# Procedure for Setting Goals for an Introductory Physics Class

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Details at http://groups.physics.umn.edu/physed

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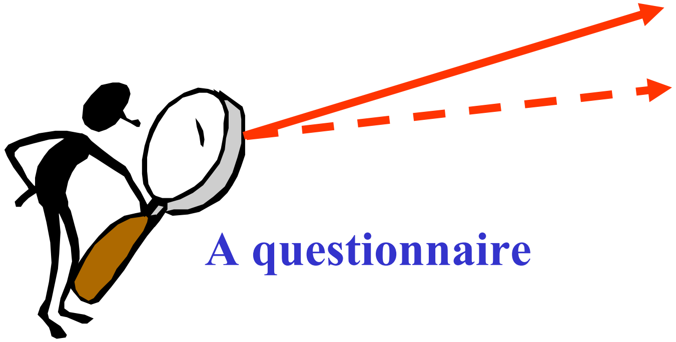
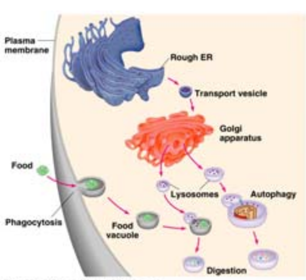
# Setting Goals

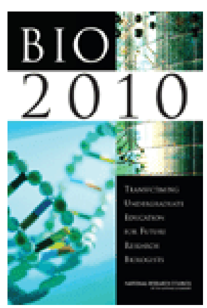


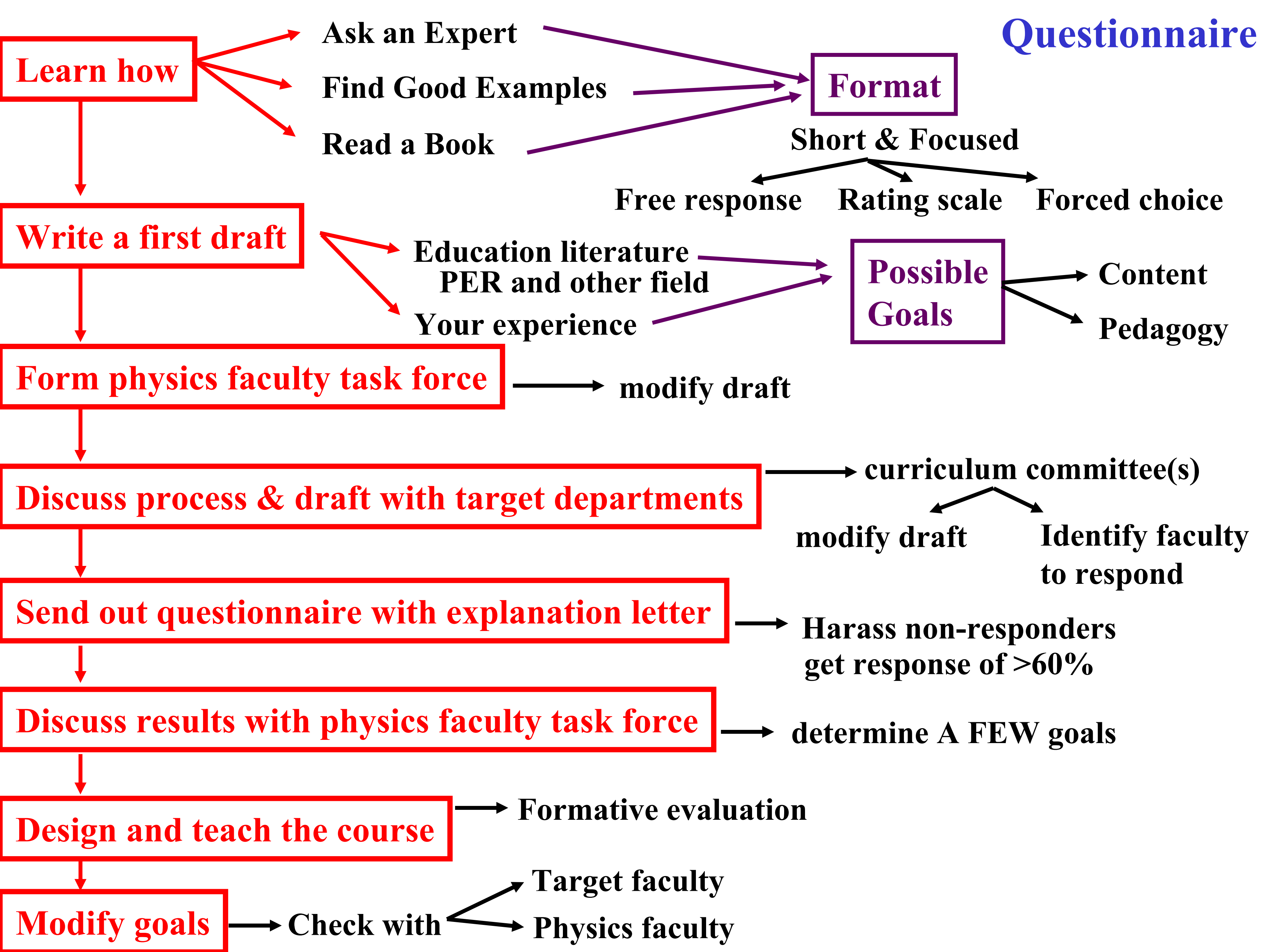
A questionnaire

- Whose Goals?
  - Faculty of Students' Majors
  - Physics Faculty
  - Students
  - Employers
  - Society
- Do they make sense?
  - Student Skill & Knowledge Base
  - Internal Logic of Physics
  - Research Background on Learning
  - Instructional Framework
  - Constraints of Reality
- At what level can you accomplish them?
  - How Much Is Enough
  - Data and Quality Assurance

Physics for Biology Majors




Questionnaire
Learn how
Ask an Expert
Find Good Examples
Read a Book
Format
Short & Focused
Free response
Rating scale
Forced choice
Write a first draft
Education literature
PER and other field
Your experience
Possible Goals
Content
Pedagogy
Form physics faculty task force
modify draft
Discuss process & draft with target departments
curriculum committee(s)
modify draft
Identify faculty to respond
Send out questionnaire with explanation letter
Harass non-responders
get response of >60%
Discuss results with physics faculty task force
determine A FEW goals
Design and teach the course
Formative evaluation
Modify goals
Check with
Target faculty
Physics faculty

# The Questionnaire

## Originally Designed to Change Algebra Based Course. Then Used to Change Calculus Based Course

- **What Goals? – Free Response**
- **When should student take course? – Forced Choice - 4**
- **How many semesters? – Forced Choice - 7**
- **What Goals? – Ratings (with additional free response) – 18 on scale of 1 to 5**
- **What Goals? – Forced Choice - 2**
