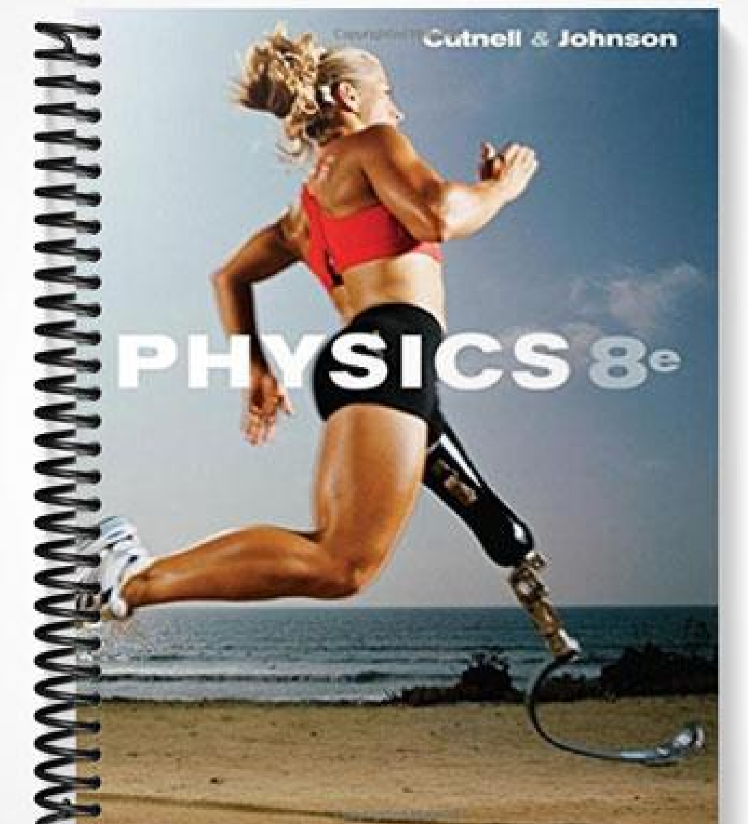
SOLUTIONS MANUAL



WILEY

Instructor's Resource Guide

to Accompany

Physics

by

John D. Cutnell & Kenneth W. Johnson

Eighth Edition

David T. Marx

Physics Department
Illinois State University

PREFACE

Resources: *More than an Instructor's Guide*

If this is your first time using Cutnell & Johnson's *Physics*, welcome. The text has enjoyed being the number one algebra-based physics text for more than 15 years. A quick glance of the table of contents reveals that it has been organized in the now standard sequence, but a closer look within reveals the features that have helped make this the leading college physics text. The book is enjoyed by students for its readability, smart design, and thorough explanation of concepts and problem-solving strategies. Features that instructors appreciate are the careful development of physical principals, reasoning strategies, conceptual examples and questions, and thought-provoking homework problems with a range of difficulty. Students will appreciate the vast array of supplementary material available on the *Student Companion Website* at www.wiley.com/college/cutnell and through *WileyPLUS.*

The things that I felt instructors, beginners or veterans, would want in an instructor's guide are:

- ▷ tips for general course management (syllabi, policies, grading, exams, etc.)
- ▷ a comprehensive guide to the internet and its physics resources
- ▷ advice on using lecture demonstrations, computers, and audio/visual technologies
- ▷ teaching strategies – including implementing interactive classroom techniques
- ▷ tips for getting the most out of the instructor's supplementary text materials

Other features that have been retained include: lecture planning and notes, a textbook conversion table that compares the leading algebra-based physics texts, a list of available transparencies, a homework problem map from the seventh to the eighth editions of the text, films, lecture demonstrations, computer simulation programs, and suggested usage of the text.

A discussion of physics teaching strategies can quickly turn into a heated debate. Every instructor develops his/her own teaching method or style from experience as both student and educator as well as their own uniqueness as human beings. Some people are more attuned to the modes in which information is communicated and learned, make careful mental notes of what works or doesn't, and continually seek better methods. Others enter into teaching without ever having thought much about it and simply review the text in a simple lecture format with little additional effort. As we all know, the spectrum is broad indeed. The approaches and advice given in this book are naturally affected by my own biases. In preparing this manuscript, information has been drawn from a number of sources including the instructors who taught me, past and present colleagues, e-mail discussion groups, selected physics education literature, and resources available on the internet.

Dedication

This book is dedicated to the exceptional people who move us to new levels of understanding of both ourselves and the universe we live in and ask us to find the very best in ourselves. Two individuals, Frank R. Valentine and Henry John Deutschendorf, Jr. have been two such people in my life.

Acknowledgments

I am indebted to John D. Cutnell and Kenneth W. Johnson for their continued support, ideas, and inspiration. Many thanks also go out to the many internet colleagues mentioned above who share in the joy of teaching and in the love of physics; your sharing of knowledge, sometimes in heated debate, gave me many insights (and, occasionally, laughs). As always, it has been a pleasure to work with all of the people at John Wiley & Sons, but special thanks go to Stuart Johnson, Geraldine Osnato, and Aly Rentrop.

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CHAPTER 1

Getting Started: *Course Organization*

This chapter is meant to help both experienced and beginning instructors with various aspects of course organization and presentation. The chosen topics are wide-ranging, but not comprehensive. Much of the discussion naturally comes from my own experience both as a student and as an educator. The information also comes from discussions I've had with other educators and students as well as from various e-mail discussion groups. Therefore, because of the subjective nature of the material, there is always room for discussion about the best way to handle a particular course policy or teaching approach. Alternative approaches are suggested, wherever it is possible. I hope you'll find value in the following pages and information that will make your course run more smoothly. As educators, we all try various methods to instruct effectively. Some of these work; and some do not. My only advice when it comes to choosing an approach to teaching is this: *always seek out ways to improve your teaching, find out what works for you and your students and discard the rest, and try not to lose your enthusiasm along the way.*

Getting Started...

