Physics 105 - How Things Wor
at
The University of Virginia

http://rabi.phys.virginia.edu/105

Fall 20

Course Schedule

The Laws of Motion, Part 1		Read	Due	Slides	Videos
1. Aug 27, 2003 Wednesday	Introduction and Skating	Section 1.1			
2. Aug 29, 2003 Friday	Falling Balls	Section 1.2			
3. Sept 1, 2003 Monday	Ramps	Section 1.3	PS 0		
The Laws of Motion, Part 2					
4. Sept 3, 2003 Wednesday	Seesaws	Section 2.1			
5. Sept 5, 2003 Friday	Wheels	Section 2.2			
6. Sept 8, 2003 Monday	Bumper Cars 1	Section 2.3	PS 1		
7. Sept 10, 2003 Wednesday	Bumper Cars 2				
Mechanical Objects					
8. Sept 12, 2003 Friday	Spring Scales	Section 3.1			
9. Sept 15, 2003 Monday	Bouncing Balls	Section 3.2	PS 2		
10. Sept 17, 2003 Wednesday	Carousels and Roller Coasters	Section 3.3			
11. Sept 19, 2003 Friday	Bicycles	Section 3.4			
Fluids					
12. Sept 22, 2003 Monday	Balloons 1	Section 4.1	PS 3		
13. Sept 24, 2003 Wednesday	Balloons 2				
14. Sept 28, 2003 Friday	Water Distribution 1	Section 4.2			
15. Sept 29, 2003 Monday	Water Distribution 2		PS 4		
Fluids and Motion					
16. Oct 1, 2003 Wednesday	Garden Watering 1	Section 5.1			
17. Oct 3, 2003 Friday	Garden Watering 2				
18. Oct 6, 2003 Monday	**No Class - Yom Kippur**				
19. Oct 8, 2003 Wednesday	**Midterm Review**		PS 5		
20. Oct 10, 2003 Friday	**Midterm Examination**				
21. Oct 13, 2003 Monday	**No Class - Reading Holiday**				
22. Oct 15, 2003 Wednesday	Balls and Frisbees 1	Section 5.2			
23. Oct 17, 2003 Friday	Balls and Frisbees 2				
24. Oct 20, 2003 Monday	Airplanes	Section 5.3	PS 6		

25. Oct 22, 2003 Wednesday	Rockets				
Heat and Thermodynamics					
26. Oct 24, 2003 Friday	Woodstoves 1	Section 6.1			
27. Oct 27, 2003 Monday	Woodstoves 2		PS 7		
28. Oct 29, 2003 Wednesday	Incandescent Light Bulbs 1	Section 6.2			
29. Oct 31, 2003 Friday	Incandescent Light Bulbs 2				
30. Nov 3, 2003 Monday	Air Conditioners 1	Section 6.3	PS 8		
31. Nov 5, 2003 Wednesday	Air Conditioners 2				
32. Nov 7, 2003 Friday	Automobiles 1	Section 6.4			
33. Nov 10, 2003 Monday	Automobiles 2		PS 9		
Phase Transitions					
34. Nov 12, 2003 Wednesday	Water, Steam, and Ice 1	Section 15.1			
35. Nov 14, 2003 Friday	Water, Steam, and Ice 2				
Resonance and Mechanical Waves					
36. Nov 17, 2003 Monday	Clocks 1	Section 7.1			
37. Nov 19, 2003 Wednesday	Clocks 2				
38. Nov 21, 2003 Friday	Violins and Pipe Organs 1				
39. Nov 24, 2003 Monday	Violins and Pipe Organs 2		TP		
40. Nov 26, 2003 Wednesday	**Thanksgiving Recess**	Section 7.2			
41. Nov 28, 2003 Friday	**Thanksgiving Recess**				
42. Dec 1, 2003 Monday	The Sea and Surfing 1	Section 7.3	PS 10		
43. Dec 3, 2003 Wednesday	The Sea and Surfing 2				
44. Dec 5, 2003 Friday	**Final Review**				
45. Dec 8, 2003 Monday	**Final Examination (9am – 12noon)**				

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Course Policy

Class Meetings:	MWF 1:00pm-1:50pm, Physics Room 203 (Lou Bloomfield) Lectures may also be seen in Physics Rooms 204 and 205 and Ruffner Room G004A (via closed-circuit television) and will posted on the web after class (see schedule page for the link).
Required Reading:	*1.* "How Thinks Work: the Physics of Everyday Life, 2nd Edition" by Louis A. Bloomfield *2.* "Lecture Notes" by Lou Bloomfield (at the UVa Bookstore)
Web Site:	http://rabi.phys.virginia.edu/105/2003
Instructor:	Lou Bloomfield, Professor of Physics Office: Physics Room 133 (See me here almost anytime) TEL: (434) 924-6595 FAX: (434) 924-4576 Email: lab3e@virginia.edu (Use only for emergencies when you can't see me in person) View Lou's Office Hours
Course Work:	10 Problem Sets (3% of Course Grade Each, 30% Total) 1 Midterm Exam (15% of Course Grade) 1 Term Paper (25% of Course Grade) 1 Final Exam (30% of Course Grade)
	A couple of guided problems per set. Questions will require independent thought on your part in order to answer them correctly. You are encouraged to work on the problems independently, but may seek help from other students when you get stuck. You must write up your answers **separately and in your own words**. Although problem sets are not pledged assignments, points will be deducted from your problem set if you use someone else's words or allow them to use your words. The true purpose of these problem sets is to help you understand the material, not to assign grades. We have observed over the years that students who simply "borrow" answers from other students or from the instructors, and who don't make a serious effort to understand why those answers are correct, do very poorly on the exams. It's in your best interest to work on the problems yourself at first and to seek help from others only when you are having trouble making headway. Similarly, you provide the best help to others when you guide them

