not be allowed to make up a missed warm-up exercise for any reason. However, to allow for sickness and other emergencies you get <u>three free warm-ups</u>: I will convert your three warm-up exercises with the most missed points into perfect scores.

Class participation: Multiple-choice quiz questions will be given throughout each lecture to encourage student participation. I will ask you conceptual questions, have you work problems, have you guess what will happen in a demonstration, etc. Some questions will be given to you individually; many will require you to talk to people sitting near you in class.

You will answer the questions electronically using an "i-clicker" transmitter available at the bookstore. On the reverse side of the transmitter is an alphanumeric ID code for your transmitter. You must go to the course website and register your transmitter ID number—we need this information in order to give you credit for quizzes. So that you are not penalized for not knowing the correct answers, these "clicker questions" will be graded on participation only. That is, if you transmit any answer, you get full credit.

You will not be allowed to make up a missed clicker quiz for any reason (tardy, absent, forgot or lost clicker, etc.). However, so that you are not penalized unduly for missing quizzes when circumstances arise, you get five free clicker quizzes: I will convert your five clicker quizzes with the most missed points into perfect scores.

Midterm Exams: Four midterm exams will be given in the Testing Center in the Grant Building (2^{nd} floor) and will be available for the days indicated on the schedule. You will be allowed a 3″ × 5″ note card (both sides) as a "cheat sheet" on which you can write anything you want. Note cards must be handwritten, not e.g. printed via computer or xeroxed.

Exams will include problems similar to homework problems, as well as conceptual questions related to things we discussed in class. The exams will be predominantly computer graded.

Exams will be returned to you sorted by the first two digits of your CID number in the bins outside N357 ESC.

Final Exam: The final exam will be given during the Final Exam Week in the Testing Center. It will be comprehensive, and *closed notes*. The most complicated equations will be given to you, but I will expect you to have learned the fundamental definitions, physical laws, and simpler equations over the course of the semester. I will give you a summary list indicating which equations I will provide on the final exam.

Calculators will not be permitted on the final exam—the questions will either be conceptual, have symbolic answers, or use easy enough numbers that you can work them out by hand.

Extra Credit: There will be at least four ways to earn extra-credit points during the semester.

Homework. Extra-credit homework problems will periodically show up on the homework assignments. These are treated like regular HW problems, except you are not penalized if you do not do them.

Short Paper. Once in the semester you may submit an extra credit paper. This must be a short paper, one page maximum, describing something you noticed in the "real world" that relates to a physics principle we discussed in class. I will pick some of the best ones to share with the class. Assuming that your paper meets a minimum standard, I will award you extra credit points—the equivalent of +5 points on one of your midterms. Additionally, if I select your paper to share with the rest of the class, I will award you an additional 5 points.

Book review. You may turn in a (single) book review of a physics-related book that you read during the semester, also one-page maximum. Write the book review in a form that you could e.g. post as a review to amazon.com: (1) a rating out of five stars, (2) some info about what the book contained, and (3) your personal assessment of the quality of the book. A list of allowed books is included later in this document; books not specifically on the list are also possible, but please get my permission first. Assuming that your review meets a minimum standard, I will award you +5 extra credit points for turning in a review, and an additional 5 points if I share your review with the class.

Physics-related lecture. Once in the semester you may attend a physics-related lecture and turn in a brief report of what you learned, no longer than one page. This could be a university forum, like that of Brian Greene in Winter 2008, a physics department colloquium, or any other physics-related science lecture that you can find. A planetarium show could count as well. Assuming that your report meets a minimum standard, I will award you +5 extra credit points.

Miscellaneous university/departmental policies:

Prevention of Sexual Harassment: BYU's policy against sexual harassment extends to students. If you encounter sexual harassment or gender-based discrimination, please talk to your instructor, or contact the Equal Opportunity Office at 378-5895, or contact the Honor Code Office at 378-2847.

Students with Disabilities: BYU is committed to providing reasonable accommodation to qualified persons with disabilities. If you have any disability that may adversely affect your success in this course, please contact the Services for Students with Disabilities Office at 378-2767. Services deemed appropriate will be coordinated with the student and your instructor by that office.

Children in the Classroom: The serious study of physics requires uninterrupted concentration and focus in the classroom. Having small children in class is often a distraction that degrades the educational experience for the entire class. Please make other arrangements for child care rather than bringing children to class with you. If there are extenuating circumstances, please talk with your instructor in advance.

Book Review Extra Credit Book List

- *A Brief History of Time*, by Stephen Hawking
- *A Short History of Nearly Everything*, by Bill Bryson
- *Einstein: His Life and Universe*, by Walter Isaacson
- *Genius: The Life and Science of Richard Feynman*, by James Gleick
- *In Search of Schrödinger's Cat: Quantum Physics and Reality*, by John Gribbin
- *Krakatoa: The Day the World Exploded: August 27, 1883*, by Simon Winchester
- *Lise Meitner: A Life in Physics*, by Ruth Lewin Sime
- *Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time*, by Dava Sobel
- *Measured Tones*, by Ian Johnston
- *Miss Leavitt's Stars: The Untold Story Of The Woman Who Discovered How To Measure The Universe*, by George Johnson
- *Mr. Tompkins in Paperback*, by George Gamow
- *Parallax: The Race to Measure the Cosmos*, by Alan Hirshfeld
- *Physics of the Impossible: A Scientific Exploration into the World of Phasers, Force Fields, Teleportation, and Time Travel*, by Michio Kaku
- *Quantum: A Guide for the Perplexed*, by Jim Al-Khalili
- *The Accelerating Universe: Infinite Expansion, the Cosmological Constant, and the Beauty of the Cosmos*, by Mario Livio
- *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*, by Brian Greene
- *The Equation That Couldn't Be Solved*, by Mario Livio
- *The Fabric of the Cosmos: Space, Time, and the Texture of Reality*, by Brian Greene
- *The Golden Ratio: The Story of Phi, the World's Most Astonishing Number*, by Mario Livio
- *The Making of the Atomic Bomb*, by Richard Rhodes
- *The New Cosmic Onion: Quarks and the Nature of the Universe*, by Frank Close
- *The Physics of NASCAR: How to Make Steel + Gas + Rubber = Speed*, by Diandra Leslie-Pelecky
- *The Physics of Star Trek*, by Lawrence Krauss
- *The Physics of Superheroes*, by James Kakalios
- *The Quantum World: Quantum Physics for Everyone*, by Kenneth Ford
- *The Structure of Scientific Revolutions*, by Thomas Kuhn
- *Thirty Years that Shook Physics: The Story of Quantum Theory*, by George Gamow
- *Voodoo Science: The Road from Foolishness to Fraud*, by Robert Park
- *What Einstein Told His Barber: More Scientific Answers to Everyday Questions*, by Robert Wolke

Other books are certainly also allowed, but please get my permission first.

Note that I personally have only read seven of these books, so I'm interested to hear what you think about them! (Most of these have been recommendations I got from other people.)

"Interesting things I learned in Physics 105"
From students in Fall 2007

- That *x* and *y* motions are independent of each other.
- That a bullet shot from a rifle will hit the ground at the same time as one dropped from the same height if the bullet is shot parallel to the ground (neglecting air resistance).
- That if you have a feather and a lead ball in a vacuum, they will fall and hit the ground at the same time because gravity acts the same on them.
- When you are in a car and it turns, the "force" you feel pushing out on you really isn't a force, rather its the force of the car on you, seeing as your body wants to keep going straight.
- Why you are "lifted" out of your seat while on a roller coaster.
- That Newton's Third Law explains why pushing my skis against the snow causes me to turn in the opposite direction.
- That anti-lock breaks work because the static coefficient of friction is larger than the kinetic.
- Why my dad's company launches rockets from the equator of the earth near the Christmas Islands. It is because there the earth is spinning and has some rotational energy that helps the rocket escape from earth. Colton addition: it is also because geosynchronous orbits must go around the equator.
- Why your satellite dish can always be pointed in the same direction
- That satellites [including the moon] don't fall to the ground because they are in a constant state of free-fall but are moving move forward fast enough that they always 'miss' the earth.
- Why wrenches work better than fingers!
- How the rotation of the wheel helps keep me balanced on my dirtbike.
- That conservation of angular momentum makes an ice-skater's rotation speeds up when she brings in her arms.
- That snowshoes prevent a person from sinking into the soft snow because the force on the snow is spread over a larger area—just like a person can withstand a bed of nails because the force is spread over a larger area (the total area of all of the nail points).
- Why pressure is lower at higher altitudes.
- That how large a lake is doesn't affect the force on a dam, but rather how deep the lake is.
- That straws work due to atmospheric pressure and not from a "suction force." I also thought it was interesting that the longest straw that one could use would be 10 meters.
- That a hydraulic system can allow a small force to lift a heavy car.
- Why a boat sinks further into the water when more people get on.
- Why it's easier to lift someone inside a swimming pool than on the outside ground.
- Why you will float better in the Great Salt Lake than in a swimming pool (greater buoyant force due to the density of the salt water).
- Why the water shoots out of a hose faster when you put your finger over the opening
- That chimneys work better on windy days because the wind decreases the pressure above the chimney, allowing the "fluid" (aka soot) to rise easier.
- That the shape of an airplane wing is crucial to the entire reason as to why planes can fly (Bernoulli's principle). The fluid traveling over the tear shaped wing travels faster and thus has a lower pressure than the air beneath it, creating lift.
- How a curveball works.

- That if I ever have something stuck in a metal object with a hole in it, I can heat it up and hopefully remove the stuck object.
- Why double-paned windows keep a house warmer/cooler—thermal conductivity of air is less than glass. Colton addition: also, a lot of double-paned windows have vacuum in the middle, which doesn't conduct heat at all.
- That an electric burner glows red because of the "blackbody radiation" emitted by all hot objects.
- How grandfathers clocks work/what the thing at the bottom is for.
- That sound waves aren't really a separate physical entity, but are caused by the impact of neighboring molecules, and that there is no sound in a vacuum.
- That when my wife yells at me I can jump into a box with her and have a giant vacuum suck the air out and I will not hear her!!!!
- Why my guitar strings change tune when I tighten the tension, and why I can get the strings to play "harmonics" by shortening the wavelength.

Physics 105

Homework Submission and Grading

Here is some detailed information about how to submit the homework assignments and how submitted assignments will be graded.

Data for Problems. The homework problems for this course are later in this packet. Problems 1-1 through 1-6 belong to Homework 1, problems 2-1 through 2-6 belong to Homework 2, etc. Each of you will do the problems using different data, resulting in answers that are different from those of other students. Blanks are left in the problem statements where you can write in your own data. Your data for the entire semester is available over the internet. Once you have a CID, you may go to the class website, click on “Online Homework”, and then click on “Homework Data Sheet.” You can get your personalized data anytime during the semester if you lose your original data sheet. Assume that the numbers given in the problem and in your data sheet are **exact**. If you are given 2.2 m/s, it means 2.2000000..., to as many digits as you wish to imagine.

Solution Range and Precision. At the end of the homework problems, there is information about the answers. You are given a range of possible values for each answer, along with the units you must use, if any; for example 400, 800 J means that your answer will lie between 400 and 800 J. These numbers also indicate the accuracy to which you must calculate the answer. This is simply the number of digits shown—for example, 400, 800 J means that the answer must be given to the nearest 1 J. As another example: 15.0, 60.0 N means that the answer must be given to the nearest 0.1 N. In some cases, the accuracy is indicated explicitly. For example, 32000, 39000 ±100 km means the answer must be given to the nearest 100 km. You can always submit extra significant digits without penalty. Tip: do not round off intermediate answers, or your rounding may cause the final answer to be outside the specified precision range.

Submit Answers. After working the problems, submit your answers over the internet. Go to the class website, click on “Online Homework”, and then click on the assignment number. Fill in the answers as indicated. Do not put units on your answer, but make sure that the number you submit is given in units specified by the answer range. If a very large or very small value needs to be written in scientific notation, indicate the exponent of 10 with an “e.” For example, 3.00×10^8 would be written 3.00e8, and 1.6×10^{-19} would be written 1.6e-19. Do not put any spaces, commas, or “x”s in the number! Do put in negative signs where appropriate.

Grading and Correct Answers. Your submission will be graded overnight. After it’s graded you may see your score: go to the class website, click on “Online Homework”, and then on “Homework Status.” You will see your score and also the correct answers for any problems you missed. Having the correct numerical answer should help you figure out where you went wrong.

Try Again. You will have 5 tries for each problem. The first try is due at 11:59 pm on the day indicated on the course schedule. All retries must be done before the *next* homework assignment is due to avoid being counted as late. After each try, a new set of data will appear at the bottom of the homework status page (because you will have been given the answers for the old set of data). Use this new data for the next try. You only need to resubmit answers that you missed in the previous try. Retries will be graded immediately when submitted.

Points per Problem. You will receive 5 points for each problem done correctly on the first try, 4 points for the second try, 3 points for the third try, 2 points for the fourth try, and 1 point for the fifth try. You will receive no points for a problem until it is done correctly. If a problem has multiple parts, you will receive no points unless all parts are answered correctly. Multiple-choice questions are worth 2 points each and will have a drop-down box for submitting your answers. You do not get a second try on those questions.