Course Planning and Policies

The semester is starting next week and you are just starting to think about the algebra-based introductory physics course you've been assigned to teach. Perhaps it's one of several courses you'll be teaching. If you've taught the course before, perhaps you've thought of some new things you'd like to incorporate, or you are looking for ways to avoid some of the problems you have had in the past. If you are new to teaching, this section will help point out some of the pitfalls of teaching. In either case, one quickly realizes that there's more to teaching than just preparing and delivering lectures. This section will point out these pitfalls and suggest ways of avoiding them. There is no substitute for good course planning; and this time is well spent before the course gets underway because it will help minimize policy-related problems that can interfere with both teaching and learning.

Good course planning does not begin with "course content," but rather it begins by asking the right questions…

Here are some questions you may want to consider in starting your course planning:

1. What are my goals for the students in the class?
2. What are the backgrounds of the students? What are their needs?
3. Who are the stakeholders in my course?
4. Are there any new teaching strategies that I want to try?

5. How do I want to utilize graduate assistants? (*if applicable to your institution*)
6. What are some things that I can do to maintain a high rate of attendance throughout the semester?
7. Will the assigned homework problems be graded? Should I use multiple choice answer sheets or grade the content of each problem? What about web-based homework?
8. How will the overall grade be determined? What will the initial grading scale be and should a grading curve be used?
9. How can I use lecture demonstrations, computer simulations, and audio/visual resources to improve the course?
10. What chapters do I want to cover? Which sections can be omitted? Which is more important, depth or breadth?
11. How many exams (quizzes) should there be?
12. To what extent do I want to use the internet? How can I effectively use a class website? Should I set up a class listserv? What about using online courseware? WileyPlus?
13. How will I handle cheating and prevent it from occurring?
14. Are there any materials I want to put on reserve at the library?
15. What items should students buy other than the textbook? Do I want to specify the type of calculator students may use?

Course Goals

The algebra-based physics course is one opportunity we have as physicists to reach out to non-scientists and to prove the value that physics can have for everyone. It is about public relations as much as it is about education. Our goal is not to turn everyone into a physicist, but rather to start individuals on the road to critical thinking, to better problem-solving abilities, and to become better citizens in this increasingly technical world. Long after students leave our courses, they may not remember all the concepts and equations, but they will remember whether or not they enjoyed the course and, perhaps, they will recognize some of the tools that they carry with them and use and the value of physics.

Here are some goals to consider:

* to dispel the popular notion that physics is only accessible to smart people and to show that physics is interesting, useful, and valuable (physics is fun and cool) to everyone
* to dispel the popular notion that physics is just a collection of equations used to solve obscure problems
* to challenge students to improve their abilities to reason, to think critically, and to solve problems
* to help students gain conceptual understanding of the physical universe by studying the interrelationships between the concepts that are the framework of physics and to apply mathematical tools as an aid to understanding those relationships

After you've thought through your goals, write a letter to your students (which you may consider to include on your syllabus) that expresses your attitude about physics and the course as well as your goals for the coming semester. With these overarching goals set, consider how each lesson can fulfill these goals as your create your lesson plans. Make students aware of the learning goals as you move through the lessons. We have the big picture of what the course is, but students do not, unless you show them. We certainly want students to recognize the importance and interconnectedness of physical concepts and laws. They cannot do this alone.

Students and Their Needs

Students come into the physics classroom with different backgrounds, levels of ability, preconceptions, reasons for taking the course, and needs. In my algebra-based physics courses, I've had students from a spectrum of majors including: biology, pre-medical, pre-veterinary, computer science, philosophy, art, administration of justice, history, engineering technology, humanities, continuing education, pre-law, education, and the undecided. Students have ranged from seventeen to sixty-eight years old and have represented nations from all continents. With all of this diversity, one cannot possibly account for, or address, all of the varied life experiences of students, but there is always some common ground on which the entire course can be built. This is a necessary first step; and it must occur as early as possible in the course or students will be quickly left behind, feel alienated, and drop out. The easiest way to do this first step is to point out that you recognize the differences in backgrounds, abilities, preconceptions, reasons for enrolling the course, and needs. Point them out and discuss as many of them as you can. The students will know that you understand and are accessible. Tell them your goals and your plan for helping them meet the challenge you've laid out for them.

Respect the individuality of students. Take time to learn their names and something about each of them, whether you have a class of thirty or two hundred. Students will be more responsive, feel less inhibited about asking questions, and make a greater effort to succeed in the course if you show you care about them and their needs.

Most students take the course because they are required to take it as part of the requirements for their major. Point out that there is a definite reason why physics is required for their majors and that they are expected to gain certain skills in this course that they will probably not get anywhere else. Often, students are under pressure to achieve a particular (high) grade in the course, especially pre-med. or pre-vet students. The problem then becomes moving the students away from their focus on grades to a focus on learning. Unfortunately, in this era of diminishing standards and grade inflation, students are generally not shown a correlation between doing the work to learn and grades. They also want to fall back on varied study habits that may work against their learning physics.