- **What Content? – Forced Choice (with additional free response) – 44 chapters to choose 26, then choose 4 most important**
- **What Lab Pedagogy? – Forced Choice (with additional free response) – 3 common styles**
- **What Discussion Section Pedagogy?– Forced Choice (with additional free response) – 6 common styles**

# Responding Faculty

**N = 20  (60% response)**

- **Biochemistry, Molecular Biology and Biophysics (5)**
- **General Biology (1)**
- **Genetics, Cell Biology and Development (3)**
- **Ecology, Evolution and Behavior (2)**
- **Microbiology (3)**
- **Neuroscience (3)**
- **Plant Biology (3)**

# Faculty Ratings in Percent – 18 Goals

**Many different goals could be addressed through this course. Would you please rate each of the following possible goals in relation to its importance for your students on a scale of 1 to 5?**

**1 = unimportant** **2 = slightly important** **3 = somewhat important** **4 = important** **5 = very important**

| | 1 | 2 | 3 | 4 | 5 | * | Ave |
|---|---|---|---|---|---|---|---|
| Know the basic principles behind all physics (e.g. forces, conservation of energy, ...) | 0 | 0 | 0 | 17 | 83 | 35 | 4.8 |
| Know the range of applicability of the principles of physics (e.g. conservation of energy applied to fluid flow, heat transfer, …) | 0 | 0 | 9 | 61 | 26 | 9 | 4.0 |
| Be familiar with a wide range of physics topics (e.g. specific heat, AC circuits, rotational motion, geometrical optics, fluids, relativity, …) | 4 | 9 | 48 | 17 | 22 | 13 | 3.4 |
| Solve problems using general quantitative problem solving skills within the context of physics | 4 | 4 | 9 | 43 | 39 | 22 | 4.1 |
| Solve problems using general qualitative logical reasoning within the context of physics | 0 | 4 | 13 | 35 | 48 | 9 | 4.3 |
| Formulate and carry out experiments | 0 | 9 | 43 | 26 | 13 | 0 | 3.3 |