A. Problem Sets:	back onto the correct path, rather than simply giving them an answer. Each problem set will be issued via the web on a Friday and will usually be due 10 days later on a Monday. Problem set #0 is due on Monday, Sept 1, 2003, 1:00:00pm Problem set #1 is due on Monday, Sept 8, 2003, 1:00:00pm Problem set #2 is due on Wednesday, Sept 17, 2003, 1:00:00pm Problem set #3 is due on Monday, Sept 22, 2003, 1:00:00pm Problem set #4 is due on Monday, Sept 29, 2003, 1:00:00pm Problem set #5 is due on Wednesday, Oct 8, 2003, 1:00:00pm Problem set #6 is due on Monday, Oct 20, 2003, 1:00:00pm Problem set #7 is due on Monday, Oct 27, 2003, 1:00:00pm Problem set #8 is due on Monday, Nov 3, 2003, 1:00:00pm Problem set #9 is due on Monday, Nov 10, 2003, 1:00:00pm Problem set #10 is due on Monday, Dec 1, 2003, 1:00:00pm Problem set 0 is an introduction to the web submission system and course rules. Although it is ungraded, it must be submitted to remain enrolled in the course.
B. Term Paper:	An original discussion of how something works. Term paper may be written individually or in a group of 2 or 3 people. The term paper is a pledged assignment that must be completed entirely on your own or by your official group. Submission and grading will occur only over the web. See the course web site for the link and instructions. Length for Individual Term Paper: 1500-1750 words. Length for a Group Term Paper: 3000-3500 words. Additional pages detail what is expected in a term paper, a list of topics used by previous students, a list of topics that are not permitted, and a sample grading sheet for the term paper. The term paper is due on Monday, Nov 24, 2003, 1:00:00pm. In general, you may not write about an object that is discussed extensively in my book, in class, or on my web pages. If you're uncertain whether a topic is acceptable, ask me. While you do not need to get our permission when selecting a topic, we will be glad to assist you up until Monday, Nov 18, 2003.
C. Midterm Exam:	A fifty-minute, closed-book, in-class examination given on Friday, Oct 10, 2003, 1:00pm-1:50pm. 2/3 of the grade will involve multiple-choice questions. 1/3 of the grade will involve short answer questions. The exam will emphasize **understanding of concepts** so that memorization will be far less valuable for answering the questions than basic insight into how things work. **Compelling** reason for an alternate midterm exam time will be

	considered only up until Friday, Oct 3, 2003.
D. Final Exam:	A three-hour, closed-book examination given during Finals Week on Monday, Dec 8, 9:00am-12:00noon. 2/3 of the grade will involve multiple-choice questions. 1/3 of the grade will involve short answer questions. The exam will emphasize **understanding of concepts** so that memorization will be far less valuable for answering the questions than basic insight into how things work. **Compelling** reason for taking the final exam late, as a **1-hour oral examination**, will be considered only up until Monday, December 1 (the College deadline for such requests). You must obtain permission from the Dean. No early final exams will be given.
Late Policy:	Specific grade deductions for late work and final deadlines are discussed on the list of course rules. Exceptions for illness, family illness or death, religious holidays must be obtained **in advance**. You must contact us **before** something is due or before you miss an examination.
Meeting Place:	If you do not know anyone with whom to discuss the problem sets, meet in Clemons Library on the 4th floor at 2:00pm on the Sunday before a problem set is due. Look for other people carrying the textbook.
Guests and Visitors:	Guests and visitors are always more than welcome (except during the exams, naturally). No special permission is required.
Grading Information:	Course grades will be based strictly on your numerical scores for the semester. To minimize internal competition within the class, we will consider the numerical scores from previous semesters when we establish the relationship between numerical grades and letter grades. Your course numerical grade is determined by summing your scores on the problem sets, the exams, and the term paper (weighted by the factors mentioned previously): (Problem Set #1 Score) x 0.03 + (Problem Set #2 Score) x 0.03 ... + (Problem Set #10 Score) x 0.03 + (Midterm Exam Score) x 0.15 + (Term Paper Score) x 0.25 + (Final Exam Score) x 0.30 Course Numerical Grade Work not turned in or tests not taken will receive a zero (0 pts), far worse than a failing grade (typically 30 pts or more). If you are taking this course Credit/No Credit, your course letter grade must be at least a C- to receive Credit.
Term Paper Incentive:	If you select a topic for your term paper promptly and submit that topic via the EClass site by Monday, Nov 17, 2003 at 1:00:00pm, we will drop your lowest problem set score when computing your semester grade. This arrangement applies to both individual and group term papers.
Evaluation	If you complete the course evaluation on the EClass web site before Monday,

Incentive:	Dec 8, 2003 at 5:00:00pm, we will add 1 point to your overall semester score.
University Deadlines:	Drop Deadline: Wednesday, Sept 10, 2003 Add Deadline: Friday, Sept 12, 2003 Credit/No Credit Deadline: Friday, Sept 12, 2003 Withdraw Deadline: Wednesday, Oct 22, 2003