Set your standards as high as you like, students can be motivated to rise to the level you set (with enough guidance and assistance from you, teaching assistants, and other students). Reassure them that everyone has an equal chance of succeeding in the course (the meaning of *success* is subjective), but not everyone will get an A. The reward for everyone is whatever they are able to carry with them from the class, not the grade. I tell students that they will get through the course, complete their majors, and get their degrees; but then I ask them what will make them stand out from the crowd after graduation when they are trying to get their first jobs or a year after starting that job? The answer isn't their physics grade or their GPA, but rather the skills they carry with them that others didn't bother to do the work to achieve. Sure, students will come to the course with unrealistic expectations ("I can avoid going to lecture by getting notes from someone else, then read the notes five or six times in the two hours before the exam, skim the text, and get an A."); and we can't expect to reach everyone in a class of two hundred with our message, but it is well worth the effort.

I've mentioned the above philosophy to some colleagues and some have asked, how do you deal with students that come from poor educational backgrounds and lack necessary math and/or language skills? My view is that it is *my job* to teach, not just physics, but also anything else that will help the student understand and learn the material better. I give my students as much time in my office as they need. I let them know that I'm always available for their questions about anything at all (not just the next homework assignment or quiz). I've used the pronoun "I" in the previous few sentences because I know this isn't for everyone. Many instructors have too many obligations outside of the classroom, have only specific office hours, and cannot find more time for students. There's nothing wrong with that approach either. At least point the students to a place where their questions can be asked and answered, such as a tutoring center or a graduate assistant's office.

For an instructor, it's easy to forget that students are taking a number of other courses and have responsibilities to each. Students tend to only make an effort toward those things that affect their grades and, generally, this is done at the last possible moment. If you want students to change a behavior, make it part of their grade.

Course Content

Each instructor sets his or her goals for the students in the course; and depending on those goals, the amount of coverage and the order of the topics must be determined. You may have 75 hours of contact time to accomplish these goals within the academic year. The text contains 32 chapters of material, organized in the somewhat standard sequence: mechanics, thermal physics, waves, electricity and magnetism, light/optics, and modern physics. To cover the entire book, one would use only two to three hours of contact time per chapter. This can be done, but few instructors probably attempt it; and it may lead to frustration for many students. [For students preparing for the MCAT, it is important to cover all of the major topics in the book to some extent. I had one student come back after the MCAT and thank me for getting through Chapter 32 because two questions on the exam came from the material that we had just discussed in class two weeks before the MCAT.] Material in the text that may be omitted with little impact to the overall development of the material is either placed in separate sections, denoted with an asterisk, or at the end of a main topic section. The section below on Reading Quizzes may provide one way to cover more material. This Resource Guide provides suggested schedules for both the quarter and the semester systems.

Some people argue that college physics courses have become a survey of topics without the necessary depth to provide an understanding of what physics is about or the scientific process that allows new knowledge and understanding to be acquired. The ideal then is to find a balance between breadth and depth that meets both the goals of the instructor and the needs of the students. An approach to maintaining a sense of structure to the course without physics appearing to be just an encyclopedic compilation of physical phenomena is to follow the connection between the various topics via the *Concepts at a Glance* feature. The course planning document of this Resource Guide is designed as an aid to your course planning and includes a description of the *Concepts at a Glance* figures in each chapter. All of the sections of each chapter of the text are listed as well as teaching objectives, available transparencies, internet resources, laboratory experiments, and lecture demonstrations.

Teaching Assistants

Teaching assistants (TAs) can be both a benefit and a hindrance to teaching. One thing that we may lose as instructors in using teaching assistants is the ability to directly monitor students' progress on homework assignments, quizzes, and laboratory exercises. We may not see how students interpret problems, how they answer them, nor hear the questions they are asking. How can we gauge our effectiveness in teaching without being in touch with our students?

Teaching assistants can lessen an instructor's burden by doing grading, supervising laboratory sections, handling tutoring sessions, conducting discussion (recitation or quiz) sessions, and proctoring exams. Using TAs can also lead to problems. For example, if more than one person is involved with grading, there will likely be inconsistencies in grading that students will notice. Another problem can arise if the assistants do not attend the lectures. Students in tutoring or discussion sections may be confused by assistants using notation or explanations that differ from those used in class or in the text. Requiring that everyone use the notation and language in the text will minimize confusion.

To further reduce potential problems, meet with the assistant(s) and discuss your approach to teaching, course policies, grading procedures, and your expectations of them. Ask them to attend your lectures. Ask them to read the text before meeting with students to discuss the current material. If they teach laboratory sections, ask them to perform the experiment (individually or as a group) before attempting to lead others through it and to examine each experimental station before class time.

Quizzes, Tests, and Exams

No matter which word you choose *quiz*, *test*, or *exam*, nothing elicits a student's fear response more quickly than having to take one of these. The connotative meaning of these three words varies, but the word *quiz* seems to be the gentlest. There are many ways to assess student learning over the course of a semester. I'll try and mention as many ways as I can think of in the paragraphs that follow, but here is how I conduct testing in my classes: a 30 minute quiz is given every other week. This results in six or seven quizzes per semester; and lowest quiz score is not counted toward the course grade. The quiz covers one or two chapters and is divided into two parts: conceptual questions (two or three) and problems (two or three). For the conceptual questions, students are asked to write a short answer (no fill-in-the-blanks or true/false-type questions). For the problems, students are asked to show how the problem is set-up (drawing and/or free-body diagram), to show and apply the correct equations for the situation, and to choose the correct units. Students are provided the necessary equations and constants for the quiz. The final *exam* is comprehensive; and students are allowed to use their handwritten or typed class notes. Students may also use a non-programmable, scientific calculator (see the discussion on calculators below) for both the quizzes and the final exam.