Changing Answers. You can change any computer-graded "first try answer" by reentering an answer any time before the assignment is due. You only need to resubmit the answer you want to change. Leave the other answers blank, and the computer will automatically use previously-submitted answers.

Late Points. If the first try is late, each completed problem on any of the subsequent tries will be deducted one point. These deducted points become "late points". Any points generated by tries submitted after the retries deadline (the due-date of the *next* HW assignment) will also become late points. You will receive full credit for late points on the three assignments with the most late points. That is, you get three free late assignments, chosen to maximize your points. You will receive half credit for all other late points. You will always receive at least partial credit for all late work (until the end of the semester).

Free-body Diagrams. Some problems require turning in a hardcopy "free-body diagram". These diagrams will be graded by hand and the score added to the computer grade for the assignment. These diagrams are worth a total of 2 points per problem regardless of the number of diagrams you had to complete for a given problem. The late rules for the diagrams are somewhat different than for the computer-graded part of the assignment: if the hardcopy is turned in late, you get half credit for that problem (no free late problems here). No resubmissions are possible if you get the problem wrong.

Extra Credit. Some problems are labeled "Extra Credit Activity". These problems will be graded via the same system as regular problems, but the points you earn will be extra credit.

Final Thoughts. Many students get good scores on the HW, but poor scores on exams because they really didn't master the HW… perhaps they got someone to help them get correct answers but didn't understand things themselves. Your goal should not be to *memorize* how to do the problems, but rather to **master the strategy, concepts and skills that you will need to solve new problems**. Exam problems will be similar to homework problems in terms of the concepts and methods used to solve them, but the final equations and final numerical answers may be very different. If you get help on homework, be sure to learn the concepts and steps used to solve the problem, and how they might be different for other situations.

Be sure to keep a copy of your own HW solutions—your worked-out solutions, not you're your numerical answers— to use for studying for exams.

Problem Solving

This is a summary of professional research of physics problem-solving. Your goal is to move from the "novice" column to the "expert" column. Notice how experts stop to think about the problem, draw pictures to visualize the problem, plan out their strategy, etc., before beginning—and *still* manage to solve problems much faster than novices. Short-cuts aren't always short!

Novice problem solver	**Expert problem solver**
Studies worked examples rapidly, without bothering to understand the examples	Studies worked examples until *sure* examples are understood
Not able to construct a physical picture of what's going on, or is unable to recognize when chosen picture is inappropriate	Constructs a useful physical picture of the problem
Does not stop to think of a qualitative answer before starting to solve the problem	Uses qualitative physics principles/physical reasoning to have a reasonable answer in mind before beginning to solve numerically
Little or no planning before trying to solve equations	Develops a definite problem-solving strategy before starting to solve equations
Focuses on surface structure (physical *items* involved in problem)	Focuses on deeper structure (physical *laws* involved in problem)
Works backward (looks for equation that has the *unknown* in it)	Works forward (looks for equations that include the *given* quantities)
Consults worked examples in hopes of finding a plan	Consults worked examples to verify that chosen plan is correct
Does not stop to think about the answer that was obtained	Stops to think if answer makes sense (checks against qualitative answer)
Collection of knowledge is a random jumble of miscellaneous facts	Collection of knowledge is well organized in person's head: centered around physical principles and hierarchies (topic trees)
Separates intuition/"real world" knowledge from theoretical/formal knowledge	Constantly integrates "real world" with theoretical knowledge

In short, here's the "Colton method" for solving physics problems:

Picture – Draw a picture. Make sure you understand the situation described in the problem.
Think – Figure out what general physics concept/s is/are involved in the situation. Think about what your final answer should be (approximately).
Equations – Figure out which equations relating to those general concepts contain (some of) the given information.
Algebra – Be careful to get the algebra right as you solve the equations for relevant quantities.
Calculator – Plug in numbers to obtain numerical results; be careful with your calculator. On exams, punch in all calculations *twice*.
Think – Does your final answer make sense? Does it have the right units? Is it close to what you were expecting? In not, figure out if/where you went wrong.

Remember the following phrase: **"Physicists Think Equations Are Cool, but Think again."**

Free-Body Diagrams

(If this doesn't make sense to you at the beginning of the semester,
please return here after we discuss Newton's Second Law problems in class.)

Some homework problems will require turning in a hardcopy "free-body diagram". Follow the description below for those problems. (Even on problems where a free-body diagram is not explicitly required, it is frequently a good idea to use one.)

A free-body diagram is a useful tool to solve problems involving Newton's Second Law. It is simply a representation of the object that includes all of the forces acting on the object. First, draw the object all by itself—for example, if the object is sitting on a table, do not draw the table in the diagram. That is why this is called a "free"-body diagram.

Next, draw vectors representing the forces acting on the object. Each vector should be an arrow attached to the object, starting at the point where the force acts and going outward in the direction of the force. Stronger forces should be drawn with longer arrows.

Label each vector with a symbol, using different symbols for different forces. Use mg or w (for *weight*) to label the force of gravity acting on the object. Do not use mg or w for any other force—for example, if the object is sitting on a table, the force of the table acting upward on the object is a normal (pushing) force, not a gravitational force. Even though this normal force may be numerically equal to the weight of the object, it is still a different force and must *not* be labeled mg or w.

If you need to draw two or more free-body diagrams representing different objects in a single situation, be sure to use different symbols for different forces. For example, do not use mg or w for two different objects: use m_1g or w_1 for one and m_2g or w_2 for the other. The only exception to this rule is for forces which are equal because of Newton's Third Law. If two objects are producing Third Law partner forces on each other, then you may use the same symbol for these forces in the two free-body diagrams.

If an object is moving or accelerating, then it is often helpful to draw vectors showing the direction of the velocity and/or acceleration, but do not attach these vectors to the object. Do not get them confused with the force vectors in the free-body diagram. (The same advice goes for angular velocity and angular acceleration.)

Physics 105 Homework Problems, Fall 2008

Secs. 1 & 2, John Colton

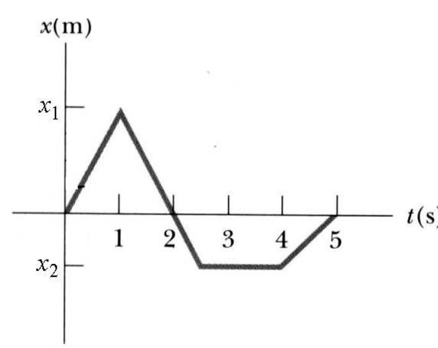
These problems are adapted from Serway and Faughn, *College Physics*, and are used with permission from Harcourt Brace College Publishers.

1-1. Two boats start together and race across a 60-km-wide lake and back. Boat A goes across at [01] ________ km/h and returns at the same speed. Boat B goes across at 30 km/h and its crew, realizing how far behind it is getting, returns at 90 km/h. Turnaround times are negligible, and the boat that completes the round trip first wins. (a) Which boat wins and (b) by how much time?

1-2. In order to qualify for the finals in a racing event, a race car must achieve an average speed of 250 km/h on a track with a total length of 1600 m. If a particular car covers the first half of the track at an average speed of [02] ________ km/h, what minimum average speed must it have in the second half of the event to qualify? Warning: The average speed is defined to be the total distance traveled divided by the total time elapsed. This is not the same as the average of the two speeds.

1-3. A motorist drives north for [03] ________ minutes at 85.8 km/h and then stops for 15.2 minutes. He then continues north, traveling 133 km in 2.00 h. (a) What is his total displacement? (b) What is his average velocity?

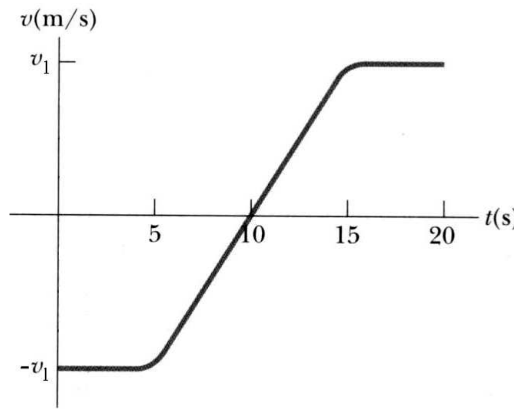
1-4. A tennis player moves in a straight-line path as shown in the figure. On the vertical axis in the figure, x_1 = [04] ________ m and x_2 = [05] ________ m. Find her average velocities in the time intervals (a) 0 to 1.0 s, (b) 0 to 4.0 s, (c) 1.0 s to 5.0 s, and (d) 0 to 5.0 s.



1-5. A certain car is capable of accelerating at a rate of [06] ________ m/s^2. How long does it take for this car to go from a speed of 55 mi/h to a speed of 60 mi/h?

1-6. Extra credit activity: Average Braking Acceleration. Drive your car at 30 mi/hr. Stop suddenly. Be sure there isn't another car following behind you when you do this. Have your passenger use a stop watch or the second hand on a wrist watch to measure how long it takes for you to stop. Record the result Δt as the answer to part (a) of this problem. Calculate the average braking acceleration $\bar{a}$ in SI units (m/s^2) and record the result (to the nearest 0.1 m/s^2) as the answer to part (b) of this problem. Also calculate the average braking acceleration in terms of g ($g = 9.80$ m/s^2) and record the result (to the nearest $0.01g$) as the answer to part (c) of this problem. Note: Enter all of your answers as positive values.

2-1. The velocity-versus-time graph for an object moving along a straight path is shown in the figure. On the vertical axis in the figure, $v_1 =$ [01] ________ m/s. (a) Find the average acceleration of this object during the time intervals (a) 0 to 5.0 s, (b) 5.0 s to 15 s, and (c) 0 to 20 s. Find the instantaneous accelerations at (d) 2 s, (e) 10 s, and (f) 18 s.

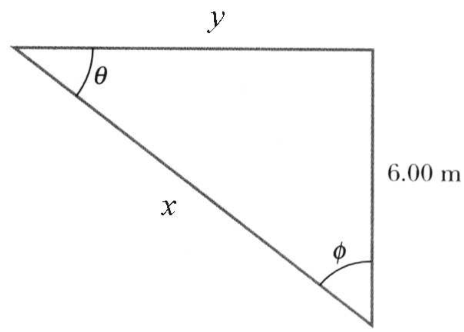


2-2. The minimum distance required to stop a car moving at 35.0 mi/h is 42.6 ft. What is the minimum stopping distance for the same car moving at [02] ________ mi/h, assuming the same rate of acceleration?

2-3. Using a rocket pack with full throttle, a lunar astronaut accelerates upward from the Moon's surface with a constant acceleration of 2.03 m/s^2. At a height of [03] ________ m, a bolt comes loose. (The free-fall acceleration on the Moon's surface is about 1.67 m/s^2.) (a) How fast is the astronaut moving at that time? (b) How long after the bolt comes loose will it hit the Moon's surface? (c) How fast will it be moving then? (d) How high will the astronaut be when the bolt hits? (e) How fast will the astronaut be traveling then?

2-4. A ball is thrown directly downward, with an initial speed of [04] ________ m/s, from a height of 28.3 m. After what interval of time does the ball strike the ground?

2-5. Consider the right triangle shown in the figure. The side labeled x has length [05] __________ m. What are (a) the length of the side labeled y, (b) $\tan\theta$, and (c) $\sin\phi$?



2-6. Extra credit activity: Reaction time. Ask a friend to hold the top end of a ruler so that it hangs in a vertical position (see figure). A ruler that measures centimeters would be most convenient. If not available, you will need to convert inches to meters. Hold your thumb and index finger about 1 cm apart on the two sides of the ruler near the bottom end. Ask your friend to release the ruler without warning, and you try to catch it by pressing your thumb and finger together. Measure the distance the ruler drops between the time your friend releases it and the time you catch it. (Subtract the initial position of your finger from the final position of your finger on the ruler.) Record the result Δy (in meters) as the answer to part (a) of this problem. (Enter a positive value, not a negative value.) Knowing Δy and the acceleration g of free-fall, you can calculate the time the ruler spent falling. This is your reaction time. Record the result (to the nearest 0.01 s) as the answer to part (b) of this problem.

3-1. One of the fastest recorded pitches in major-league baseball, thrown by Nolan Ryan in 1974, was clocked at 100.8 mi/h. If a pitch were thrown horizontally with this velocity, how far would the ball fall vertically by the time it reached [01] __________ ft away? (Do not put any sign on the answer.)

3-2. An artillery shell is fired with an initial velocity of 328 m/s at [02] __________° above the horizontal. To clear an avalanche, it explodes on a mountainside 42.1 s after firing. What are the (a) x and (b) y coordinates of the shell where it explodes, relative to its firing point?

3-3. A home run is hit in such a way that the baseball just clears a wall 21 m high, located 130 m from home plate. The ball is hit at an angle of [03] ________° to the horizontal, and air resistance is negligible. Find (a) the initial speed of the ball, (b) the time it takes the ball to reach the wall, and (c) the speed of the ball when it reaches the wall. (Assume the ball is hit at a height of 1.0 m above the ground.)