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Course Goals

1. To begin to see science in everyday life
2. To learn that science isn't frightening
3. To learn to think logically in order to solve problems
4. To develop and expand your physical intuition
5. To learn how things work
6. To begin to understand that the universe is predictable rather than magical
7. To obtain a perspective on the history of science and technology

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Course Rules

The rules in this list may seem rather harsh and arbitrary but they are essential to maintaining the integrity of the course. We have stories to tell about each rule. Some of these stories are predictable and easy to imagine while others are stranger than fiction. Although most of you will never come up against any of the rules, we have a handful of students each semester who just cannot seem to avoid them. If these rules are going to cramp your style, then this class is probably not for you. -- Lou Bloomfield

Coursework:

1. All homework must be submitted via the web, including the problem sets and the term paper. No paper copies will be accepted.
2. You will receive a receipt via email when you submit homework to be graded. Save this receipt in electronic form (e.g. on a hard disk or CDrom).
3. Claims that we lost your homework following submission will not be considered without the email receipt in electronic form.
4. Exam booklets and bubble sheets must be placed in the boxes at the front of the lecture hall upon completion. Exam materials not placed in these boxes will not be accepted.

Grading and Regrading:

1. All grading is final except in cases where the scores were added or recorded incorrectly. However, we may, at our option, regrade materials that are brought to us in person during the 48 hour period after the class at which those materials were returned. We will not regrade term papers that were poorly proofread.
2. Regrading may result in lower scores. If you bring in a printout of your friend's work for comparison, that person must sign the printout to indicate that they understand that we will also regrade it and that its score may be lowered as a result.
3. No regrading will be done after the semester grades have been sent out via email.
4. The final exam will not be regraded under any circumstances.
5. We will not tell people how close they came to the next higher semester grade. That information only promotes grade grubbing, a practice that we strongly discourage.

Problem Sets:

1. Problem sets may be submitted only via the web.
2. You may discuss problem sets with other students but you must write them up **separately and in**

your own words. Points may be deducted from problem sets that are found to have similar answers, regardless of who obtained those answers from whom.

3. Problem sets are usually due on Mondays at 1:00:00pm, as listed in the course schedule. We will deduct 10% of the numerical grade for each day (24 hours) a problem set is late. Once the solutions have been posted on the fifth day (usually Friday afternoon), the problem sets are no longer acceptable under any circumstances.
4. If you find someone else who has a nearly identical answer but received more credit than you, we will not necessarily raise your grade. That person may have received more than they deserved and the proper action would be for us to lower that person's grade.

Term Paper:

1. The term paper is due via the web on Monday, November 24, 2003 at 1:00:00pm. We will deduct one grade step (A becomes A-) for each day the term paper is late (including Saturday and Sunday). After the seventh day (Monday, December 1, 2003 at 1:00:00pm), term papers are no longer acceptable under any circumstances.
2. You must cite all of the sources you use in preparing your term paper, include people, online materials, and student papers. Citations must be placed appropriately in the body of your paper, using an accepted citation style (e.g. Modern Language Association Style or Chicago Style), and you must include a list of works cited and/or a bibliography at the end of your paper.
3. Term papers must be written in your own words, using your own structure, style, and language. Copying material essentially word-for-word from another source without crediting it as a quotation is plagiarism and will not be tolerated. Using another person's structure or style is also plagiarism and will not be tolerated.
4. Except for papers published under *The Journal of How Things Work*, you may not use any other student's paper as a model, reference, or template for your own paper.
5. You may not resubmit a term paper, in whole or part, that you submitted previously for a grade in any other class. Such resubmissions violate the UVa honor code clause prohibiting "multiple submission" and will not be tolerated.
6. You may not contribute your term paper to any private file or resource at the University of Virginia. Since the term paper is pledged work, granting private access to it gives aid to future students and is in violation of the honor code.
7. You may not write on the same topic you used in a previous semester of How Things Work.
8. You may not work together with anyone on an individual term paper. If you are writing a group term paper, you may work together only with the 1 or 2 other members of your group.
9. Term papers may not be written on objects that are part of the course syllabus or the other semester of How Things Work. A list of such forbidden topics is part of this packet.
10. We will not assist in topic selection for the term papers after Monday, November 17, 2003.

Exams:

1. The midterm exam will be given on Friday, October 10, 2003, from 1:00pm to 1:50pm. The final exam will be given on Monday, December 8, 2003, from 9:00am to 12:00noon. If you miss either exam without prior permission from me, you will receive a score of 0 for that exam. There are no exceptions except fully documented medical emergencies that prevent you from telephoning us or our answering machines. In case of a family emergency you or the deans must notify me at (434) 924-6595 before the end of the exam.
2. Exams must be taken in Physics rooms 203, 204, or 205 or in Ruffner G004a, unless authorized by me. Under no circumstances may exam materials ever leave these rooms during the exam. If you remove your exam materials from one of these rooms, even briefly, you will receive a score of 0 on the exam.

3. If you miss the start of an exam, you will still be expected to turn the exam in at the regular time. If you miss the exam entirely, you will receive a 0.
4. We will consider compelling reasons for an alternative midterm time only up until Friday, October 3, 2003. After that time, you must take the midterm exam as scheduled.
5. We will consider compelling reasons for delaying your final exam only up until the College deadline for such requests. After that time, you must take the final exam as scheduled. You must also get permission from the Dean. All late finals will be given as 1-hour oral examinations.