Reading Quizzes

If you want students to actually read the text, then make it part of their grade. You can assign two, three, or more sections of the text for students to read before each lecture. If a short quiz is given at the beginning of the lecture period or online, students will have a good idea before coming to lecture about the material. This can free up lecture time to go more in depth on topics, spend more time on difficult concepts, to do lecture demonstrations, or any of the interactive techniques described in the section on the interactive classroom in this Resource

Guide. I have written a set of multiple-choice Reading Questions that is available on the Instructor's Companion website for the Cutnell & Johnson *Physics* text.

Number of Tests

Because of large class sizes, many instructors prefer to give only two or three exams, including the final. Unless these are given in a separate section, one has to give up two lecture sessions to give these exams. Six or seven quizzes require about the same amount of lecture time, but students are under less stress because they believe they have a greater chance at succeeding in the course when there are seven quizzes than they do if they have two mid-term exams. Everyone has a bad day from time to time when we're just not at our best performance for one reason or another. With several quizzes, a student can have one such bad day without seriously affecting his or her chance at proving herself/himself over the course of the semester (especially if the lowest grade isn't counted). It's really just an illusion since the same number of questions are asked and the same number of points are given whether quizzes or exams are given. The difference here is that students are more comfortable, less fearful, and more likely to focus on the content of the test and spend less time dwelling on whether or not they will pass it.

Multiple Choice versus Written Tests

Again, if saving time is a necessity, the choice is clear. Multiple choice (MC) tests are graded by computer and the results are immediately returned with all the statistical information one could ever want. MC test grading, therefore, doesn't have the subjectivity or time demand that grading of a written test has (especially if more than one grader would be used).

A test bank to accompany the text that contains over 2200 multiple choice questions is available on the Instructor's Companion website. The questions are both conceptual and quantitative and have three levels of difficulty. The questions can be used for either multiple choice or written tests.

I prefer to use written tests for the following reasons:

* I can get an idea of a student's thought process on conceptual questions since the answers are in her or his own words. Adjustments to the manner in which concepts are introduced in lecture may then be made to clear up recurring misconceptions.
* I can write comments directly to the student suggesting ways to improve their performance. I can even give direct praise to a student that seems to really understand the material well or has come up with an answer that I had not considered, but is nevertheless correct.
* I can see if the student is using a viable problem-solving approach and give partial credit for all correct steps. On a multiple choice test, credit is all or nothing. The scenario often occurs that a student understands the problem, takes a correct approach, but then a small math error occurs (or the wrong button is hit on a calculator), and the wrong answer is obtained. [Some MC test systems can be set up to give partial credit for specific wrong answers.] Sometimes, the student merely shades in the wrong circle on the answer form.
* In looking over the tests, one can easily see which students are doing well and which students need help (and exactly what kind of help is needed). A short discussion with the student in need of help often further clarifies the problem and leads to a satisfactory resolution. If a "drowning" student goes unnoticed, he or she will likely drop the course or be consistently absent and fail it.

Open- versus Closed-book Tests

Memorization has never been a cornerstone of physics. Most physicists value conceptual understanding and problem-solving skills above memorization. We do tend, over time and repeated encounters, to remember physical constants, solutions to particular problems, mathematical formulas, equations, the particular wording of a physical law, etc. A student generally doesn't have the necessary time to have repeated encounters with material within the course to achieve that kind of familiarity, so for tests, instructors usually choose a method to help the student with lists of physical constants, formulas, and equations.

Here are some methods (listed in order of increasing openness):

A list of equations and physical constants is given to the students along with the test. Some instructors include additional equations or constants that are not applicable to the material on the test.

A single sheet of paper (or some fraction) is prepared by the student and may include anything the student thinks will be useful. Instructors sometimes place limits on what may be on the sheet, such as: "no solved problems" or "no photocopies."

Students are allowed to use their written class notes. Presumably, these notes contain all necessary constants, equations, and examples presented in lecture. Students are thus encouraged to maintain complete and well-organized notes. Students may also be allowed to use their own homework assignments. Photocopies should not be allowed because it does not encourage the student to read the text, to attend lecture, to think about the material, or to keep a notebook. If a student has written out their notes (even copying portions of the text), the information has at least has passed through his(her) brain (at least once) and onto the paper.

Students are allowed to use the entire textbook, but they may not use any written notes or homework assignments. This gives students all available equations (including the mathematical formulas in the appendix) and physical constants. Students must know their book well in order to find the needed information quickly.

Students may use the textbook, their notes, and homework assignments.

The greater the degree of openness of the test, the more students will rely on that openness and do less preparation for the test. Students who are ill-prepared can be observed taking an open book test, loudly flipping pages and feverishly searching their (entire) text for an equation that looks like it will work or an example problem that resembles the test question. I warn my students time and again about not relying too heavily on the openness, but rather to view their notes as something to fall back on if something is forgotten or as a security blanket. If they have written their own notes, they don't have to search for something; they know exactly where they have written it. Lastly, as I indicated before, using open notebooks encourages attendance (especially if material is given, and later tested, that is not in the text).

Homework Assignments

Homework is the place where students have an opportunity to be challenged and to learn physics. Students, of course, do not realize this (in general); and many seek ways to minimize their effort on homework assignments. The actual effort is proportional to the weight the homework has in computing the course grade and the seriousness with which the instructor treats the assignments. Therefore, the instructor must determine how much of his or her time will be put into grading the assignments. One time-saving solution is to use the multiple choice homework answers provided in the *Computerized Homework Set* and the accompanying software available on the Instructor's Companion website. You can use these within any of the online homework services, such as WileyPlus!