| | 1 | 2 | 3 | 4 | 5 | * | Ave |
|---|---|---|---|---|---|---|---|
| **Analyze data from physical measurements** | 4 | 0 | 26 | 39 | 30 | 0 | 3.9 |
| **Use modern measurement tools for physical measurements (e.g. spectrophotometers, computer data acquisition, timing techniques,...)** | 0 | 4 | 35 | 30 | 26 | 4 | 3.7 |
| **Use computers to solve problems within the context of physics** | 9 | 9 | 35 | 30 | 9 | 0 | 3.1 |
| **Overcome misconceptions about the behavior of the physical world** | 0 | 4 | 24 | 26 | 43 | 17 | 4.0 |
| **Understand and appreciate 'modern physics' (e.g. nuclear decay, quantum optics, cosmology, quantum mechanics, elementary particles,...)** | 0 | 26 | 52 | 22 | 0 | 0 | 3.0 |
| **Provide biological examples of physical principles within the context of physics** | 0 | 9 | 13 | 13 | 65 | 35 | 4.3 |
| **Understand and appreciate the historical development and intellectual organization of physics** | 9 | 30 | 43 | 17 | 0 | 0 | 2.7 |

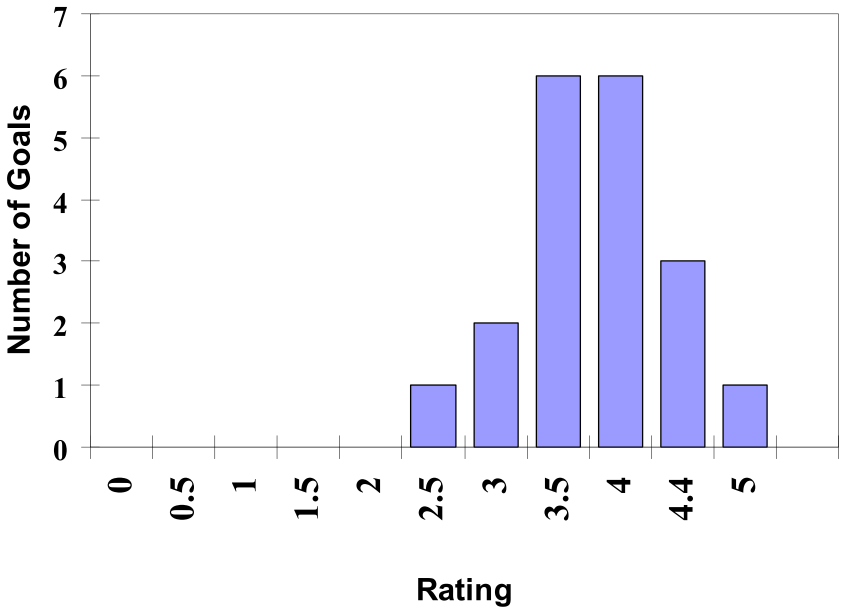
| | 1 | 2 | 3 | 4 | 5 | * | Ave |
|---|---|---|---|---|---|---|---|
| Express, verbally and in writing, logical, qualitative thought in the context of physics | 5 | 0 | 35 | 45 | 10 | 0 | 3.4 |
| Provide real world applications of mathematical concepts and techniques within the context of physics | 0 | 5 | 20 | 45 | 30 | 0 | 4.0 |
| Use with confidence the physics topics covered | 5 | 0 | 40 | 50 | 5 | 0 | 3.5 |
| Apply the physics topics covered to new situations not explicitly taught by the course | 5 | 5 | 20 | 45 | 25 | 5 | 3.6 |
| Prepare students for the MCAT | 20 | 25 | 40 | 5 | 5 | 0 | 2.4 |
| Other goal. Please specify here. | 0 | 0 | 0 | 0 | 10 | 0 | 5.0 |