General:

1. We will not sign any petitions to change the grading from Credit/No-Credit to Letter Grade or vice versa after the Credit/No-Credit deadline. Check your registration form carefully.
2. We will not sign any petitions to add into the course after the Add deadline. Check your registration forms carefully.
3. Any student who does not sign the honor statement of Problem Set #0 will be dropped from the course.
4. Any student who does not turn in Problem Sets #1 & #2 will be dropped from the course.
5. We do not give any extra credit work.
6. Permission for exceptions from the normal classwork schedule must be requested in advance. We will not make exceptions after the fact.
7. We will not fail a student who makes a *serious effort* at *all* the assigned work. If you do not submit a homework assignment or do not take an exam, it becomes possible for you to fail the course.
8. We will enforce all of the rules of the University of Virginia's Honor System, including those associated with academic fraud. By enrolling in this course, a student implicitly agrees to be bound by that honor system and its rules.
9. It is the responsibility of each student to learn the rules of the UVa Honor System. Ignorance of these rules will not excuse a failure to follow them.
10. The following is a list of some specific forms of academic fraud that concern us most in this course. This list is intended only as a reminder and is not comprehensive. All other forms of academic fraud and other honor violations are still forbidden in this course.
    1. It is an honor violation to submit for a grade work that is not your own or to permit another student to do so.
    2. It is an honor violation to submit for a regrade any work that was modified after it was graded.
    3. It is an honor violation to lie to us in an effort to improve your grade or to obtain any special consideration or exception from the normal classwork schedule.
    4. It is an honor violation to obtain aid on an exam through any means, including copying another student's work, having another student complete portions of your exam, referring to materials other than the exam booklet itself during the exam, or discussing the exam with anyone other than the instructor or instructor's assistants during the exam.
    5. It is an honor violation to knowingly provide aid to another student during an exam.
    6. It is an honor violation to plagiarize or conduct multiple submission on the term paper. The term paper must be your original work and must never have been submitted before, in whole or part, in any context including a previous semester of this course. You may not copy your term paper, in whole or part, from any source, including another student, yourself, or a third party. Only brief and properly cited quotations are permitted.
    7. It is an honor violation to offer us a forged receipt for electronically submitted work.
    8. It is an honor violation to copy or paraphrase answers from another student's problem set without their permission.
11. The honor pledge is implicit for the term paper and the exams. By turning in any one of those

items, with or without a written pledge, a student agrees to be bound by the honor pledge and the UVa Honor System with regard to that item.

12. We will contact the University Administration, the University Police, and/or the University Judiciary Committee regarding any student who attempts to intimidate us or harass us in an effort to improve their grade or to obtain any special consideration or exception from the normal classwork schedule.
13. Documentation from the Learning Needs and Evaluation Center (LNEC) must be submitted to the instructor in person no later than 1 week (7 days) after the date that documentation was prepared and signed. Documents retained beyond that period reflect a lack of interest or importance to the student involved and therefore will be considered to be irrelevant to the course.

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Term Paper Instructions

Goals for the Term Paper:

This course is designed to provide you with a broad, general understanding of the physics of your everyday world. I can think of no better way to put what you have learned into practice, and thus solidify that understanding, than to do what I do: explain the physics of an everyday object or situation. This paper is an educational exercise and you will get out of it no more than you put into it. I don't expect you to turn in the finest paper that anyone can write on some sophisticated, impenetrable topic; I expect you to turn in the finest paper that you can write, with your own mind and hands, on a topic that you really care about. I hope that in the end, you will be proud of what you've accomplished and learned in the process of writing this paper. It's not a lengthy assignment, but it takes time and thought. If you give it a chance, you'll construct something valuable to you.

Basic Concept of the Term Paper:

Your term paper should be 1500 to 1750 words long (the equivalent of approximately 5 double-spaced, typewritten pages), not counting citations or pictures. Your paper should focus on one object or situation from the world around you and identify within that object several different physical concepts that make the object what it is. You should describe what these physical concepts are and how they contribute to the behavior of the object. Well chosen objects will involve physical concepts that range from mechanics to electricity to heat to optics. However, avoid an object that is so broad that you can only describe a tiny piece of it. The paper should feel complete to the reader.

You should be able to cover the main structure of the object in enough detail to make the reader feel like you actually understand "how it works" overall. Your paper should cover a number of different physical issues relating to your object, rather than "beating to death" one or two of those issues. Avoid unnecessary repetition. The grade you receive will reflect how well your paper conveys an overall understanding of how the object works, including a fair amount of specificity. Don't be vague or mushy. In the physical world, there really are correct and incorrect statements. Vague statements that can be misinterpreted in a way that makes them incorrect are not helpful. Please check your grammar and spelling, and proofread your papers. Bad writing will reduce your grade.

For example, imagine that you were writing a paper on a wind surfer. You should note that its behavior involves buoyancy (it floats), drag (it has a top speed), friction (your feet stay on it), inclined planes (the keel and sail), and various forces (the wind, your arms, the water on the keel). You should describe how these various concepts create the specific behavior you see in the wind surfer (e.g. how buoyancy keeps

the board from sinking and what changes in the buoyancy, up or down, might do to the behavior of the boat.) You should describe how the forces of the wind and the water work together to accelerate the wind surfer in a particular direction. You might describe why you can't go directly into the wind, no matter how hard you try.