Students usually work in pairs or in groups on homework assignments (a cooperative effort sometimes fosters learning better than that within a competitive environment). This should probably be encouraged with the warning that students can help each other, but no one should rely on anyone other than himself or herself to learn the physics. Reinforce the notion that learning and corresponding good grades are the result of doing the necessary work. You'll still find students copying answers from each other up until the very last minute (a form of cheating, to be sure), but some will get the message (sometimes after it is pointed out that their "high" homework average does not result in a "high" quiz average). Exact copies are often considered plagiarism; and may be treated as such.

Grades and Curves

> **grade** (grād) *n.* - an unsubstantiated report by a biased and variable judge of the extent to which the student has attained an undefined level of mastery of an indeterminate amount of material.
>
> - adapted from the original version by Paul Dressel, *Basic College Quarterly*, Michigan State University (winter issue, 1957).

Grades are much less meaningful and less important than students believe, but one cannot easily change the popular perception. Some educators fantasize about what it might be like to teach in a world without grades, a place where diligent students are "thirsty" for knowledge. Some instructors and even some schools have been bold enough to attempt teaching without grades, but most of us simply face the day to day inquiries, such as: "What do I need to get an A?" or "What's my grade?" Students are indeed focused on their grades due to both imagined and very real pressures to obtain a particular grade and to maintain a particular grade point average. The instructor needs to be aware of and understand the student's focus on grades and accommodate the student. The student's motivation, desire to work, and performance is partially based on the student's sense of security, often based in knowing his or her current standing in the course.

After the evaluation tools of the course have been selected - homework, class participation, quizzes, tests, laboratory exercises, reports, final exam, attendance, etc. - one then has to determine the value of each of these. This is very subjective as we all tend to value each of these differently. The rule here is, once again, that if you want students to do something, make that item a substantial part of their overall grade. Once decided, the percentages should be indicated on the course syllabus.

The grading scale is always a subject of contention between the instructor and the students. Some instructors select a grading scale such as (90.0 - 100 %) = A, (80.0 - 89.0 %) = B, etc. and do not alter it in any way. Others provide students with a tentative scale and alter it as the course progresses. Sometimes, the scale is revised so that it matches a normalized distribution, or bell curve. The more variable the grading scale is, the less comfortable students feel in the course. They lack the security of knowing their grade at any instant in time as discussed above. My preference is to set a reasonable, but tentative grading scale at the beginning of the semester and tell the students that the ranges may be adjusted by one or two points before the end of the semester. The scale is then finalized at that time. If one prefers to scale the grades, a useful method is given by D. H. White, *Am. J. Phys.* **26**, 643 (1958).

Attendance Policies

An instructor must sometimes be creative in finding ways to maintain a high rate of lecture attendance. Many instructors have the opinion that attendance is the sole responsibility of the student; and as adults, they have the choice to attend or not to attend. Others (including myself) have the opinion that in order for an instructor to do his or her job, the student must be present. The student has the responsibility to attend and the instructor has the responsibility to provide incentives for the student to attend. Students will not want to attend a lecture that is simply a monologue summary of the text. These incentives include:

* *lecture time that is engaging, informative, and interesting* - This is very much dependent on the creativity and personality of the instructor. A great deal of the field of physics education research has been to find alternatives to the traditional lecture format. This Instructor's Guide contains resources and references for incorporating new elements into the lecture format.
* *lecture demonstrations (or audio/visual media or computer simulations) that are educational, relevant, and entertaining* - Many departments have personnel that develop, maintain, and, sometimes, present lecture demonstrations. These people are a tremendous resource and can help an instructor choose and schedule demonstrations throughout the semester (or quarter).
* *a safe environment for asking and answering questions* - Students demand and deserve respect. They need to feel that every question that is asked is important and taken seriously by the instructor. Getting a class to open up can be difficult because of students' past experiences. It's much safer to remain silent than to face the possibility of ridicule. If the class will not interact with the instructor or with other students, lecture time will be spent in monologue. One technique that instructors use is to ask a question and simply wait for the first brave soul to hazard a guess at the answer. Silence can be uncomfortable. Depending on the instructor's response to that brave person, the tone will be set for the rest of the course. Using a classroom response system, allows instructors to get answers from all students in an anonymous way is one way to engage everyone.
* *grade-related measures* - Any grade incentive that is fair will, in general, work.

The Syllabus

The syllabus is a written document distributed to the class at the beginning of the course. It may list general information about the instructor (name, office, phone, etc.), office hours, course policies, the grading scale, homework assignments and due dates, quiz dates, etc. The syllabus is, in essence, a legal contract between the instructor and the students enrolled in the course that the student accepts by remaining in the course. The sense that the syllabus is a contract is becoming more prevalent today than ever before. Departments retain copies of the course syllabus on file in the case that a dispute occurs in the future. Some universities require legal counsel to review the syllabi before they are distributed to the class. Instructors may also require students to sign a copy of the syllabus that is then kept on file.

As is the case with other types of contracts, the participants (i.e. students) will try to find loopholes in the policies and continually ask for renegotiation or special treatment. The instructor's contract is with the entire class, not with individual students. Any changes in an announced policy, therefore, should be carefully considered. Usually, one may simply ask oneself, "Will it be fair to the class if this change is made?" If the answer is yes, then it's unlikely that anyone will complain about the change in policy.