3-4. The pilot of an airplane notes that the compass indicates a heading due west (his direction relative to the air). The airplane's speed relative to the air is 154 km/h. If there is a wind of [04] ________ km/h toward the north, find (a) the magnitude and (b) the direction of the velocity of the airplane relative to the ground.

3-5. The pilot of an aircraft wishes to fly due west in a [05] ________-km/h wind blowing toward the south. If the speed of the aircraft relative to the air is [06] ________ km/h, (a) in what direction should the aircraft head, and (b) what will be its speed relative to the ground?

3-6. How long does it take an automobile traveling in the left lane at [07] ________ km/h to overtake (become even with) another car that is traveling in the right lane at [08] ________ km/h, when the cars' front bumpers are initially [09] ________ m apart?

3-7. Extra credit activity: Projectile motion of a ball. Throw a ball a distance of 10 m or more. Launch the ball at an angle between about 30 and 60°. Use a baseball or a basketball or some other ball with enough weight so that air resistance won't affect the results very much. Do not use a foam ball or beach ball or any ball made of thin plastic, because these aren't heavy enough. Ask a friend to measure the time t from the moment you release the ball to the moment the ball hits the ground. Record t (in seconds) as the answer to part (a) of this problem. Also ask your friend to note the spot where the ball landed so that you can measure the horizontal displacement Δx of the ball. Record Δx (in meters) as the answer to part (b) of this problem. Calculate (to the nearest 0.1 m/s) (c) the horizontal component v_{x0}, (d) the vertical component v_{y0}, and (e) the magnitude v_0 of the initial velocity of the ball. (f) Calculate (to the nearest 1°) the angle θ between the initial velocity and the horizontal direction. (g) Calculate (to the nearest 0.1 m) the maximum height h of the ball during its flight. In all of these calculations, ignore the difference in height between the position where the ball was released by your hand and the position where the ball hit the ground. Your results should agree with what you observed.

4-1. A bag of sugar weighs [01] __________ lb on Earth. (a) What should it weigh in newtons on the Moon, where the free-fall acceleration is $\frac{1}{6}$ that on Earth? (b) Repeat for Jupiter, where g is 2.64 times that on Earth. Find the mass of the bag of sugar in kilograms on (c) Earth, (d) the Moon, and (e) Jupiter.

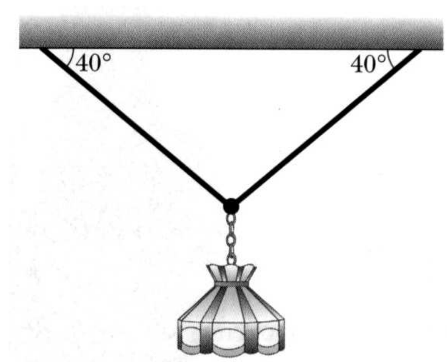
4-2. A performer in a circus is fired from a cannon as a "human cannonball" and leaves the cannon with a speed of [02] __________ m/s. The performer's mass is 82.6 kg. The cannon barrel is 9.29 m long. Find the average net force exerted on the performer while he is being accelerated inside the cannon.

4-3. A boat moves through the water with two forces acting on it. One is a 2270-N forward push by the water on the propeller, and the other is an [03] __________-N resistive force due to the water around the bow. (a) What is the acceleration of the 982-kg boat? (b) If it starts from rest, how far will it move in 10.0 s? (c) What will its velocity be at the end of this time?

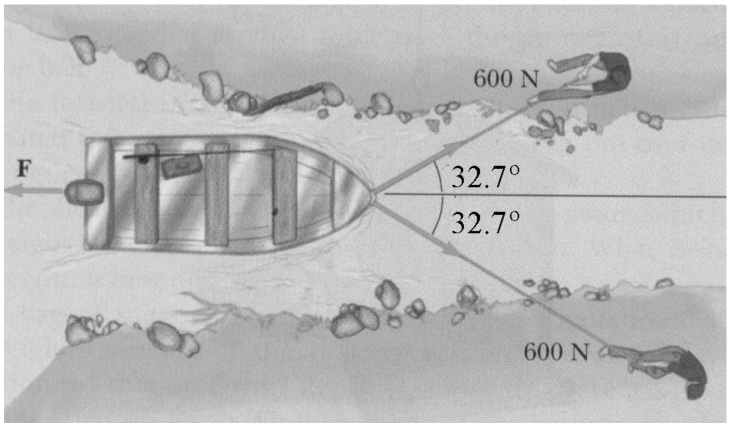
5-1. The parachute on a race car of weight [01] __________ N opens at the end of a quarter-mile run when the car is traveling at 35 m/s. What total retarding force must be supplied by the parachute to stop the car in a distance of 1000 m?

5-2. A freight train has a mass of [02] _______________ kg. If the locomotive can exert a constant pull of 7.54×10^5 N, how long does it take to increase the speed of the train from rest to [03] __________ km/h?

5-3. Find the tension in the two wires that support the [04] __________-N light fixture in the figure.

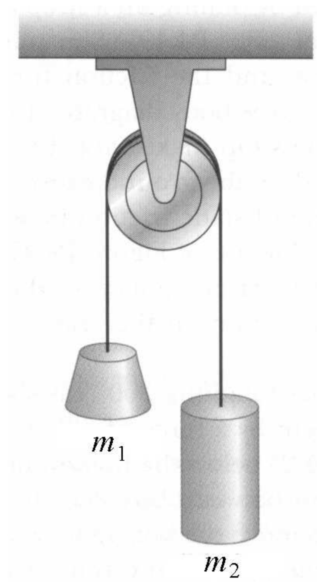


5-4. Two people are pulling a boat through the water as in the figure. Each exerts a force of [05] ________ N directed at a 32.7° angle relative to the forward motion of the boat. (a) Draw a free-body diagram of the boat. (b) If the boat moves with constant velocity, find the resistive force **F** exerted by the water on the boat. (Turn in part (a) on the sheet provided in your packet.)



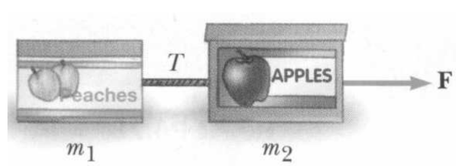
5-5. A [06] ________-kg bucket of water is raised from a well by a rope. The upward acceleration of the bucket is 3.37 m/s^2. (a) Draw a free-body diagram of the bucket. (b) Find the force exerted by the rope on the bucket. (Turn in part (a) on the sheet provided in your packet.)

6-1. Two objects with masses $m_1 = 3.24$ kg and $m_2 =$ [01] ________ kg are connected by a light string that passes over a frictionless pulley as in the figure. (a) Draw a free-body diagram of the object with mass m_1. (b) Draw a free-body diagram of the object with mass m_2. Determine (c) the acceleration of each object, (d) the tension in the string, and (e) the distance each object will move in the first second of motion if both objects start from rest. (Turn in parts (a) and (b) on the sheet provided in your packet.)

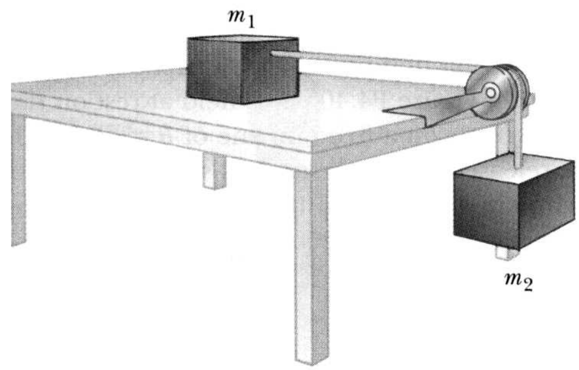


6-2. An inventive child named Chris wants to reach an apple in a tree without climbing the tree. Sitting in a chair connected to a rope that passes over a frictionless pulley (see figure), Chris pulls on the loose end of the rope with such a force that the spring scale reads [02] __________ N. Chris's true weight is 327 N, and the chair weighs 168 N. (a) Draw a free-body diagram of Chris. (b) Draw a free-body diagram of the chair. (c) Find Chris's upward acceleration. (d) Find the force Chris exerts on the chair. (Turn in parts (a) and (b) on the sheet provided in your packet.)

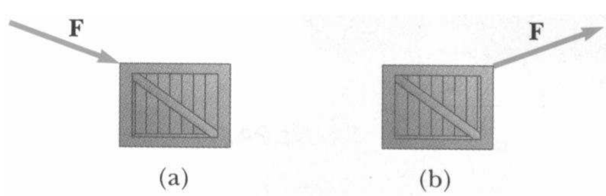
6-3. Two boxes of fruit on a frictionless horizontal surface are connected by a light string as in the figure, where $m_1 =$ [03] __________ kg and $m_2 = 25.4$ kg. A force of 52.1 N is applied to the 25.4-kg box. (a) Draw a free-body diagram of the box on the right. (b) Draw a free-body diagram of the box on the left. Determine (c) the acceleration of each box and (d) the tension in the string. Suppose now that the surface is not frictionless, the coefficient of kinetic friction between each box and the surface being 0.10. Add this force of friction to the free-body diagrams you drew in parts (a) and (b). Determine (e) the acceleration of each box and (f) the tension in the string. (Turn in parts (a) and (b) on the sheet provided in your packet.)



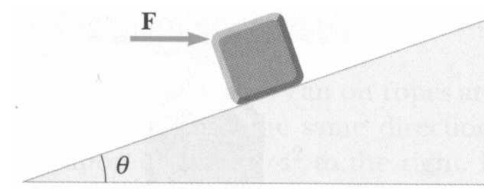
6-4. A mass, $m_1 =$ [04] __________ kg, resting on a frictionless horizontal table is connected to a cable that passes over a pulley and then is fastened to a hanging mass, $m_2 =$ [05] __________ kg, as in the figure. When we release the mass m_1, it accelerates across the table. (a) Draw a free-body diagram of the mass on the table, and (b) draw a free-body diagram of the hanging mass. Find (c) the acceleration of the masses and (d) the tension in the cable. Neglect the mass of the cable and pulley. (Turn in parts (a) and (b) on the sheet provided in your packet.)



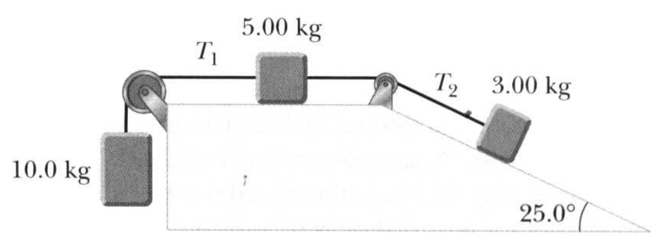
6-5. A [06] __________-N crate is being pushed across a level floor at a constant speed by a force **F** of 312 N at an angle of 23.7° below the horizontal as shown in Figure (a). (a) Draw a free-body diagram of the crate in Figure (a). (b) What is the coefficient of kinetic friction between the crate and the floor? Suppose next that the 312-N force is instead pulling the block at an angle of 23.7° above the horizontal as shown in Figure (b). (c) Draw a free-body diagram of the crate in Figure (b). (d) What will be the acceleration of the crate? Assume that the coefficient of friction is the same as found in (b). (Turn in parts (a) and (c) on the sheet provided in your packet.)



7-1. A 2.00-kg block is held in equilibrium on an incline of angle $\theta =$ [01] _________ ° by a horizontal force **F** applied in the direction shown in the figure. The coefficient of static friction between the block and incline is $\mu_s = 0.334$. (a) Draw a free-body diagram of the block. Determine (b) the minimum value of **F** and (c) the normal force of the incline on the block. (Turn in part (a) on the sheet provided in your packet.)



7-2. The three blocks of masses 10.0 kg, 5.0 kg, and 3.0 kg are connected by light strings that pass over frictionless pulleys as shown in the figure. The acceleration of the 5.00-kg block is [02] _________ m/s^2 to the left and the surfaces are rough. (a) Draw a free-body diagram of the 10.0 kg block. (b) Draw a free-body diagram of the 5.0 kg block. (c) Draw a free-body diagram of the 3.0 kg block. Find (d) the tension T_1 and (e) the tension T_2 in the two strings, and (f) the coefficient of kinetic friction between blocks and surfaces. (Assume the same μ_k for both blocks in contact with surfaces.) (Turn in parts (a), (b), and (c) on the sheet provided in your packet.)



7-3. A shopper in a supermarket pushes a cart with a force of [03] _________ N directed at an angle of 25.3° downward from the horizontal. Find the work done by the shopper as she moves down a 50-m length of aisle.

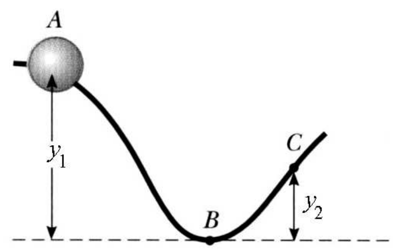
7-4. An outfielder throws a 0.150-kg baseball at a speed of [04] _________ m/s and an initial angle of 32.8°. What is the kinetic energy of the ball at the highest point of its motion?