Important Rules:

- **Originality:** You are encouraged to use references, written or otherwise, but create the paper entirely on your own. Your term paper is a pledged assignment and must be original work, never submitted in any other venue in whole or part by you or anyone else. All the rules of the UVa Honor Code apply to this assignment, including those listed explicitly on the course rules page.
- **Language:** Quotations should be rare and brief, appearing only when the wording of the quotation is itself important or memorable. Quotations should always be attributed to their authors. The structure and style of a passage or paper also belong to its author and may not be copied without full attribution. If you are in doubt about whether or not you can use something that appears in another person's work, ask me (434-924-6595).
- **Independence:** You may not work with anyone else on an individual term paper and, except for papers published under *The Journal of How Things Work*, you may not use any other student's paper as a model, reference, or template for your own paper. If you read a paper from *The Journal of How Things Work*, you may not write on its topic or a closely related topic. You may get technical information from a knowledgeable person (e.g. a repair person or an engineer) as long as you do the thinking about that information and you write the paper.
- **Sources:** The term paper is a research paper—you are expected to synthesize your own understanding of your object or situation, although that understanding may be based in part on information collected elsewhere. Visit the library. If you use the web, remember that the web is entirely unedited and contains a great deal of misinformation. You must cite your sources in the body of your paper wherever appropriate and you must include a list of works cited and/or a bibliography at the end of your term paper. These lists should include any people or online materials that you consulted while preparing your paper.

Key Suggestions:

- **Audience:** Your paper should be readable and informative to a student who is doing well in this class. That student is your target audience. Don't bore that student by repeating definitions or simple laws, but don't be afraid to present brief reminders of important conceptual issues. Your space is precious in this paper, so use it wisely.
- **Focus:** Try to keep the paper well structured and fairly specific. Please don't ramble. If the reader gets lost, the reader will not be impressed. Types of subjects to avoid:
  - - "A radio wave" (too specific - no range of concepts)
  - - "A city" (too broad - every possible principle)
  - - "A vehicle" (too vague)
  - - "Pumps" (too focused on a principle rather than an object -- try a water pump instead)
- **Organization:** Your term paper will be graded by one of several graders. These graders are physics students, who speak English well, who have a relatively good grasp of physics itself, and who understand much of how things around them work. However, do not assume that the grader reading your paper will understand specialized jargon or that he or she already knows exactly how the object you are writing about works. You must pursue each physical issue carefully and in sufficient detail that a person knowledgeable in basic physics will understand how that issue relates to the workings of the object. You must also ensure that the reader has a good overall picture of the object. In short, structure the paper carefully so that it provides a good overall picture and many specific details that fit clearly into that overall picture.

Expectations:

The graders will attach a grading sheet to your term paper and use that sheet to assign a grade. Physics 106 is a physics course and your term paper will be judged according to how effective it is at explaining the physics and physical concepts that make the object work. In particular, the **A** range papers will be those that get right to work discussing physical concepts in their object and work efficiently to cover many of the important ways in which physics contributes to the workings of their object. **B** range papers will be those that discuss some physical concepts, but either bog down while discussing only a few physical concepts, have significant mistakes in them, or waste too much space on non-physics issues such as history, users' manuals, description, or engineering instructions. **C** range papers will be those that fail almost completely to discuss physical concepts and instead dwell on history, users' manuals, description, or engineering instructions. If your paper doesn't contain much that you learned in this course (or its equivalent), you probably haven't written a physics paper.

Here examples of what to do or not to do in writing a paper about paper clips:

HOW PAPER CLIPS WORK
(Physical Concepts - The Desired Approach)

Paper clips are small objects, usually constructed from metal wire (Fisher 741), that serve to hold several sheets of paper together as a single unit. In effect, a paper clip consists of two metal surfaces that are pressed against one another by the elasticity of the metal wire from which the paper clip is built. As you distort the paper clip away from its equilibrium shape, by spreading the two surfaces apart, it experiences restoring forces. These forces tend to return the paper clip to its equilibrium shape and push the two surfaces together. Because the paper clip behaves like a spring, the restoring forces are proportional to the distance separating the two surfaces (Bloomfield 81). When several sheets of paper are placed between the two surfaces, the restoring forces on the metal surfaces cause them to exert inward, compressing forces on the paper sheets. Because each sheet of paper does not accelerate, it is clear that the sheet experiences no net force. Instead, forces appear between each sheet of paper and its neighbors to oppose the compressing forces from the paper clip. The force between each sheet and its neighbor gives rise to friction between the sheets. The sheets cannot slide easily across one another because they will experience frictional forces whenever there is relative motion.....

(This paragraph is very extreme and I do not expect even the best papers to be this serious and intense. The point is that you should get down to business: tell the reader what you are going to discuss, why it is important, and then discuss it. Focus primarily on physical issues, although you may include other aspects of the object to make the paper more interesting and readable.)

HOW PAPER CLIPS WORK
(A Historical Study - Wrong Approach #1)

Paper clips are used to hold several sheets of paper together. Paper clips were invented in 1872 by John Smith (Fortunoy 11). Prior to the invention of the paper clip, people had resorted to pinning sheets of paper together with straight pins (Popinjay 78). Pins damaged the sheets and offered the possibility of injury. Because it avoided these two shortcomings, the paper clip was an immediate success (Glubnik 163). For his invention, Smith received U.S. patent #12345. This was among the first patents ever granted. In the patent, Smith described the paper clip as a device for restraining several leafs of paper together as a single document (Smith 7).

The first paper clips suffered from several short comings. It was difficult to insert the pages between the

metal sections (Glubnik 174). In the decade following the initial patent, dozens of different designs appear (Fluffpoint 78). Many of these designs still exist today. The most common paper clip style is the Gem.....