When the syllabus is written, it's a good idea to indicate those policies or due dates that are tentative or flexible. For example, one exam policy might be, "No make up exams will be given unless special arrangements are made before the scheduled exam and the absence is unavoidable and documentation can be provided." The policy is fair because it is available to everyone. Flexibility lies in the fact that the instructor decides whether or not the absence is necessary and agrees to the special arrangement. There is rigidity in that the arrangement must be made before the exam. The instructor should then be prepared to face the student who misses the exam for an acceptable, but unavoidable reason occurring shortly before the exam.

I indicated above that the course policies may be challenged by students, so it's important to have support from the department and the administration for your policies. When considering new course policies, it's a good idea to find out what other instructors' policies are and discuss the pros and cons of them. Discuss the policies with administrators and make use of the school's legal counsel. While some of these steps may seem excessive, it's worth the effort to minimize the potential for disputes that can be carried into a civil court.

Course policies are meant to provide order and fairness in the students' learning environment. Every policy an instructor chooses has a rationale behind it. It's very important to communicate that rationale to the students and discuss each policy when the syllabus is distributed. Give students the sense that the policies are in their best interest and that *fairness* is the metric used in carrying out policies and in adjusting them. **When people understand the rules of the game, they are more likely to play it.**

Example Spring Semester Syllabus

Physics 202 Fall 2009

Lecture Section I M W F 2:00 - 2:50 PM

Instructor: Dr. David T. Marx
Office and Office Hours: Physics Hall 312
Mondays and Thursdays: 9:00 - 11:00 AM
other hours by appointment or drop-in

Required Items:
Text: *Physics* (8th edition) by John D. Cutnell and Kenneth W. Johnson
Lab Manual: *Physics 202 Laboratory Manual*
Classroom Response Pad

e-mail: I will frequently communicate with the class via a listserv that I have set up for the class. I have used your campus e-mail address for the list. If you would rather use a different address, please let me know as soon as possible. Please do check your email for these very important messages.

Reading Quizzes: At the beginning of the lecture period following assigned reading, we will have a very short reading quiz using the interactive response pads. No calculator will be needed for these quizzes. The reading assignments will be posted on the class website well in advance. The three lowest scores for reading quizzes will be dropped.

Class Participation: Much of the course will involve in-class participation, which will be described fully in lecture and will involve interactive questions and group exercises. The three lowest scores for class participation will be dropped. The ID for your classroom response pad must be registered on the class website before January 20.

Homework Assignments: Ten problems are assigned per week. You should work out these problems, primarily on your own. You may also work with others in the class. The homework must be submitted for grading via the link on the class website on or before the due date. The answers must be your own work.

Quizzes: The quizzes will cover material presented in lecture and encountered in homework assignments. The quizzes will be open notes, but closed book. You may use a non-programmable scientific calculator. You will also need to bring a ruler with a centimeter scale. Photocopies may not be included in notes. Seven quizzes will be given, of which, the lowest grade will be dropped. Anyone found cheating on a quiz will receive a zero for that quiz which cannot be dropped. In general, no make up quizzes will be given.

Final Exam: The final exam will cover all material presented in the course. It will be open notes. A scientific calculator may also be used. You will also need to bring a ruler with a centimeter scale. Cheating will result in a zero grade for the exam.

			Grading Scale (*subject to change*)	
Grading:	Reading Quizzes	10 %	A	89 - 100 %
	Class Participation	5 %	B	77 - 88
	Homework	20 %	C	65 - 76
	Lab	10 %	D	53 - 64
	Quizzes	30 %	F	< 53
	Final Exam	25 %		

Example Spring Semester Syllabus (continued)

Homework Assignments

Chapter	Focus on Concepts	Problems	Due Date
16	5, 8, 15	6, 24, 27, 45, 54, 61	Jan. 24
18	5, 11, 13	2, 9, 24, 37, 43	Jan. 31
19	3, 10, 11	2, 11, 17, 29, 36, 49	Feb. 7
20	1, 2, 11, 15	4, 9, 20, 37, 48	Feb. 14
21	2, 5, 11	1, 9, 15, 24, 44	Feb. 21
22	3, 4, 10	1, 12, 27, 32, 41, 49	Feb. 28
24	3, 4, 8	1, 10, 13, 18, 38	Mar. 24
25	1, 5, 7	1, 5, 11, 16, 32	Mar. 31
26	4, 7, 19, 21	5, 10, 23, 29, 36, 54	Apr. 7
27	3, 5, 15	3, 9, 18, 24, 32	Apr. 14
28	3, 4, 7	1, 8, 15, 22, 27	Apr. 21
29	1, 7, 8	1, 14, 20, 27, 36	Apr. 28
30	4, 7, 10	3, 9, 20, 29, 38	May 5
31	3, 11	7, 12, 18, 27, 30	May 12
32	1, 5, 8	4, 6, 16, 27, 33	May 12

Quiz Dates

January 30
February 14 and 28
March 13 and 27
April 10 and 24

Final Exam

Wednesday, May 14, 3:10 - 5:10 PM
Plan to arrive at the lecture hall at 3:00 PM.

On the previous two pages, I've included an example syllabus. The due dates and assigned material are designed to work through all 32 chapters of the text during an academic year consisting of two semesters. The listed homework questions and problems were chosen randomly for this example. Again, this is only an example; your syllabus will be based on your own course organization and policies as discussed above.