7-5. On a frozen pond, a 8.54-kg sled is given a kick that imparts to it an initial speed of $v_0 =$ [05] _________ m/s. The coefficient of kinetic friction between sled and ice is $\mu_k =$ [06] _________. Use the work-kinetic energy theorem to find the distance the sled moves before coming to rest.

7-6. A 42.6-N toy is placed in a light swing that is attached to ropes [07] ________ m long. Find the gravitational potential energy associated with the toy relative to its lowest position (a) when the ropes are horizontal, (b) when the ropes make a 32.7° angle with the vertical, and (c) at the bottom of the circular arc.

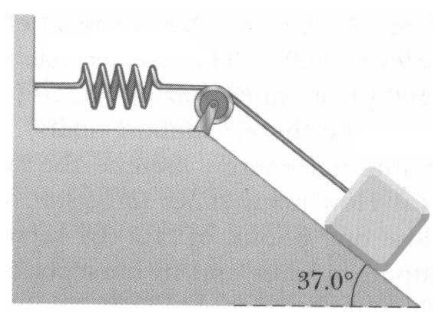
8-1. Tarzan swings on a 28.6-m long vine initially inclined at an angle of [01] ________° with the vertical. What is his speed at the bottom of the swing (a) if he starts from rest? (b) if he pushes off with a speed of 4.28 m/s?

8-2. A 378-g bead slides on a curved wire, starting from rest at point A in the figure. In the figure, y_1 = [02] ________ m and y_2 = [03] ________ m. If the wire is frictionless, find the speed of the bead (a) at B and (b) at C.



8-3. In the dangerous "sport" of bungee jumping, a daring student jumps from a balloon with a specially designed elastic cord attached to his waist The unstretched length of the cord is 25.3 m, the student weights [04] ________ N, and the balloon is 36.5 m above the surface of a river below. Calculate the required force constant of the cord if the student is to stop safely 4.00 m above the river.

8-4. A [05] ________-kg block situated on a rough incline is connected to a spring of negligible mass having a spring constant of 119 N/m (see figure). The block is released from rest when the spring is unstretched, and the pulley is frictionless. The block moves 22.3 cm down the incline before coming to rest. Find the coefficient of kinetic friction between the block and incline.



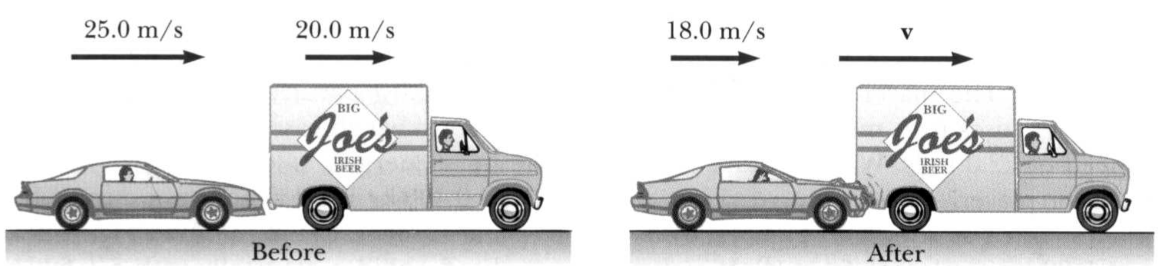
8-5. A [06] ________ -kg student climbs a 5.00-m-long rope and stops at the top. (a) What must her average speed be in order to match the power output of a 200-W light bulb? (b) How much work does she do?

8-6. A [07] ________-kg elevator starts from rest. It moves upward for 3.00 s with constant acceleration until it reaches its cruising speed, 1.66 m/s. (a) What is the average power of the elevator motor during this interval? (b) Compute its power during an upward cruise with constant speed (equal to its cruising speed).

9-1. A pitcher claims he can throw a 0.145-kg baseball with as much momentum as a [01] ________-g bullet moving with a speed of 1500 m/s. (a) What must the baseball's speed be if the pitcher's claim is valid? (b) Which has greater kinetic energy, the ball or the bullet?

9-2. A [02] ________-N man stands in the middle of a frozen pond of radius 5.41 m. He is unable to get to the other side because of lack of friction between his shoes and the ice. To overcome this difficulty, he throws his 1.29-kg physics textbook horizontally towards the north shore, at a speed of 5.12 m/s. How long does it take him to reach the south shore?

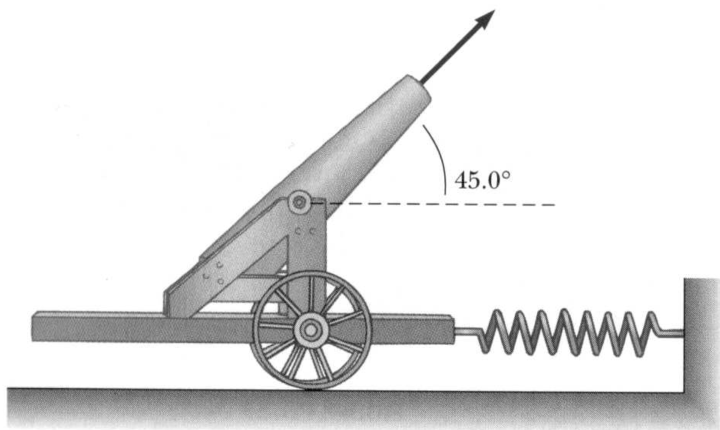
9-3. A [03] ________-kg car traveling initially with a speed of 25.0 m/s in an easterly direction crashes in the rear end of a 9150-kg truck moving in the same direction at 20.0 m/s (see figure). The velocity of the car right after the collision is 18.0 m/s to the east. (a) What is the velocity of the truck right after the collision? (b) How much mechanical energy is lost in the collision?



10-1. Most of us know intuitively that in a head-on collision between a large dump truck and a subcompact car, you are better off being in the truck than the car. Why is this? Many people imagine that the collision force exerted on the car is much greater than that experienced by the truck. To substantiate this view, they point out that the car is crushed, whereas the truck is only dented. This idea of unequal forces, of course, is false. Newton's third law tells us that both objects experience forces of the same magnitude. The truck suffers less damage because it is made of stronger metal. But what about the two drivers? Do they experience the same forces? To answer this question, suppose that each vehicle is moving at [01] ________ m/s and that they undergo a perfectly inelastic head-on collision. Each driver has mass 82.6 kg. Including the drivers, the total vehicle masses are 810 kg for the car and 4280 kg for the truck. If the collision time is 0.129 s, (a) what force does the seat belt exert on the truck driver? (b) What force does the seat belt exert on the car driver?

10-2. A 11.4-g object moving to the right at [02] ________ cm/s makes an elastic head-on collision with a 14.3-g object moving in the opposite direction with some unknown velocity. After the collision, the second object is observed to be moving to the right at [03] ________ cm/s. Find the initial velocity of the second object. Be sure to include a minus sign if it is moving to the left. (*Hint:* Use Eqs. [6.10] and [6.14] in the textbook, similar to Example 6.7. (Eqs. [6.7] and [6.11] in the 5th edition of the textbook))

10-3. A cannon is rigidly attached to a carriage, which can move along horizontal rails but is connected to a post by a large spring, initially unstretched and with a force constant $k = 2.26 \times 10^4$ N/m, as in the figure. The cannon fires a [04] ________-kg projectile at a velocity of 125 m/s directed 45.0° above the horizontal. (a) If the mass of the cannon and its carriage is 5000 kg, find the recoil speed of the cannon. (b) Determine the maximum extension of the spring. (c) Find the maximum force the spring exerts on the carriage. (d) Consider the system consisting of the cannon, carriage, and shell. Is the momentum of this system conserved during the firing?



10-4. An 8.29-kg mass moving east at [05] ________ m/s on a frictionless horizontal surface collides with a 18.5-kg mass that is initially at rest. After the collision, the first mass moves south at [06] ________ m/s. What is (a) the magnitude and (b) the direction of the velocity of the second mass after the collision? (c) What percentage of the initial kinetic energy is lost in the collision? Note that the first mass changes the direction of its motion. Use the approach as in the example, "Collision at an Intersection", in the textbook (Example 6.8 in the 7th and 8th editions, Example 6.9 in the 6th edition, and Example 6.10 in the 5th edition).

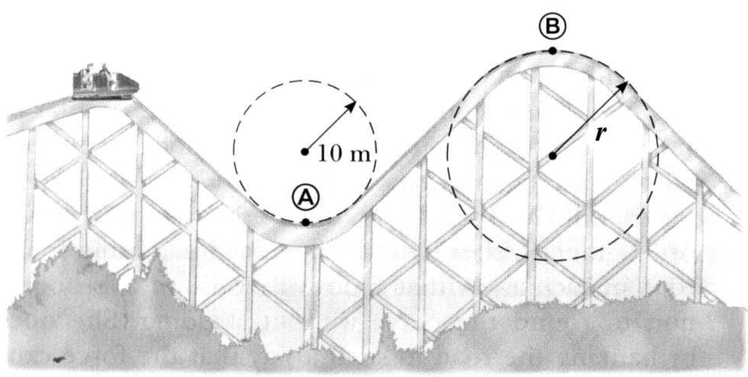
10-5. A dentist's drill starts from rest. After 3.23 s of constant angular acceleration, it turns at a rate of [07] ________ rev/min. (a) Find the drill's angular acceleration.
(b) Determine the angle (in radians) through which the drill rotates during this period.

10-6. An electric motor rotating a workshop grinding wheel at a rate of 128 rev/min is switched off. Assume constant negative angular acceleration of magnitude [08] ________ rad/s^2. (a) How long does it take for the grinding wheel to stop?
(b) Through how many radians has the wheel turned during the interval found in (a)?

11-1. A race car starts from rest on a circular track of radius 400 m. The car's speed increases at the constant rate of [01] ________ m/s^2. At the point where the magnitudes of the centripetal and tangential accelerations are equal, determine (a) the speed of the race car, (b) the elapsed time, and (c) the distance traveled.

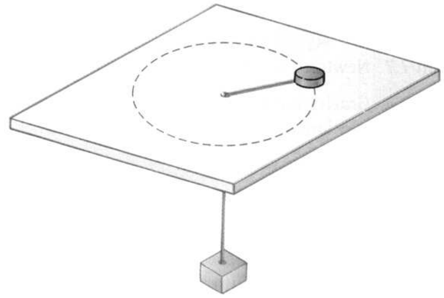
11-2. An engineer wishes to design a curved exit ramp for a toll road in such a way that a car will not have to rely on friction to round the curve without skidding. She does so by banking the road in such a way that the force causing the centripetal acceleration will be supplied by the component of the normal force toward the center of the circular path. (a) Draw a free-body diagram of the car. (b) Find the angle at which the curve should be banked if a typical car rounds it at a 50.0-m radius and a speed of [02] ________ m/s. Hint: Do not use "tilted" coordinate axes. (Turn in part (a) on the sheet provided in your packet.)

11-3. A roller-coaster vehicle has a mass of 500 kg when fully loaded with passengers (see figure). (a) Draw a free-body diagram of the vehicle at A. (b) If the vehicle has a speed of [03] ________ m/s at A, what is the magnitude of the force that the track exerts on the vehicle at this point? (c) Draw a free-body diagram of the vehicle at B. (d) If the radius of curvature of the track at B is $r =$ [04] ________, what is the maximum speed the vehicle can have at B in order for gravity to hold it on the track? (Turn in parts (a) and (c) on the sheet provided in your packet.)

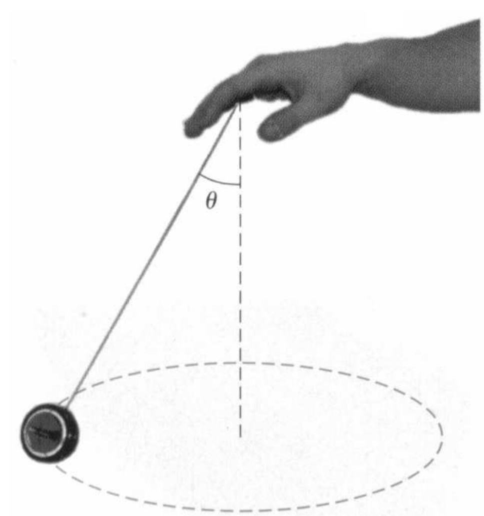


11-4. A 0.434-kg pendulum bob passes through the lowest part of its path at a speed of [05] ________ m/s. (a) What is the tension in the pendulum cable at this point if the pendulum is 80.7 cm long? (b) When the pendulum reaches its highest point, what angle does the cable make with the vertical? (c) What is the tension in the pendulum cable when the pendulum reaches its highest point?

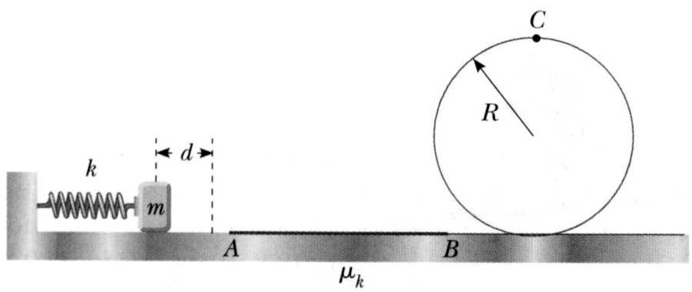
11-5. An air puck of mass 255 g is tied to a string and allowed to revolve in a circle of radius 1.04 m on a frictionless horizontal table. The other end of the string passes through a hole in the center of the table, and a mass of [06] __________ g is tied to it. The suspended mass remains in equilibrium while the puck on the tabletop revolves. (a) What is the tension in the string? (b) What is the force causing the centripetal acceleration of the puck? (c) What is the speed of the puck?