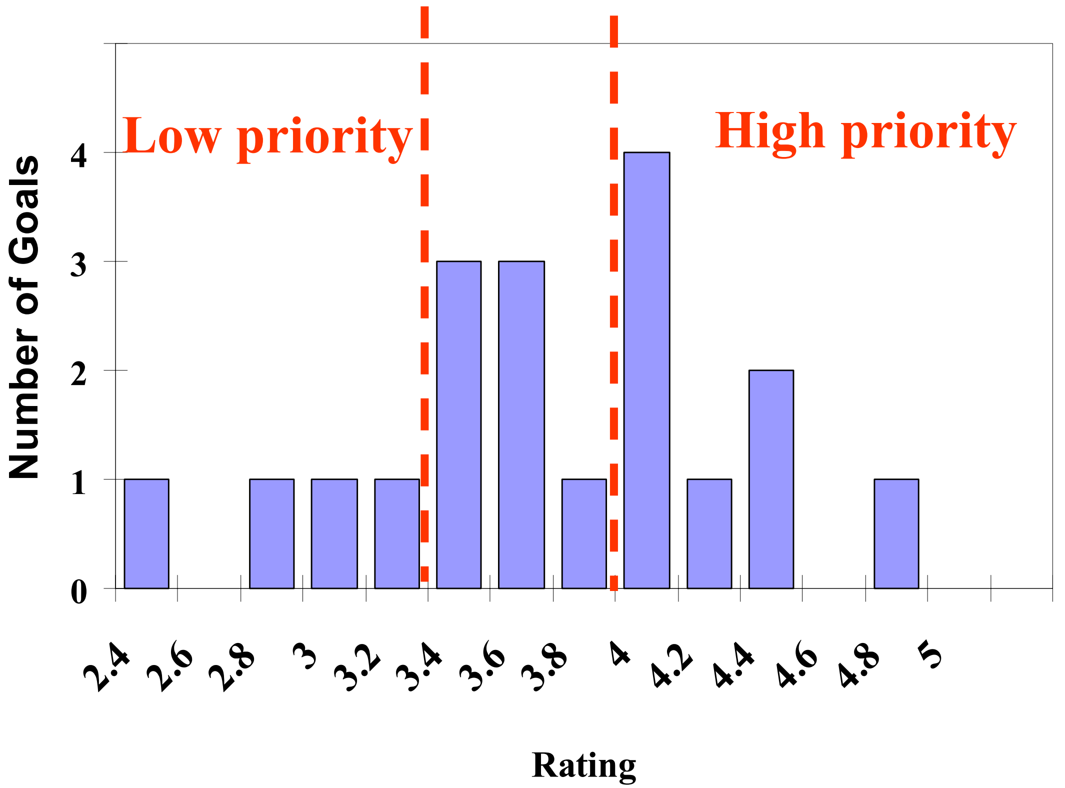
**Please place a star (*) next to the TWO goals listed above that you consider to be the MOST IMPORTANT for your students.**

**Other Goals:**

1. Would prefer bio students take physics as early in their careers as possible, but this is often difficult to arrange.
2. Provide examples of physics within a biological context. (5)
3. Conceptual thinking. Seeing a big picture rather then only memorizing facts. Concept mapping is a useful tool for organizing the details around a main concept or theme. (5)

# Goal Histogram



# Lowest Rated

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Prepare students for the MCAT | 20 | 25 | 40 | 5 | 5 | 0 | 2.4 |
| Understand and appreciate the historical development and intellectual organization of physics | 10 | 25 | 50 | 15 | 0 | 0 | 2.7 |
| Understand and appreciate 'modern physics' (e.g. nuclear decay, quantum optics, cosmology, quantum mechanics, elementary particles,...) | 0 | 30 | 45 | 25 | 0 | 0 | 3.0 |
| Use computers to solve problems within the context of physics | 10 | 10 | 35 | 30 | 10 | 0 | 3.1 |
| Formulate and carry out experiments | 10 | 10 | 40 | 25 | 15 | 0 | 3.3 |
| Express, verbally and in writing, logical, qualitative thought in the context of physics | 5 | 0 | 35 | 45 | 10 | 0 | 3.4 |