Cheating and Its Prevention

You may have noticed specific reference to cheating on quizzes and the final exam on the example syllabus. Cheating occurs despite our best efforts to prevent it. Most often, students cheat because they are overwhelmed and they panic. Some universities have specific policies regarding cheating and it's a good idea to be aware of them and make sure the students understand them. The reputation of the school is dependent on maintaining a high standard of intellectual honesty. Some schools have and enforce an honor code. For a clear listing of cheating and plagiarism instances and policies, see the Carnegie Mellon University policy on the internet at:

http://www.cmu.edu/policies/documents/Cheating.html

If cheating is proven, the punishment is often failure of the course, suspension, or expulsion. Proof is sometimes difficult, however; and many instructors avoid pursuing cheaters because of the difficulty in proving that cheating has occurred and the possible ramifications of being wrong. Cheating can be confronted (and should be) as long as the instructor is discreet. In the few instances that I've discovered cheating, I received a full and sincere apology from the student and he/she accepted the consequences with no argument.

Cheating during a test may occur in a number of ways, but all of them cannot be addressed here. An obvious example would be one student copying information from another student's test (with or without the other student's knowledge). If the test is multiple choice, it is difficult to prove cheating occurred, even if all of the answers are identical. The best way to prevent cheating on multiple choice tests is to have multiple versions with no easy way for a student to determine which version a neighbor has. The questions on all versions may be the same, but both the questions and the choices reordered. In my classes I use the same color paper for all versions so that no one can tell which version they have or their neighbors have. If I use a computer form, all forms are the same color. When students hand in their papers, a quick glance reveals which version they have and they are easily sorted.

If the test is written, detection during grading is very easy if there is a single grader and she is attentive. Students will usually copy a neighbor's paper exactly, with each equation and drawing in the same location on the test. Mistakes are copied as well. How does one tell which student cheated? It's usually easy. The cheater has more erasures, incomplete drawings, numerous sign and math errors (but, miraculously, the correct answer), etc. Often, exponents on the offending student's test are different because they're too small to read at a distance.

If tests are "closed book" and "closed notes," cheating may be accomplished using advanced calculators. An individual may be capable of programming equations, class notes, example problems, etc. into a calculator for use on the exam. This would clearly be unfair to the rest of the class that is abiding by the closed test rule. Some calculators even have infrared transmitters and receivers built in that allow communication between calculators, even across the classroom.

This could allow students to take the test cooperatively, again unfair to the rest of the class. One way to prevent this kind of cheating is to insist on the use of a standard scientific, non-programmable calculator. Another way is to use problems that only require algebraic manipulation and disallow the use of calculators (some calculators can also do symbolic math).

Because many cell phones have built in calculators, students may ask to use their cell phone for that purpose, but be aware that the cell phone may also be used for text messaging.

Another attempt at cheating I have encountered: a student asks for additional credit for an assignment or quiz that has already been graded and returned. Upon closer examination of the paper, one can see that the student has altered either what is written or has added information. This is combated by one instructor by having the course grader draw a line around each item on the paper and then put an "X" through it.

Getting Started...

The Lecture

The lecture is traditionally a rhetorical discourse between an instructor and a somewhat *passive* class. Most classes are conducted in this manner beginning in grade school and continuing through the graduate level. The student is obliged to listen and take notes. The instructor's job in this environment is to lead the class through the material, providing examples and demonstrations that aid understanding. The instructor also *activates* the students by assigning work to be done outside the lecture. At some point, the instructor will evaluate the student's level of understanding and a grade will be issued. We are all familiar with this process and many are fairly comfortable with it. Some physics educators have found the traditional lecture to be ineffective in teaching physics and have sought numerous other approaches. In this section, a modified traditional lecture format will be discussed, but resources for finding other approaches and new ideas for created courses that make use of the findings of Physics Education Research are listed in later parts of this Resource Guide.

The First Lecture

For some, standing in front of two hundred people and speaking for fifty minutes is a frightening experience. For others, it makes no difference if it is a conversation with one person or a speech given to eighty million people on television. We find ourselves somewhere on that spectrum. Becoming an effective educator requires facing any fears we might have and breaking down those barriers that prevent us from communicating fully. Effective teaching and learning requires multi-directional communication with all parties being good listeners as well. The relationship between the instructor and the class begins with the first lecture meeting. Students attending that first lecture make decisions about what their own level of participation will be in that relationship throughout the course. Some will choose to work very hard in the course; and some may choose to withdraw from it.

An instructor should do some things during the first lecture:

- introduce herself/himself
- discuss in general what physics is and, perhaps, what it isn't
- lay out course goals and indicate why they are worth achieving

- provide a syllabus, discuss all course policies, indicate policies that are flexible, and note any due dates or grading scales that are tentative
- give students the idea that the lecture environment is safe by indicating that they are free to ask questions or make comments at any time and that these are welcomed because you prefer the communication be multidirectional
- discuss the use of office hours, tutorials, discussion (or quiz) sections, and the lab sections
- ensure that students have a good understanding of what is required to achieve a given grade in the course
- if she/he is using a non-traditional lecture approach, it should be explained in detail how it works and why it was chosen
- introduce the text, its features, and how it should be used
- any remaining time can be used to begin presenting the course material, to perform some engaging demonstrations, or to show a short film or video

After each of the above items is presented, there should be a short pause for questions or comments from the students.

The Remaining Lectures

The remaining lectures are whatever you have planned for them to be. Each can be self-contained with its own set of goals or it can be a continuing sequence. Since the various topics in physics are not independent of each other, but rather built upon common principles, lectures should begin with a reminder of what was covered in the previous lecture. At the end of the lecture, students can be informed of what will occur in the next lecture. This provides a seamless presentation/exploration of physics.