11-6. A 0.537-kg ball that is tied to the end of a [07] __________-m light cord is revolved in a horizontal plane with a cord making a 28.6° angle with the vertical (see figure). (a) Draw a free-body diagram of the ball. (b) Determine the ball's speed. (c) If instead the ball is revolved so that its speed is 4.24 m/s, what angle does the cord make with the vertical? Hint: Recall that $\sin^2\theta = 1 - \cos^2\theta$. You will need to use the quadratic formula to solve for $\cos\theta$. (d) If the cord can withstand a maximum tension of 8.76 N, what is the highest speed at which the ball can move? (Turn in part (a) on the sheet provided in your packet.)



12-1. A massless spring of constant $k = 78.4$ N/m is fixed on the left side of a level track. A block of mass $m = 0.525$ kg is pressed against the spring and compresses it a distance d, as in the figure. The block (initially at rest) is then released and travels toward a circular loop-the-loop of radius $R = 1.53$ m. The entire track and the loop-the-loop are frictionless except for the section of track between points A and B. Given that the coefficient of kinetic friction between the block and the track along AB is $\mu_k =$ [01] __________, and that the length of AB is 2.54 m, determine the minimum compression d of the spring that enables the block to just make it through the loop-the-loop at point C. (Hint: The force exerted by the track on the block will be zero at point C if the block barely makes it through the loop-the-loop.)

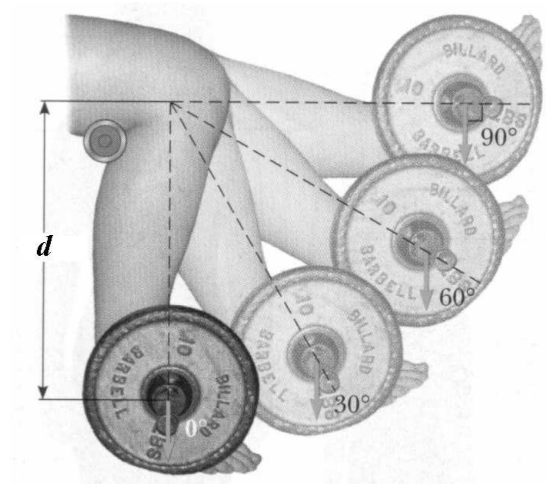


12-2. Use the data in the textbook to find the net gravitational force exerted by Earth and the Moon on a spaceship with mass [02] __________ kg located halfway between them. Use 384,000 km for the distance from Earth to the Moon.

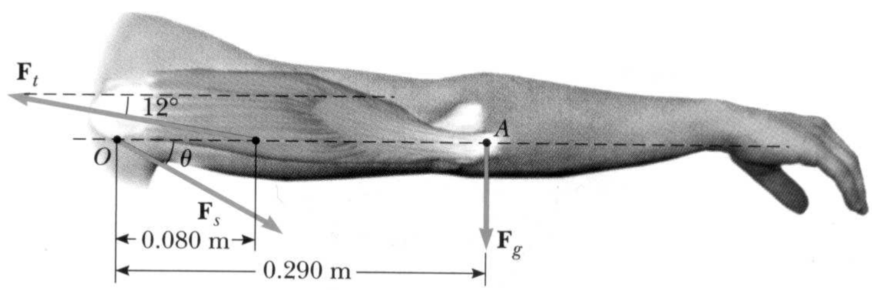
12-3. Neutron stars are extremely dense objects that are formed from the remnants of supernova explosions. Many rotate very rapidly. Suppose that the mass of a certain spherical neutron star is twice the mass of the Sun and its radius is [03] __________ km. Determine the greatest possible angular speed it can have so that the matter at the surface of the star on its equator is just held in orbit by the gravitational force.

12-4. Geosynchronous satellites have a angular velocity that matches the rotation of the Earth and follow circular orbits in the equatorial plane of the Earth. (Almost all communications satellites are geosynchronous and appear to be stationary above a point on the Equator.) Consider a satellite in geosynchronous orbit about a planet similar to the Earth except that its mass is [04] ____________________ kg and the period of the rotation about its axis is [05] __________ h. What must be the radius of the orbit of this satellite?

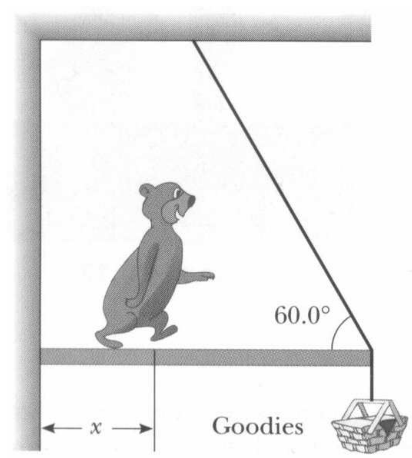
12-5. As part of a physical therapy program following a knee operation, a 10.0-kg object is attached to an ankle, and leg lifts are done as sketched in the figure. The value of d in the figure is [06] __________ cm. Calculate the torque about the knee due to this weight for the position at (a) 0°, (b) 30°, (c) 60°, and (d) 90°.



12-6. The arm in the figure weighs [07] __________ N. The force of gravity acting on the arm acts through point A. Determine the magnitudes of (a) the tension force $\mathbf{F}_t$ in the deltoid muscle and (b) the force $\mathbf{F}_s$ exerted by the shoulder on the humerus (upper-arm bone) to hold the arm in the position shown. Hint: For part (b) you will need two equations to solve for the two unknowns, $\mathbf{F}_s$ and θ.



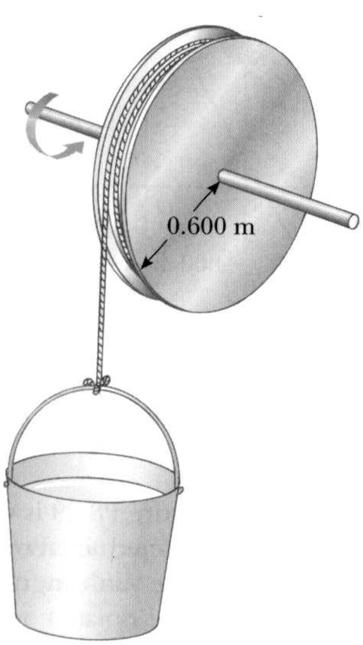
13-1. A hungry 728-N bear walks out on a beam in an attempt to retrieve some "goodies" hanging at the end (see figure). The beam is uniform, weighs 216 N, and is [01] __________ m long; the goodies weigh 82 N. (a) Draw a free-body diagram for the beam. When the bear is at $x = 1.00$ m, find (b) the tension on the wire and (c) the magnitude of the reaction force at the hinge where the beam is connected to the wall. (d) If the wire can withstand a maximum tension of 900 N, what is the maximum distance the bear can walk before the wire breaks? (Turn in part (a) on the sheet provided in your packet.)



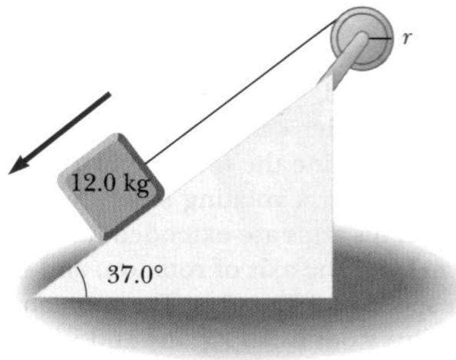
13-2. An 8.31-m, 267-N uniform ladder rests against a smooth (frictionless) wall. The coefficient of static friction between the ladder and the ground is 0.582, and the ladder makes a 52.6° angle with the ground. A [02] ________-N person is standing on the ladder a distance d from the bottom end of the ladder. (a) Draw a free-body diagram of the ladder. (b) How far up the ladder (distance d) can the person climb before the ladder begins to slip? Hint: Among other things, you may want to look at the sum of the torques about the point where the ladder touches the wall. Be careful with angles! (Turn in part (a) on the sheet provided in your packet.)

13-3. A bicycle wheel has a diameter of 64.7 cm and a mass of 1.85 kg. Assume that the wheel is a hoop with all the mass concentrated on the outside radius. The bicycle is placed on a stationary stand and a resistive force of [03] ________ N is applied tangent to the rim of the tire. (a) What force must be applied by a chain passing over a 9.4-cm diameter sprocket in order to give the wheel an angular acceleration of 4.57 rad/s^2? (b) What force is required if you shift to a 5.6-cm diameter sprocket?

13-4. A cylindrical 5.87-kg reel with a radius of 0.600 m and a frictionless axle, starts from rest and speeds up uniformly as a [04] ________-kg bucket falls into a well, making a light rope unwind from the reel (see figure). The bucket starts from rest and falls for 4.00 s. (a) Draw a free-body diagram of the reel. (b) Draw a free-body diagram of the bucket. (c) What is the linear acceleration of the falling bucket? (d) How far does it drop? (e) What is the angular acceleration of the reel? (Turn in parts (a) and (b) on the sheet provided in your packet.)

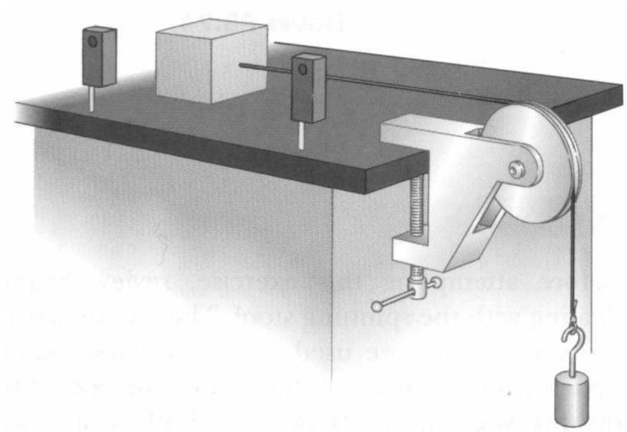


13-5. A 12.0-kg object is attached to a cord that is wrapped around a wheel of radius $r = 11.2$ cm (see figure). The acceleration of the object down the frictionless incline is measured to be [05] ________ m/s^2. The axle of the wheel is frictionless. (a) Draw a free-body diagram of the object. (b) Draw a free-body diagram of the wheel. Determine (c) the tension in the rope, (d) the moment of inertia of the wheel, and (e) the angular speed of the wheel 2.00 s after it begins rotating, starting from rest. (Turn in parts (a) and (b) on the sheet provided in your packet.)



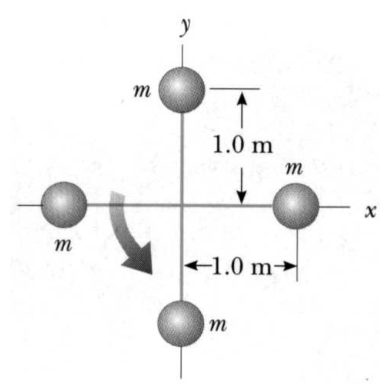
14-1. In a circus performance, a large 5.13-kg hoop of radius 3.62 m rolls without slipping. If the hoop is given an angular speed of 3.13 rad/s while rolling on the horizontal and allowed to roll up a ramp inclined at [01] ________° with the horizontal, how far (measured by the change in position of the center of mass along the incline) does the hoop roll?

14-2. In the figure the sliding block has a mass of 0.858 kg, the counterweight has a mass of [02] ________ kg, and the pulley is a uniform solid cylinder with a mass of 0.354 kg and an outer radius of 0.0310 m. The coefficient of kinetic friction between the block and the horizontal surface is 0.255. The pulley turns without friction on its axle. The light cord does not stretch and does not slip on the pulley. The block has a velocity of 0.824 m/s toward the pulley when it passes through a photogate. (a) Use energy methods to predict its speed after it has moved to a second photogate, 0.700 m away. (b) Find the angular speed of the pulley at the same point.