## Goals: Biology Majors Course 2003

**Highest Rated**

- 4.9 **Basic principles behind all physics (*1)**
- 4.4 **General qualitative problem solving skills**
- 4.3 ***Use biological examples of physical principles (*2)***
- 4.2 ***Overcome misconceptions about physical world* (*4)**
- 4.1 **General quantitative problem solving skills (*3)**
- 4.0 ***Real world application of mathematical concepts and techniques***
- 4.0 ***Know the range of applicability of the principles of physics***

**Modified survey in response to CBS Curriculum Committee**

## Goals: Calculus-based Course (88% engineering majors) 1993

- 4.5 **Basic principles behind all physics**
- 4.5 **General qualitative problem solving skills**
- 4.4 **General quantitative problem solving skills**
- 4.2 **Apply physics topics covered to new situations**
- 4.2 ***Use with confidence***

## Goals: Algebra-based Course (24 different majors) 1987

- 4.7 **Basic principles behind all physics**
- 4.2 **General qualitative problem solving skills**
- 4.2 ***Overcome misconceptions about physical world***
- 4.0 **General quantitative problem solving skills**
- 4.0 **Apply physics topics covered to new situations**

# Free Faculty Responses - Goals

**1. In your opinion, what is the primary reason your department requires students to take this physics course?**

## Underlying Principles

- To get basics for understanding parts of chemistry, Biochemistry, physiology, other biological disciplines such as cell biology.
- To gain necessary background knowledge about heat, motion, light, & other physical processes to be well-educated scientists.
- The concepts and techniques of Biochemistry rely on understanding physics.
- Physics is basis of the physical interactions which define much of what occurs in biochemistry.
- A number of biological phenomena can't be understood without a feel for the physical principles underlying them.
- So that they will know the principle physical laws that underlie chemistry and biology.

## Application

• To be able to apply physical principles to Biochemistry questions.

• To learn the laws of physics that constrain what organisms do. Also to be able to apply physics in lab settings.

## Problem solving/math

• To understand the basic laws of physics; to be able to apply physical principles to other problems; to overcome fear of math, quantitative approach to science.

• General understanding of how 1st & 2nd order linear differential equations explain behavior of various physical systems (mechanics, thermodynamics, electricity).

• Living things rely on a number of physical principles. Concepts we cover in lecture & techniques/equipment used in the laboratory require an understanding of physics. Physics is fundamental to many biological processes, & develop skills in problem-solving & modeling.

• Provide basic concepts in physics as applied to biological functions; learn how to think quantitatively about these applied physics concepts.

# Content

In two semesters it is impossible to cover every topic in physics. The purpose of this question is to determine your priorities of the topics in the course. Below are the chapter headings from a typical textbook at this level. Please place the integer number of weeks for each chapter that, in your judgment, allows students to understand the material at the level you desire. Each week consists of 3 lectures, 1 discussion section, and a 2-hour laboratory. The total number of weeks should equal 26 to account for a course introduction at the beginning of the semester and a review at the end. Please do not use fractions of a week.

Please place a star (*) next to the FOUR chapters listed above that you consider to be the MOST IMPORTANT for your students.

| | %T | %* | |
|---|---|---|---|
| ✓ | 90 | 15 | Potential energy and conservation of energy |
| ✓ | 85 | 15 | Kinetic energy and work |
| | 85 | 20 | Entropy and the second law of thermodynamics |
| ✓ | 85 | 15 | Electric charge and force |
| ✓ | 85 | 13 | Electric potential |
| ✓ | 80 | 0 | Linear motion |
| ✓ | 80 | 0 | Forces and Newton's Laws |
| ✓ | 75 | 15 | Units, dimensions and vectors |
| ✓ | 75 | 5 | Temperature and ideal gas |
| ✓ | 75 | 0 | Electric field |
| | 75 | 5 | Molecules and gases (e.g. probability distributions of velocity, equipartition) |
| ✓ | 75 | 9 | Mirrors and lenses |
| ✓ | 70 | 0 | Momentum and collisions |
| ✓ | 70 | 9 | Nuclear physics and radioactive decay |
| ✓ | 65 | 0 | Two dimensional motion |
| | 65 | 0 | Gravitation |
| ✓ | 65 | 4 | Currents in materials (e.g. resistance, insulator, semiconductors) |
| ✓ | 65 | 15 | Heat flow and the first law of thermodynamics |
| ✓ | 65 | 0 | Magnetic forces and fields |
| ✓ | 60 | 4 | Geometrical optics (e.g. reflection and refraction) |
| ✓ | 60 | 0 | Diffraction |
| ✓ | 55 | 0 | Oscillatory motion |
| ✓ | 55 | 4 | Currents and DC circuits |