(While this may be fun to write and read, it gives the reader very little idea of how the object works. You could write this paper without knowing any physics)

HOW PAPER CLIPS WORK
(A User's Manual - Wrong Approach #2)

Paper clips are used to hold several sheets of paper together. The stack of papers is collected together by holding it upright on a table and tapping it lightly on the table's surface. If many sheets are to be clipped together, a device called a jogger is sometimes used to align the sheets together neatly. The paper is then slipped between the two halves of the paper clip until the stack is fully inserted. As long as you avoid inserting so much paper that the clip is deformed, it will hold the sheets together. If you have too much paper for a small clip, you should find a larger clip.....

(Again, you could write this paper without knowing any physics. This is not a "how the paper clip works" paper, it is a "how to use a paper clip" paper.

HOW PAPER CLIPS WORK
(Description - Wrong Approach #3)

Paper clips are used to hold several sheets of paper together. They are constructed from wire that has been bent in several places. There are usually three 180° bends so that the overall piece of metal forms a spiral. The spiral is somewhat disguised because it includes a number of straight sections. The metal wire is normally shiny, silver in color, and about 0.05 inches in diameter. It is also quite stiff. Common paper clips range in size from less than half an inch long to over three inches. Sometimes paper clips are used a desk ornaments/organizers, in which case they may be as much as 6 inches long.

In use, the two halves of the paper clip are spread apart and the stack of paper is gripped between the two halves. Bigger paper clips generally grip the paper more tightly than smaller paper clips. There are also special paper clips for holding together large stacks of paper. The most common clip of this type is called the Ideal clip. It consists of two overlapping triangles. A much thicker wire is used to form the ideal paper clip.....

(Another paper that you could write without knowing any physics. This is not a "how the paper clip works" paper, it is a "what the paper clip is like" paper. Even though the paper tries to explain a bit about how the paper clip works, the explanation is vague and without any physical concepts in it. You can write a very long, detailed description of how something "works," without including any physical concepts in it. For example: "the stick pushes on the knob, which turns 35° and lowers the shelf, causing the rod to stretch until it breaks through the surface". No physics.)

HOW PAPER CLIPS WORK
(Engineering Instructions - Wrong Approach #4)

Paper clips are used to hold several sheets of paper together. A paper clip is made by bending a steel wire in three places. This bending is done in a special jig so that each segment of the clip has precisely the right length. If the bending is done incorrectly, the wire segments will not be closely parallel to one another and the paper clip will be less effective at holding together the paper. To construct the most

common type of paper clip, the Gem clip, the wire is bent in a smooth arc, over an angle of 180°, at each of three locations. In other clips, one or more of the smooth arcs are replaced by pairs of angular 90° bends. These bends make it easier to insert sheets into the clip, but are more likely to damage the paper during insertion.

Because the wire comes from the factory on spools, it has a natural curvature and must be straightened before use. This straightening is performed by passing the wire through a group of pulleys. Once it is straight, an automatic device measures the proper length for the paper clip.....

(Still another paper that you could write without knowing any physics. This is not a "how the paper clip works" paper, it is a "how to make a paper clip" paper.)

HOW PAPER CLIPS WORK
(Over packaged, Physics Avoidance Maneuver - Wrong Approach #5)

As a humanities major, I rarely have an opportunity to look into the concepts and mechanisms that create the structure of the universe around us. So much of what we see in this glorious world of ours can be explained if only we take the time to investigate it. Through the use of logic, as developed over the centuries since at least the time of the Greeks, blah blah blah....(*somewhere on page 2, the reader is told that this paper is about the paper clip, but it is not until page 3 that our attention turns specifically to the paper clip itself. Two paragraphs later, the paper returns to contemplating the cosmos and the place of physics and science in that cosmos*)

*(This paper avoids the issue of trying to explain how the paper clip works by packaging a little meat in a large amount of filler. Some wonderful, **A+** papers that students have submitted in past semesters have included interesting and clever packaging. However, the packaging in those papers served as a condiment for the meat inside, not as a way to avoid the physical issues.)*

HOW PAPER CLIPS WORK
(Quotation City - Wrong Approach #6)

The celebrated 11th Edition of the Encyclopedia Britannica, published before WWI, describes papers clips as "clever little doodads that allow several sheets of paper to be held together in a temporary manner and that can be removed easily, without the need of any additional tools" (Ency. Brit. XI, 822) According to Sir Winston Churchill's secretary, "paperclips are what held together most of Churchill's notes whenever he gave a speech" (Hoyle 728) Less well know is the fact that "paperclips are generally assembled out of medium carbon steel so that they have a nice balance between springiness and deformability" (Ebert, pg 101).

(This paper tries to avoid any independent thought or intellectual synthesis by assembling a collection of quotations. Some of the quotes are irrelevant to the physics of paperclips and the quotes that are relevant are not inherently interesting. If the wording itself isn't important or memorable, don't quote another author's words. Instead, understand the concepts in the author's writing and put together your own statements on the subject. Then credit the author in your references for the author's thoughts, not the author's words.)

HOW PAPER CLIPS WORK
(Definitions-R-Us - Wrong Approach #7)

When you bend a paper clip, it experiences a restoring force. A restoring force is defined as a force that

"acts to restore the spring to its equilibrium length" (Bloomfield 81) and a force is defined as "an influence that if exerted on a free body results chiefly in an acceleration of the body and sometimes in deformation and other effects" (Bloomfield 482). In carrying out this bend, you push the clip's end in one direction and it pushes you in the other direction, an example of Newton's third law, which states that "for every force that one object exerts on a second object, there is an equal but oppositely directed force that the second object exerts on the first object" (Bloomfield 22). An object is defined as...