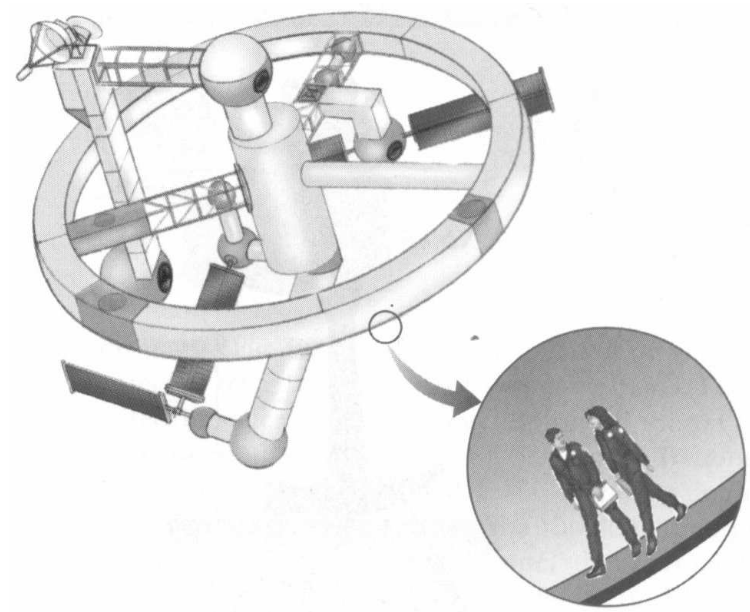


14-3. (a) Calculate the angular momentum of Earth that arises from its spinning motion on its axis, and (b) the angular momentum of Earth that arises from its orbital motion about the Sun. Assume that Earth is a sphere with uniform density.

14-4. The system of small objects shown in the figure is rotating at an angular speed of [03] ________ rev/s. The objects are connected by light, flexible spokes that can be lengthened or shortened through internal forces (*e.g.*, motors triggered via romote control). What is the new angular speed if the spokes are shortened to 0.56 m? (An effect similar to that illustrated in this problem occurred in the early stages of the formation of our Galaxy. As the massive cloud of dust and gas that was the source of the stars and planets contracted, an initially small angular speed increased with time.)



14-5. A space station shaped like a giant wheel has a radius 118 m and a moment of inertia of [04] _________ kg·m^2. A crew of 150 are living on the rim, and the station is rotating so that the crew experience an apparent acceleration of 1 g (see figure). The people add to the total angular momentum of the system. When 100 people move to the center of the station for a union meeting, the angular speed changes. What apparent acceleration is experienced by the managers remaining at the rim? Assume an average mass of 65 kg for all the inhabitants.



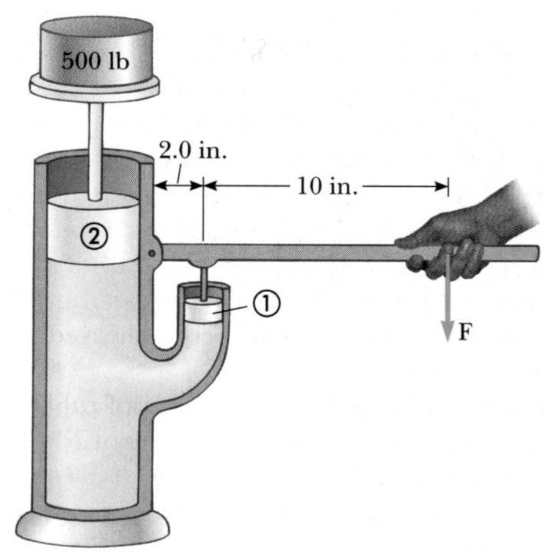
14-6. A student sits on a rotating stool holding two 3.09-kg masses. When his arms are extended horizontally, the masses are 1.08 m from the axis of rotation, and he rotates with an angular speed of [05] _________ rad/s. The moment of inertia of the student plus stool is 3.25 kg·m^2 and is assumed to be constant. (Note that this moment of inertia does not include the two 3.09-kg masses.) The student then pulls the masses horizontally to 0.34 m from the rotation axis. (a) Find the new angular speed of the student. Find the kinetic energy of the rotating system (student, stool, and masses) (b) before and (c) after the masses are pulled in.

15-1. For safety in climbing, a mountaineer uses a nylon rope that is 50 m long and 1.0 cm in diameter. When supporting a 90-kg climber, the rope elongates [01] _________ m. Find its Young's modulus.

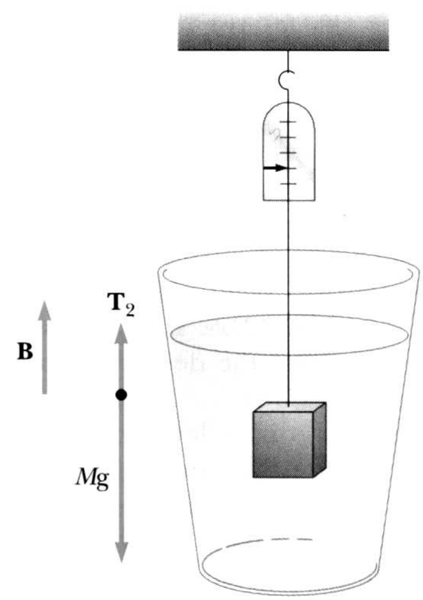
15-2. Bone has a Young's modulus of about 18×10^9 Pa. Under compression, it can withstand a stress of about 160×10^6 Pa before breaking. Assume that a femur (thigh bone) is [02] __________ m long and calculate the amount of compression this bone can withstand before breaking.

15-3. A [03] __________-kg ballet dancer stands on her toes during a performance with 26.5 cm^2 in contact with the floor. What is the pressure exerted by the floor over the area of contact (a) if the dancer is stationary, and (b) if the dancer is leaping upwards with an acceleration of 4.41 m/s^2?

16-1. Piston 1 in the figure has a diameter of [01] __________ in.; piston 2 has a diameter of 1.5 in. In the absence of friction, determine the force F necessary to support the 500-lb weight.

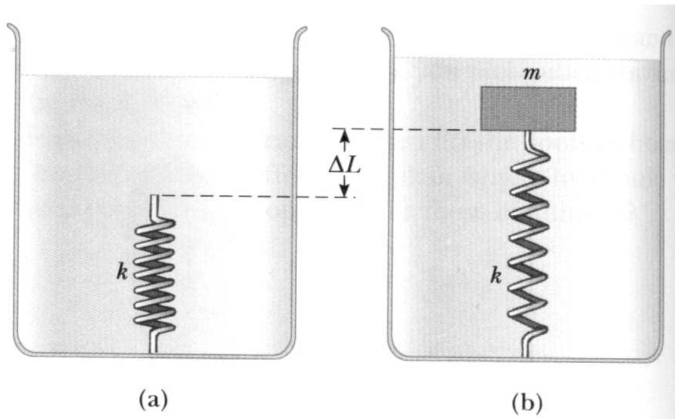


16-2. A 10.0-kg block of metal is suspended from a scale and immersed in water as in the figure. The dimensions of the block are 12.0 cm × 10.0 cm × [02] __________ cm. The 12.0-cm dimension is vertical, and the top of the block is 5.00 cm below the surface of the water. What are the forces exerted by the water on (a) the top and (b) the bottom of the block? (Take atmospheric pressure to be 1.0130×10^5 N/m^2.) (c) What is the buoyant force? (d) What is the reading of the spring scale?



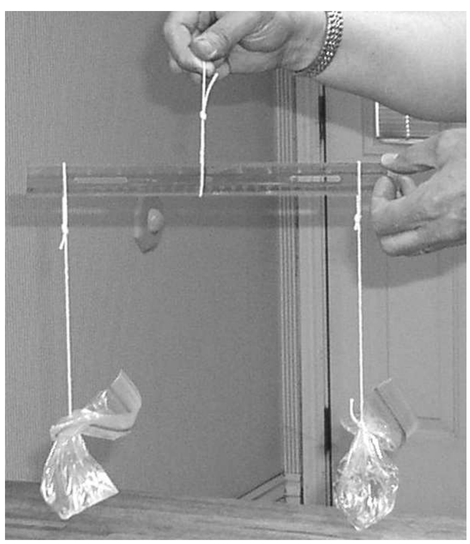
16-3. A rectangular air mattress is 2.1 m long, 0.48 m wide, and [03] __________ m thick. If it has a mass of 2.3 kg, what additional mass can it support in water?

16-4. A light spring of constant $k = 163$ N/m rests vertically on the bottom of a large beaker of water. A 5.29-kg block of wood (density=[04] ________ kg/m^3) is connected to the spring and the mass-spring system is allowed to come to static equilibrium. (a) Draw a free-body diagram of the block. (b) What is the elongation ΔL of the spring? (Turn in part (a) on the sheet provided in your packet.)



16-5. (a) Calculate the mass flow rate (in grams per second) of blood ($\rho = 1.0$ g/cm^3) in an aorta with a cross-sectional area of 2.0 cm^2 if the flow speed is [05] ________ cm/s.
(b) Assume that the aorta branches from a large number of capillaries with a combined cross-sectional area of 3.0×10^3 cm^2. What is the flow speed in the capillaries?

16-6. Extra credit activity: Density of cooking oil. The purpose of this activity is to compare the density of cooking oil with the density of water. Measure a half cup of water, pour it into a plastic sandwich bag, and seal the bag shut. Measure a half cup of cooking oil, pour it into another bag, and seal the bag shut. If you don't have a measuring cup, make a mark on a drinking cup about half-way to the top and use that. The exact volume doesn't matter. We only care that the volume of water and volume of cooking oil are equal. Cut two pieces of string, each about 15 inches long, and tie the bags to opposite ends of a ruler (see figure). Tie a third string at the center of the ruler. Holding the center string, adjust the positions of the bags until they are balanced and the ruler hangs horizontally. Record the distance of each bag from the center of the ruler where the third piece of string is tied. Record the distance for the bag containing water as the answer to part (a) of this problem. Record the distance for the bag containing cooking oil as the answer to part (b) of this problem. You may use any units (inches, cm, etc) for these two values as long as you use the same units for both values. Draw a free-body diagram of the ruler. Write an expression for the net torque about the center of mass of the ruler. Solve this expression for the ratio of the mass of the water to the mass of the cooking oil. Since they have equal volumes, this result is also the ratio of their densities. Using the known density of water, calculate the density of cooking oil, and record the result (to the nearest 0.01 g/cm^3) as the answer to part (c) of this problem.



17-1. A large storage tank, open to the atmosphere at the top and filled with water, develops a small hole in its side at a point [01] ________ m below the water level. If the rate of flow from the leak is 2.53×10^{-3} m^3/min, determine (a) the speed at which the water leaves the hole and (b) the diameter of the hole.

17-2. A grandfather clock is controlled by a swinging brass pendulum that is 1.3 m long at a temperature of 20°C. (a) By how much does the length of the pendulum rod change when the temperature drops to [02] ________°C? (b) If a pendulum's period is given by $T = 2\pi\sqrt{L/g}$, where L is its length, does the change in length of the rod cause the clock to run fast or slow?

17-3. An underground gasoline tank at 54°F can hold [03] ________ gallons of gasoline. If the driver of a tanker truck fills the underground tank on a day when the temperature is 90°F, how many gallons, according to his measure on the truck, can he pour in? Assume that the temperature of the gasoline cools to 54°F upon entering the tank. Use the coefficient of volume expansion for gasoline given in the textbook.

17-4. A tank having a volume of 100 liters contains helium gas at 150 atm. How many balloons can the tank blow up if each filled balloon is a sphere [04] ________ cm in diameter at an absolute pressure of 1.20 atm?

17-5. An air bubble has a volume of 1.50 cm^3 when it is released by a submarine [05] ________ m below the surface of a lake. What is the volume of the bubble when it reaches the surface where the atmospheric pressure is 1.00 atm? Assume that the temperature and the number of air molecules in the bubble remains constant during the ascent.

17-6. Extra credit activity: Normal force on your car's tires. Park your car on a relatively smooth pavement like concrete. The tires have an approximately rectangular "footprint" where it is in contact with the pavement. Choose one of the tires and determine the area of its footprint. Do this by sliding a sheet of paper as far under the tire as possible. Use a pencil to mark the position of the paper on the pavement (see figure). Repeat for all four sides of the footprint. Use these marks to determine the width and length of the footprint. Record the width and length (in inches) as the answers to parts (a) and (b) of this problem. Be sure to record the decimal form (for example 6.5, not 6 1/2). Use a tire gauge to measure the gauge pressure of the air in the tire. Record the result in pounds/inch^2 (psi) as the answer to part (c) of this problem. If you don't have a tire gauge, use the recommended inflation pressure of your tire. This is usually printed on the end of the front left door of the car. It might also be printed on the tire itself. Assuming that the normal force of the pavement is balanced by the force exerted by the gauge pressure of the air inside the tire, calculate the normal force on the tire and record the result (to the nearest 100 pounds) as the answer to part (d) of this problem.
Optional: Multiply your answer by four (if your car has four tires) and compare this with the total weight of the car (usually printed on the end of the front left door of the car).

18-1. (a) What is the total random kinetic energy of all the molecules in 1.00 mol of hydrogen at a temperature of [01] ________ K? (b) With what speed would a mole of hydrogen have to move so that the kinetic energy of the mass as a whole would be equal to the total random kinetic energy of its molecules?

18-2. An aluminum rod is 20 cm long at 20°C and has a mass of 350 g. If [02] ________ J of energy is added to the rod by heat, what is the change in length of the rod?