It's up to the instructor to keep the course moving at a reasonable pace. The pace should not be so fast that students get frustrated trying to write everything into their notes. Students tend to write everything that is written on a whiteboard, PowerPoint presentation, or on an overhead transparency into their notes. No thinking is required, just copying. While I'm on the topic student notes, most students do not take notes when points are made during demonstrations or simulations. Also, if students are asked to take notes during a film/video, they almost never write down anything that the instructor would consider important such as the process that led to a discovery or the evidence that supports a conclusion, or even the conclusion itself. Instead, they focus on trivia such as names, places, and dates. To get around this, I have students fill out a worksheet as they are watching a video, which I collect and give class participation points toward. I then post the worksheet with the answers on the class website for them to use in their preparation for an exam.

We all know that attention spans are short. Patience tends to be short as well. The best way to keep minds from wondering is to periodically switch between any of the following modes: copying notes, giving examples, doing a demonstration, looking at a computer simulation, getting the students to work out a problem, asking and answering questions, telling a humorous anecdote, etc. One can use the ***Lecture Planning and Notes*** portion of this Instructor's Guide to time, plan, and organize lectures.

There's so much more to teaching than could ever be written here or anywhere else. Effective teaching, like "doing physics," is a skill that's acquired through study, practice, and performance. How can we expect any more from our students than we are willing to do ourselves?

CHAPTER 2

An Interactive Classroom

Several years ago, I attended a faculty workshop in Washington, DC sponsored by the American Institute of Physics (AIP) and the National Science Foundation (NSF). When I was invited, I was hesitant about attending because I knew that it was going to be a "brainwashing" in the methods being promoted by those into *physics education research*. Participants were given one of those "clickers;" and we were told we would be using them in the various sessions. I am now very glad to say that I went to the workshop and that the "brainwashing" worked. I came away totally convinced of the tremendous value of many of the techniques that were presented and that it would be relatively easy to implement in my courses. This chapter is about my experience and some resources you can use to improve your courses as well.

You may ask, "Why should I change what I am doing? I went through schools and universities attending the same kind of lectures that I give. I learned." The traditional lecture format is that of the *passive* lecture, where instructors deliver a monologue about the course content, go through some example problems, and perhaps do a few demonstrations. Students in this setting are asked to listen and take notes. The result of all of this is: (1) low attendance, (2) little gain of knowledge, (3) no long-term effect on students' misconceptions, (4) little improvement in conceptual understanding, (5) the inclination to memorize algorithms to get through the course is reinforced, and (6) disinterested students get lost in the crowd. Physics education research (PER) has demonstrated that the things that worked for you and I do not really work for the majority of students. This chapter will focus on some things you can do to make your lecture time more *interactive*. This is especially important for today's students because they are more than ever before under constant media stimulation outside the classroom. We've seen students talking on cell phones non-stop between classes, instant messaging, and listening to their iPods…all at the same time. Then, they come into the classroom; and they are expected to sit passive and listen to a monologue. Their brains shutdown under this relatively low stimulation. On the other hand, we aren't going to turn classrooms into slick special-effects laden Hollywood productions. Therefore, as educators, we need to find ways to stimulate students, encourage active participation, and motivate them to learn.

A few years ago, I was invited to do the day's science lesson for a fifth grade class. The room had about twenty 10 year olds – excited that I would be talking about forces. I said "excited." They were interactive with me – telling me stories from their experiences and asking me questions about mine. They were on the edge of their seats – listening to my every word. That afternoon, I returned to the university and faced another group of twenty, except they were 20-somethings. They were sitting in their seats, staring, and listening (sort of) to what I had to say. They were slouched down in their chairs as if they were watching TV. Their faces were expressionless; and they looked like they hadn't slept in weeks. What a difference 10 years makes! What does it take to undo ten years of passivity to return to an excitement for learning?

People that have been doing passive lectures for a while may argue that they simply do not have time to change what they are doing. There are many other obligations demanding your time, but I would like to show you some things you can do to improve your course, make it more interactive, and more rewarding for you and your students. Because if students aren't learning, why are we wasting so much of our time going through the motions of teaching? The answer is that you can start with some small things that will make a difference and add more interactive components each course offering that will make the course better. The induction of a classroom response system, which will be largely discussed here, is a great place to start.

Classroom Response Systems

We've all had the experience of asking a question of a class and getting no response. Students are often afraid of speaking up in front of their peers. They do not want to look stupid or are afraid of the response they might get from the instructor. Of course, the instructor must always be careful about his or her tone in responding to a student statement or question. Even, if students do respond, it will only be a tiny percentage of the entire class. Suppose you could get 100 % response from your class on every question, how would that change the environment in your classroom?

For more than two decades, a small number of classrooms around the United States included some kind of response system so that instructors could ask questions of students and receive responses from everyone. The early systems were hard-wired and often suffered from technical difficulties. Today, there is a revolution going on because the technologies have advanced to make these systems both easy to use and enjoyable to use. Now, students purchase or are given a device that looks like a TV remote control. These devices communicate with a computer in the classroom via infrared (IR) or radio frequency (RF) signals. These are used to communicate individual responses to the instructor as needed. The computer records each response, which can then be used to award points to the student. Only the instructor knows how a given student responded. Here are some things you can do with a classroom response system:

- take a survey
- reading quizzes
- class participation exercises
- check understanding
- interactive demonstrations
- peer instruction / think-pair-share
- pre- and post-instruction testing

There are probably additional things you will think of to make your classes more interactive as well. In the following sections, the above suggestions will be described and ideas for implementation will be discussed.