(One may quibble over whether these definitions need to be quoted and cited, or whether their wide use makes them "common knowledge" that can simply be written into the paper. However, there is no denying that this type of definition-based writing is hideously boring and contains very little new or interesting information. The definitions are simply space-filler and should be omitted. Save your precious 1500 words for something insightful.)

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Group Term Paper Instructions

Instead of writing an individual term paper, you may work together with 1 or 2 other people (for a total of 2 or 3 people) on a group term paper. This group term paper will meet the same requirement as the individual term paper. The paper will receive one grade and all of the members of the group will receive that same grade.

The expectations for a group term paper are exactly the same as for an individual term paper except that the length should be 3000 to 3500 words (the equivalent of approximately 10 double-spaced, typewritten pages), not counting citations or pictures. You should use this increased length to make a more thorough examination of the physical concepts involved in your chosen object.

My reason for offering this group term paper option is to encourage the members of a group to talk about physical concepts, using the language of physics, and thus help one another develop their understandings of both physics and the object at hand.

Once you have formed a group and have begun to prepare material on a particular object, you may not break up and write individual term papers on that same object. If your group does break up, you must each begin again on new and different objects.

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Fall 20

Possible Term Paper Topics

A FEW TERM PAPER TOPICS FROM PREVIOUS SEMESTERS *All of these topics can form the basis for a good term paper. This list is not at all comprehensive. It is taken from the topics chosen by students in previous semesters. Some topics are certainly better than others. Some depend on physical concepts not discussed in this semester's material and may be difficult for you to do well. There are many other fine topics that do not appear below. -- Lou Bloomfield*

Acetylene Lamps	Acoustic Guitars	Aerosol Cans	Aerosol Sprayers
African Drums	Air Brakes	Air Hockey	Airbags
Amusement Park Rides	Archery	Artificial Hearts	Audio Speakers
Ball Point Pens	Ballet	Baseball Pitching Machines	Basketball
Basketball Shoes	Beautification	Beer Kegs	Beserker
Bicycle Helmets	Billiards	Blimps/Dirigibles	Blood Circulation
Blowguns	Boats	Bobsledding	Boomerangs
Bowling	Breakdancing	Bungee Jumping	Burglar Alarms
Butane Lighters	Cable Cars	Can Openers	Cannons
Canoeing	Capuccino Machines	Car Accidents	Catamarans
Catapults	Cell Phones	Chainsaws	Cheerleading
Clouds	Coffee Makers	Combines	Compound Bows
Congas	Croquet	Crossbows	Crumple Zones
Curling Irons	Dancing	Darts	Dehumidifiers
Discus	Dishwashers	Diving Boards	Doorbells
Drums	Electric Blankets	Electric Fencing	Electric Guitars
Electric Irons	Electric Lawnmowers	Ergometer	Escalators
Espresso Machines	Fax Machines	Field Hockey	Fire Alarms
Fire Engine Water Pumps	Fire Extinguishers	Fishing	Fishing Poles
Flip-Flops	Flutes	Fly Fishing	Foosball
Football	Geothermal Heating And Cooling Systems	Gliders	GPS
Golf	Guitars	Gumball Machines	Guns

Gymnastics	Gymnastics Vault	Gyroscopes	Hair Dryers
Hammocks	Hang Gliders	Harpsichords	Helicopters
High Jump	Holograms	Hot Tubs	Hot Water Heaters
Hover Craft	Human Hearts	Humidifiers	Humidifiers
Hurdles	Hurricanes	Hydraulic Theatres	Hydrofoils
Ice Cream Makers	Ice Hockey	Innertube Water Polo	Jai Alai
Javelin Throwing	Jet Skis	Judo	Jump-Starting A Car
Kayaks	Kites	Lacrosse	Lava Lamps
Lawn Mowers	Lawn Sprinklers	Locks	Luge
Mechanical Pencils	Metal Detectors	Microphones	Motorcycle Jumping
Mousetraps	Night Vision Equipment	Oboes	Oscillating Fans
Overhead Projectors	Paddle Ball	Paint Sprayers	Paintball Guns
Parachutes	Pencil Sharpeners	Percolators	Pez Dispensers
Phonographs	Pianos	Pinball Machines	Ping-Pong
Pneumatic Screwdrivers	Pogo Sticks	Pointe Ballet	Pole Vaulting
Polgraphs	Polo	Pool	Pool Filter Systems
Popcorn	Potato Guns	Printing Presses	Professional Wrestling
Prosthetics	Punting	Racquetball	Radar Guns
Radar	Radiators	Record Players	Remote Controls
Revolvers	Rifles	Rock Climbing	Rollerblades
Rowing	Rugby	Running	Running Shoes
Sailboats	Sailing	Scissors Jacks	Seatbelts
Seismographs	Sewing Machines	Ships	Shot Put
Shotguns	Skateboarding	Skiing	Skydiving
Sleds	Slinkys	Smoke Detectors	Snowboarding
Soccer 0	Solar Heating	Sonar	Space Heaters
Speakers	Speech	Speedometers	Spray Cans
Springboard Diving	Stage Lighting	Staplers	Stealth Jets
Steam Engines	Steam Locomotives	Submarines	Sunglasses
Surfboards	Surfing	Swimsuits	Swingsets
Tattoo Pens	Tennis	Thermos	Thunderstorms
Toaster Ovens	Toasters	Toilets	Tornadoes
Torpedoes	Tower Cranes	Toy Cars	Track And Field
Trebuchets	Trumpets	Tubas	Ultralights
Umbrellas	VCRs	Vending Machines	Voice
Volleyball	Wakeboarding	Washing Machines	Water Bongs
Water Clocks	Water Guns	Water Pumps	Water Skiing
Water Wheels	Weight Machines	Weightlifting	Wind Surfing
Wind Tunnels	Windmills	Winter Coats	Wrestling
Xylophones	Yo-Yos		