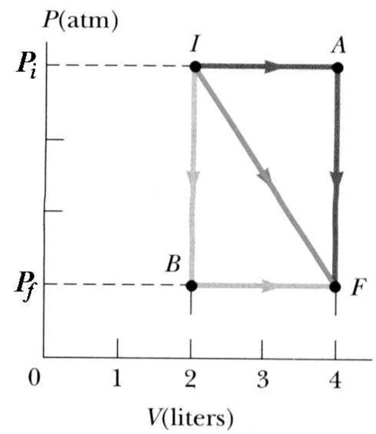
18-3. A water heater is operated by solar power. If the solar collector has an area of 6.39 m^2, and the intensity delivered by sunlight is 550 W/m^2, how long does it take to increase the temperature of 1.00 m^3 of water from 19.4°C to [03] ________ °C?

18-4. A 0.42-kg iron horseshoe that is initially at [04] ________°C is dropped into a bucket containing 19 kg of water at 22°C. By how much does the temperature of the water rise? Neglect any energy transfer to or from the surroundings.

18-5. What mass of steam that is initially at 121.6°C is needed to warm [05] ________ g of water and its 286-g aluminum container from 22.5°C to 48.5°C?

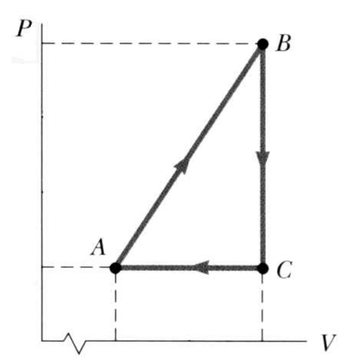
18-6. Water is being boiled in an open kettle that has a 0.52-cm-thick circular aluminum bottom with a radius of 12.0 cm. If the water boils away at a rate of [06] ________ kg/min, what is the temperature of the lower surface of the bottom of the kettle? Assume that the top surface of the bottom of the kettle is at 100.0°C. Use the thermal conductivity of aluminum at 25°C (the value given in the table in the textbook).

19-1. A gas expands from I to F along the three paths indicated in the figure. Calculate the work done on the gas along paths (a) IAF, (b) IF, and (c) IBF. P_i = [01] ________ atm and P_f = [02] ________ atm.

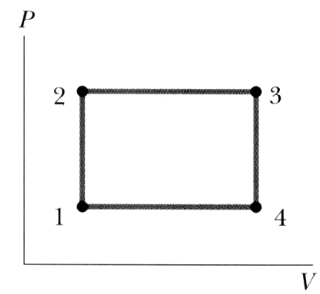


19-2. A movable piston having a mass of 7.78 kg and a cross-sectional area of 5.26 cm^2 traps 0.205 moles of an ideal gas in a vertical cylinder. If the piston slides without friction in the cylinder, how much work will be done on the gas when its temperature is decreased from [03] ________°C to 24°C? Hint: Since the piston slides without friction, the pressure will remain constant.

19-3. Consider the cyclic process described by the figure. If Q is negative for the process BC and ΔU is negative for the process CA, determine the signs of (a) Q, (b) W, and (c) ΔU associated with process AB. Determine the signs of (d) Q, (e) W, and (f) ΔU associated with process BC. Determine the signs of (g) Q, (h) W, and (i) ΔU associated with process CA.



19-4. When a gas follows path 123 on the PV diagram in the figure, [04] ________ J of energy flows into the system by heat, and -167 J of work is done on the gas. (a) What is the change in the internal energy of the system along that path? (b) How much heat energy Q flows into the system if the gas follows path 143? The work done on the gas along this path is [05] ________ J. What net work would be done on the system if the system followed (c) path 12341? (d) path 14321? What is the change in internal energy of the system if the system followed (e) path 12341? (f) path 14321?



19-5. A nuclear power plant has an electrical power output of 1000 MW and operates with an efficiency of 33%. If the excess energy is carried away from the plant by a river with a flow rate of [06] ________ kg/s, what is the rise in temperature of the flowing water?

19-6. An engine absorbs 1678 J from a hot reservoir and expels [07] ________ J to a cold reservoir in each cycle. (a) What is the engine's efficiency? (b) How much work is done in each cycle? (c) What is the power output of the engine if each cycle lasts for 0.326 s?

20-1. A 5.56-g object is suspended from a cylindrical sample of collagen 3.58 cm long and 2.12 mm in diameter. If the object vibrates up and down with a frequency of [01] ________ Hz, with is the Young's modulus of the collagen?

20-2. A [02] ________-kg block hangs without vibrating at the end of a spring ($k = 548$ N/m) that is attached to the ceiling of an elevator car. The car is rising with an upward acceleration of 3.14 m/s^2 when the acceleration suddenly ceases (at $t = 0$). (a) What is the angular frequency of oscillation of the block after the acceleration ceases? (b) By what amount is the spring stretched during the time that the elevator car is accelerating? This distance will be the amplitude of the ensuing oscillation of the block.

20-3. A man enters a tall tower, needing to know its height. He notes that a long pendulum extends from the ceiling almost to the floor and that its period is [03] ________ s. (a) How tall is the tower? (b) If this pendulum is taken to the Moon, where the free-fall acceleration is 1.67 m/s^2, what is the period there?

20-4. If the frequency of oscillation of the wave emitted by an FM radio station is [04] ________ MHz, determine the wave's (a) period of vibration and (b) wavelength. (*Hint:* Radio waves travel at the speed of light, 3.00×10^8 m/s.)

21-1. A phone cord is 4.89 m long. The cord has a mass of 0.212 kg. A transverse wave pulse is produced by plucking one end of the taut cord. That pulse makes four round trips (down and back) along the cord in [01] ________ s. What is the tension in the cord?

21-2. Suppose that you hear a clap of thunder [02] ________ s after seeing the associated lightning stroke. The speed of sound waves in air is 343 m/s and the speed of light in air is 3.00×10^8 m/s. How far are you from the lightning stroke?

21-3. The intensity level of an orchestra is [03] ________ dB. A single violin achieves a level of 68.2 dB. How does the intensity of the sound of the full orchestra compare with that of the violin's sound? (Find the ratio of the intensities.)

21-4. A stereo speaker (considered a small source) emits sound waves with a power output of [04] ________ W. (a) Find the intensity 10.5 m from the source. (Assume that the sound is emitted uniformly in all directions from the speaker.) (b) Find the intensity level, in decibels, at this distance. (c) At what distance would you experience the sound at the threshold of pain, 120 dB?

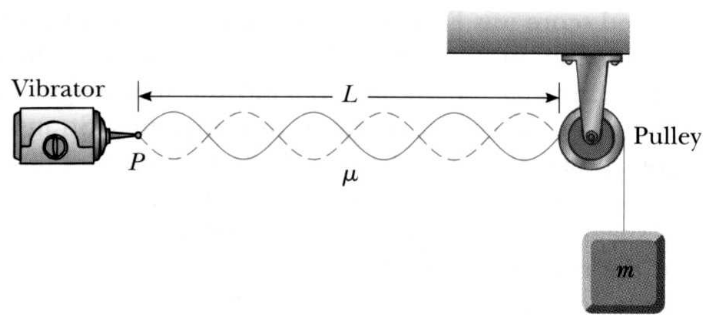
21-5. A train at rest emits a sound at a frequency of [05] ________ Hz. An observer in a car travels away from the sound source at a speed of 34 m/s. What is the frequency heard by the observer? (Take the speed of sound to be 345 m/s.)

21-6. A bat flying at [06] ________ m/s emits a chirp at 40.95 kHz. If this sound pulse is reflected by a wall, what is the frequency of the echo received by the bat? (*Hint:* This is exactly the same as the situation where the source and observer are both moving towards each other.) Use 345 m/s for the speed of sound.

22-1. An alert physics student stands beside the tracks as a train rolls slowly past. He notes that the frequency of the train whistle is 442.28 Hz when the train is approaching him and [01] ________ Hz when the train is receding from him. From this he can find the speed of the train. What value does he find? (Take the speed of sound to be 345 m/s.)

22-2. A pair of speakers separated by [02] ________ m are driven by the same oscillator at a frequency of 690 Hz. An observer, originally positioned at one of the speakers, begins to walk along a line perpendicular to the line joining the two speakers. (a) How far must the observer walk before reaching a relative maximum in intensity? (b) How far will the observer be from the speaker when the first relative minimum is detected in the intensity? (Take the speed of sound to be 345 m/s.)

22-3. In the arrangement shown in the figure, an object of mass $m =$ [03] ________ kg hangs from a cord around a light pulley. The length of the cord between point P and the pulley is $L = 2.0$ m. When the vibrator is set to a frequency of 150 Hz, a standing wave with six loops is formed. What must be the linear mass density of the cord?



22-4. A pipe open at both ends has a fundamental frequency of [04] ________ Hz when the temperature is 0°C. (a) What is the length of the pipe? (b) What is the fundamental frequency at a temperature of 30°C? Assume that the displacement antinodes occur exactly at the ends of the pipe. Neglect thermal expansion of the pipe.

22-5. Two identical mandolin strings under 205.6 N of tension are sounding tones with fundamental frequencies of 523 Hz. The peg of one string slips slightly, and the tension in it drops to [05] ________ N. How many beats per second are heard?

22-6. A speaker at the front of a room and an identical speaker at the rear of the room are being driven at 456 Hz by the same sound source. A student walks at a uniform rate of [06] ________ m/s away from one speaker and toward the other. How many beats does the student hear per second? (Take the speed of sound to be 345 m/s.)

Answers to Homework Problems, Physics 105, Fall Semester, 2008
Secs. 1 & 2, John Colton

1-1b. 15.0, 60.0 min
1-2. 300, 800 km/h
1-3a. 150, 210 km
1-3b. 60.0, 70.0 km/h
1-4a. 3.00, 5.00 m/s
1-4b. −0.25, −0.75 m/s
1-4c. −0.75, −1.25 m/s
1-4d. 0
1-5. 2.0, 6.0 s
1-6b.
1-6c.
2-1a. 0
2-1b. 1.40, 1.80 m/s^2
2-1c. 0.70, 0.90 m/s^2
2-1d. 0
2-1e. 1.40, 1.80 m/s^2
2-1f. 0
2-2. 80, 180 ft
2-3a. 4.50, 6.50 m/s
2-3b. 6.00, 9.00 s
2-3c. −6.00, −9.00 m/s
2-3d. 70, 150 m
2-3e. 15.0, 25.0 m/s
2-4. 1.50, 2.50 s
2-5a. 3.00, 11.00 m
2-5b. 0.500, 1.700
2-5c. 0.500, 0.900
2-6b.
3-1. 1.80, 3.60 ft
3-2a. 5500, 9000 ± 10 m
3-2b. 1500, 4000 ± 10 m
3-3a. 30.0, 45.0 m/s
3-3b. 3.0, 6.0 s
3-3c. 30.0, 45.0 m/s
3-4a. 150, 170 km/h
3-4b. 5.0, 20.0° north of west
3-5a. 10.0, 21.0° north of west
3-5b. 150, 230 km/h
3-6. 8.0, 30.0 s
3-7c.
3-7d.
3-7e.
3-7f.
3-7g.
4-1a. 3.0, 8.0 N
4-1b. 50.0, 120.0 N
4-1c. 2.00, 5.00 kg
4-1d. 2.00, 5.00 kg
4-1e. 2.00, 5.00 kg
4-2. 600, 1500 ± 10 N
4-3a. 0.150, 0.500 m/s^2
4-3b. 5.0, 25.0 m
4-3c. 1.50, 5.00 m
5-1. 400, 600 N
5-2. 4.00, 12.00 min
5-3. 60.0, 95.0 N
5-4b. 600, 1400 ± 10 N
5-5b. 20, 70 N
6-1c. 1.00, 3.00 m/s^2
6-1d. 30.0, 40.0 N
6-1e. 0.50, 1.20 m
6-2c. 0.40, 2.50 m/s^2
6-2d. 80.0, 100.0 N
6-3c. 1.00, 1.50 m/s^2
6-3d. 10.0, 30.0 N
6-3e. 0.10, 0.50 m/s^2
6-3f. 10.0, 25.0 N
6-4c. 6.00, 8.00 m/s^2
6-4d. 30.0, 40.0 N
6-5b. 0.150, 0.300
6-5d. 0.200, 0.700 m/s^2
7-1b. 10.0, 25.0 N
7-1c. 20.0, 30.0 N
7-2d. 70.0, 90.0 N
7-2e. 30.0, 40.0 N
7-2f. 0.500, 0.800
7-3. 900, 2000 ± 10 J
7-4. 60, 120 J
7-5. 1.30, 3.10 m
7-6a. 40.0, 90.0 J
7-6b. 5.0, 15.0 J
7-6c. 0.0, 0.0 J
8-1a. 8.0, 20.0 m/s
8-1b. 8.0, 20.0 m/s

8-2a. 8.50, 11.00 m/s
8-2b. 5.00, 10.00 m/s
8-3. 600, 1100 N/m
8-4. 0.050, 0.200
8-5a. 0.100, 0.500 m/s
8-5b. 2.00, 6.00 kJ
8-6a. 5.0, 12.0 hp
8-6b. 8.0, 20.0 hp
9-1a. 20.0, 45.0 m/s
9-2. 50.0, 70.0 s
9-3a. 20.0, 25.0 m/s
9-3b. 8000, 11000 ± 100 J
10-1a. 1000, 2000 ± 10 N
10-1b. 6000, 10000 ± 10 N
10-2. between -90 and $+10$ cm/s
10-3a. 2.50, 4.50 m/s
10-3b. 1.00, 2.50 m
10-3c. 25000, 50000 ± 100 N
10-4a. 4.50, 9.50 m/s
10-4b. 8.0, 30.0° north of east
10-4c. 15.0, 60.0%
10-5a. 600, 1000 rad/s^2
10-5b. 3000, 6000 ± 10 rad
10-6a. 5.00, 9.00 s
10-6b. 30.0, 60.0 rad
11-1a. 10.0, 20.0 m/s
11-1b. 20.0, 30.0 s
11-1c. 150, 250 m
11-2b. 10.0, 40.0°
11-3b. 15000, 40000 ± 100 N
11-3d. 9.0, 15.0 m/s
11-4a. 5.00, 10.00 N
11-4b. 30.0, 70.0°
11-4c. 1.50, 4.00 N
11-5a. 7.80, 9.40 N
11-5b. 7.80, 9.40 N
11-5c. 5.60, 6.20 m/s
11-6b. 1.50, 2.50 m/s
11-6c. 50.0, 70.0 m/s
11-6d. 3.00, 5.00 m/s
12-1. 0.750, 0.800 m
12-2. 200, 500 N
12-3. 5000, 20000 ± 100 rad/s
12-4. 32000, 39000 ± 100 km
12-5a. 0, -50 N·m
12-5b. 0, -50 N·m
12-5c. 0, -50 N·m
12-5d. 0, -50 N·m
12-6a. 650, 900 N
12-6b. 650, 900 N
13-1b. 350, 450 N
13-1c. 600, 800 N
13-1d. 3.00, 5.00 m
13-2b. 6.50, 7.50 m
13-3a. 700, 1000 ± 10 N
13-3b. 1100, 1700 ± 10 N
13-4c. 2.00, 5.00 m/s^2
13-4d. 15.0, 40.0 m
13-4e. 3.50, 8.00 rad/s^2
13-5c. 40.0, 60.0 N
13-5d. 0.200, 0.400 kg·m^2
13-5e. 30.0, 50.0 rad/s
14-1. 30.0, 60.0 m
14-2a. 1.20, 1.80 m/s
14-2b. 40.0, 60.0 rad/s
14-4. 6.0, 20.0 rev/s
14-5. 10.0, 20.0 m/s^2
14-6a. 1.80, 2.20 rad/s
14-6b. 2.50, 3.40 J
14-6c. 6.50, 9.00 J
15-1. 2.0×10^8, 5.0×10^8 Pa
15-2. 3.0, 7.0 mm
15-3a. 1.00×10^5, 3.00×10^5 Pa
15-3b. 2.00×10^5, 4.00×10^5 Pa
16-1. 1.0, 20.0 lb
16-2a. 500.0, 1100.0 N
16-2b. 500.0, 1100.0 N
16-2c. 5.0, 12.0 N
16-2d. 80.0, 100.0 N
16-3. 40, 100 kg
16-4b. 0.170, 0.320 m
16-5a. 50, 99 g/s
16-5b. 0.15, 0.40 mm/s
16-6c.

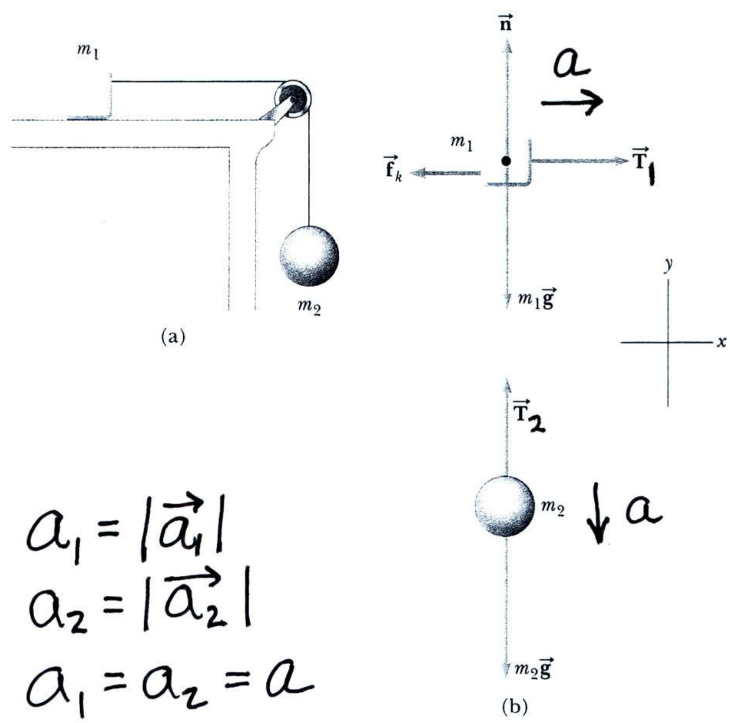
17-1a. 13.0, 20.0 m/s
17-1b. 1.50, 2.00 mm
17-2a. −0.20, −1.50 mm
17-3. 500, 1100 gal
17-4. 100, 900 balloons
17-5. 10.0, 25.0 cm^3
17-6d.
18-1a. 3500, 5000 ± 10 J
18-1b. 1500, 2500 ± 10 m/s
18-2. 1.0, 3.0 mm
18-3. 10.0, 20.0 h
18-4. 1.00, 2.00°C
18-5. 10.0, 20.0 g
18-6. 103.0, 110.0°C
19-1a. −600, −850 J
19-1b. −400, −650 J
19-1c. −200, −450 J
19-2. 500, 1000 J
19-4a. 200, 300 J
19-4b. 250, 400 J
19-4c. −50, −150 J
19-4d. 50, 150 J
19-4e. 0, 0 J
19-4f. 0, 0 J
19-5. 0.20, 0.50°C
19-6a. 30.0, 60.0%
19-6b. 500, 900 J
19-6c. 1500, 3000 W
20-1. 2.00×10^6, 4.00×10^6 Pa
20-2a. 11.0, 17.0 rad/s
20-2b. 4.5, 9.5 cm
20-3a. 20.0, 100.0 m
20-3b. 20.0, 50.0 s
20-4a. 9.0×10^{-9}, $12.0 \times 10^{-9} \pm 0.1 \times 10^{-9}$ s
20-4b. 2.70, 3.40 m
21-1. 100, 300 N
21-2. 3.00, 7.00 km
21-3. 10, 50
21-4a. 5.0, 70.0 mW/m^2
21-4b. 95.0, 110.0 dB
21-4c. 0.50, 3.00 m
21-5. 600, 850 Hz
21-6. 42.20, 42.70 kHz
22-1. 0.20, 0.80 m/s
22-2a. 0.10, 0.60 m
22-2b. 0.50, 1.50 m
22-3. 2.0, 7.0 g/m
22-4a. 0.400, 0.600 m
22-4b. 300, 450 Hz
22-5. 9.0, 17.0 Hz
22-6. 2.0, 6.0 Hz

Corrections, pp. 104-105, 7th Edition

EXAMPLE 4.13 Connected Objects

Goal Use both the general method and the system approach to solve a connected two-body problem involving gravity and friction.

Problem **(a)** A block with mass $m_1 = 4.00$ kg and a ball with mass $m_2 = 7.00$ kg are connected by a light string that passes over a frictionless pulley, as shown in Figure 4.23a. The coefficient of kinetic friction between the block and the surface is 0.300. Find the acceleration of the two objects and the tension in the string. **(b)** Check the answer for the acceleration by using the system approach.



$a_1 = |\vec{a}_1|$

$a_2 = |\vec{a}_2|$

$a_1 = a_2 = a$

Figure 4.23 (Example 4.13) (a) Two objects connected by a light string that passes over a frictionless pulley. (b) Free-body diagrams for the objects.

Strategy Connected objects are handled by applying Newton's second law separately to each object. The free-body diagrams for the block and the ball are shown in Figure 4.23b, with the + x-direction to the right and the +y-direction upwards. The magnitude of the acceleration for both objects has the same value, $|\vec{a}_1| = |\vec{a}_2| = a$. The block with mass m_1 moves in the positive x-direction, and the ball with mass m_2 moves in the negative y-direction, [redacted] Using Newton's second law, we can develop two equations involving the unknowns T and a that can be solved simultaneously. In part **(b)**, treat the two masses as a single object, with the gravity force on the ball increasing the combined object's speed and the friction force on the block retarding it. The tension forces then become internal and don't appear in the second law.

Solution

(a) Find the acceleration of the objects and the tension in the string.

Write the components of Newton's second law for the cube of mass m_1:

$$\sum F_x = T_1 - f_k = m_1 a_1 \qquad \sum F_y = n - m_1 g = 0$$

The equation for the y-component gives $n = m_1 g$. Substitute this value for n and $f_k = \mu_k n$ into the equation for the x-component:

$T_1 - \mu_k m_1 g =$ [redacted] $m_1 a$ **(1)**

Apply Newton's second law to the ball, [redacted]

$\sum F_y = -m_2 g + T_2 =$ [redacted] $-m_2 a$ **(2)**

$T_1 = T_2 = T$

Subtract Equation (2) from Equation (1), eliminating T and leaving an equation that can be solved for a_1 (substitution can also be used):

$m_2 g - \mu_k m_1 g = (m_1 + m_2)$ [redacted] a

a [redacted] $= \dfrac{m_2 g - \mu_k m_1 g}{m_1 + m_2}$

Substitute the given values to obtain the acceleration.

a [redacted] $= \dfrac{(7.00 \text{ kg})(9.80 \text{ m/s}^2) - (0.300)(4.00 \text{ kg})(9.80 \text{ m/s}^2)}{(4.00 \text{ kg} + 7.00 \text{ kg})}$

$= 5.17 \text{ m/s}^2$

Substitute the value for a_1 into Equation (1) to find the tension T:

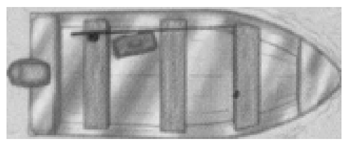
$T = 32.4$ N

Physics 105 – Fall 2008
Homework Set 5

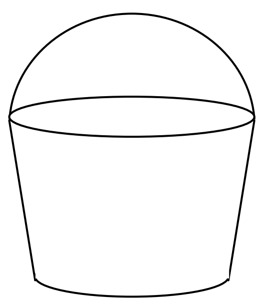
CID: ___________

Score: ________ out of 4 points

5-4. (a)



5-5. (a)



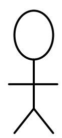
Physics 105 – Fall 2008 CID: ___________
Homework Set 6

Score: ________ out of 10 points

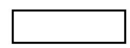
6-1. (a)

(b)

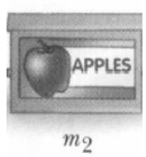
6-2. (a)



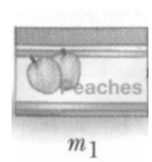
(b)



6-3. (a)

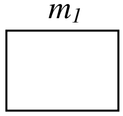


(b)



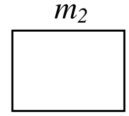
6-4. (a)

m_1

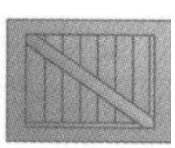


(b)

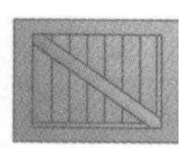
m_2



6-5. (a)



(c)

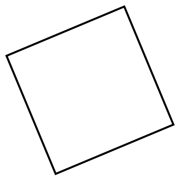


Physics 105 – Fall 2008
Homework Set 7

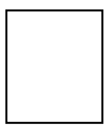
CID: ___________

Score: ________ out of 4 points

7-1. (a)

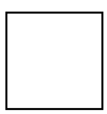


7-2. (a)



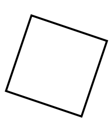
10 kg

(b)



5 kg

(c)



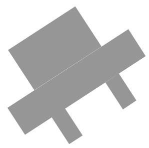
3 kg

Physics 105 – Fall 2008
Homework Set 11

CID: ___________

Score: ________ out of 6 points

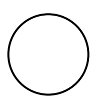
11-2. (a)



11-3. (a)

(c)

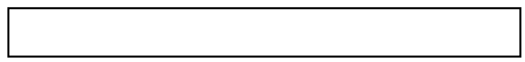
11-6. (a)



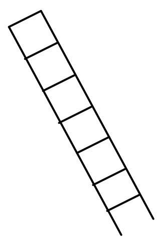
Physics 105 – Fall 2008 CID: ___________
Homework Set 13

Score: ________ out of 8 points

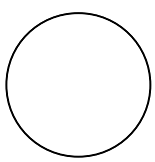
13-1. (a)



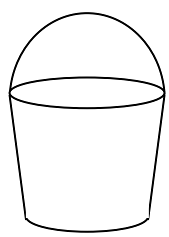
13-2. (a)



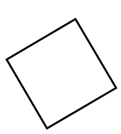
13-4. (a)



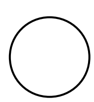
(b)



13-5. (a)



(b)



Physics 105 – Fall 2008
Homework Set 16

CID: ___________

Score: ________ out of 2 points

16-4. (a)