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at
The University of Virginia
http://rabi.phys.virginia.edu/105
Fall 20

Forbidden Term Paper Topics

The following objects or topics are covered extensively in the lectures and textbook for Physics 105 and Physics 106. You would have difficulty writing a paper on one of these subjects that is truly your own work. It would be just too easy and too tempting to copy my approach, my thoughts, even my words. My lectures and notes should be only part of the reference materials you use for your term paper. Find an object that I do not discuss directly in depth and use similarities between your object and some of mine to identify the physical principles that make your object work. -- Lou Bloomfield

Air Conditioners	Air Purification	Airplanes	Audio Amplifiers
Automobile Engines	Automobiles	Balloons	Baseball
Batteries	Bicycles	Bumper Cars	Cameras
Carousels	CD or DVD Players	Centrifuges	Clocks
Computers	Electric Motors	Electrical Power Distribution	Electrical Power Generation
Electronic Air Cleaners	Elevators	Falling Balls	Flashlights
Fluorescent Lamps	Frisbees	Glass	Heat Pumps
Incandescent Light Bulbs	Knives	Lasers	Laundry
Magnetic Resonance Imaging	Magnetically Levitated Trains	Medical Imaging	Medical Radiation
Microscopes	Microwave Ovens	Nuclear Reactors	Nuclear Weapons
Oil Refineries	Optical Fibers	Paint	Pipe Organs
Plastics	Radio	Ramps	Refrigerators
Rockets	Roller Coasters	Scales	Scuba
Seesaws	Skating	Sunlight	Swimming
Tape Recorders	Telephones	Telescopes	Television
The Sea	Thermometers	Thermostats	Vacuum Cleaners
Violins	Water Distribution	Water Faucets	Water Purification
Water, Steam, and Ice	Wheels	Woodstoves	Xerographic Copiers

PART 1: DISCUSSION OF PHYSICAL CONCEPTS AND PHYSICAL PRINCIPLES

- ❑ The paper is extensive in its discussions of physical issues involved in the object.
- ❑ The paper frequently discusses physical issues involved in the object.
- ❑ The paper discusses physical issues involved in the object.
- ❑ The paper occasionally discusses physical issues involved in the object.
- ❑ The paper rarely discusses physical issues involved in the object.
- ❑ The paper never discusses physical issues involved in the object.

PART 2: PARTICULAR ACHIEVEMENTS OF THE PAPER

- ❑ Well structured so that the reader has a good sense of where the paper is heading.
- ❑ Well written so that the paper is pleasant to read.
- ❑ Nicely packaged, enhancing the content without wasting words.
- ❑ Well thought out so that it appears complete and thorough.
- ❑ Degree-of-difficulty: your topic was especially difficult and your grade has been raised accordingly

PART 3: FLAWS IN THE PAPER

- ❑ Too much description (a small amount is fine).
- ❑ Too much historical perspective (a small amount is fine).
- ❑ Too much packaging (packaging is the condiment, not the meal).
- ❑ Too little attention to physics and physical issues of how the object works.
- ❑ Mistakes in the application or understanding of physical principles.
- ❑ Vague in the application of physical principles to the object.
- ❑ Too short (content substantially less than 5 pages).
- ❑ Too long (paper, excluding figures, substantially more than 5 pages).
- ❑ Mistakes in grammar and/or spelling significantly detract from the paper.
- ❑ Poorly written, making it difficult to read.
- ❑ The paper fails to give the reader a clear overall picture of what is being discussed.
- ❑ The paper has little or no structure and rambles.

PART 4: THE GRADE (Before deductions for lateness)

- ❑ **A+** (93.3) An extensive, accurate, and comprehensive explanation of the physical principles that make the object work, nicely packaged in an unusually readable paper.
- ❑ **A** (90) A good, accurate, and comprehensive explanation of the physical principles that make the object work. Well structured and with very few flaws.
- ❑ **A–** (86.7) A good, accurate, and fairly thorough explanation of the physical principles that make the object work. Well structured and with few flaws.
- ❑ **B+** (83.3) An accurate explanation of most of the physical principles that make the object work. Only minor flaws.
- ❑ **B** (80) A fairly accurate explanation of many of the physical principles that make the object work. Only minor flaws.
- ❑ **B–**(76.7) A fairly accurate explanation of some of the physical principles that make the object work. The paper includes some significant flaws.
- ❑ **C+** (73.3) An adequate explanation of a few of the physical principles that make the object work. The paper includes some significant flaws.
- ❑ **C** (70) The paper largely avoids explaining the physical principles that make the object work and includes some significant flaws in any such attempts.
- ❑ **C–** (66.7) A paper that completely avoids explaining the physical principles that make the object work and is significantly flawed in general.
- ❑ **D** (60) A paper that completely avoids explaining the physical principles that make the object work and is extensively flawed in general.