23 Chapters

**21 Chapters**

| | %T | %* | |
|---|---|---|---|
| | 50 | 0 | Rotations and torque |
| ✓ | 45 | 5 | Applications of Newton's laws |
| | 45 | 0 | Angular momentum |
| | 45 | 0 | Gauss' law |
| ✓ | 45 | 4 | Currents and magnetic fields (e.g. Ampere's law, Biot-Savart law) |
| ✓ | 45 | 0 | Interference |
| | 40 | 5 | Fluid mechanics |
| | 40 | 5 | Properties of solids (e.g. stress, strain, thermal expansion) |
| ✓ | 40 | 0 | Capacitors and dielectrics |
| ✓ | 40 | 4 | Maxwell's equations and electromagnetic waves |
| | 40 | 0 | Relativity |
| ✓ | 35 | 4 | Faraday's law |
| ✓ | 35 | 0 | Superposition and interference of waves |
| ✓ | 30 | 0 | Mechanical waves |
| | 30 | 0 | Statics |
| | 30 | 0 | Magnetism and matter (e.g. ferromagnetism, diamagnetism) |
| | 30 | 9 | AC circuits |
| ✓ | 30 | 0 | Atomic physics |
| | 20 | 0 | Quantum physics |
| | 15 | 0 | Magnetic Inductance |
| | 15 | 0 | Particle physics |
| | 0 | 0 | Other. Please specify. |

# Discussion Section Structure

**The discussion sections associated with this course are typically taught by graduate teaching assistants and could be structured in several ways. Please place an 'X' by that structure most appropriate for your students.**

**9 %** **Students ask the instructor to solve specific homework problems on the board.**

**35 %** **Instructor asks students to solve specific homework problems on the board.**

**17 %** **Instructor asks students to solve unfamiliar textbook problems, then gives the solution on the board.**

**17 %** **Instructor asks students to solve "real world" problems individually and write their solution on the board.**

**65 %** **Students work in small groups to solve "real world" problems with coaching from the instructor.**

**9 %** **Students work in small groups to solve conceptual questions with coaching from the instructor.**

**17 %** **Other. Please describe.**

**Other:**

**x: Progression from 2 to 3 to 4 to 5.**

**x: It might be best to start with 1 - perhaps half of the hour - then give the students some "real world" examples to solve.**

**x: Again, I don't think any single approach is ideal on its own.**

# Laboratory Structure

**The laboratory associated with this course is typically taught by graduate teaching assistants and could be structured in several ways.  Please place an 'X' by that structure most appropriate for your students.**

**39%** **A lab with well defined directions explaining how to use a simple apparatus to verify a physical principle.**

**39%** **A lab with a well defined question or problem illustrating a physical principle and minimal guidance about how to use the simple apparatus.**

**30%** **A lab where the students are given a general concept from which they must formulate an experimental question, then design and conduct an experiment from a choice of apparatus.**

**26%** **Other.  Please describe.**

**Other:**
**The first option followed by a lab section in which students design the experiment.**
**Progression from 1 to 2 to 3.**
**I suspect most students would benefit from 1 most.  But the better students (honors?) would find 2 more interesting.**
**A mixture of these approaches.**

# Course Structure

| | |
|---|---|
| **LECTURES** | **Three hours each week, sometimes with informal cooperative groups. Model constructing knowledge, model problem solving framework.** |
| **RECITATION SECTION** | **One hour each Thursday – cooperative groups practice using problem-solving framework to solve context-rich problems. Peer coaching, TA coaching.** |
| **LABORATORY** | **Two hours each week -- *same* groups practice using framework to solve concrete experimental problems. *Same* TA. Peer coaching, TA coaching.** |
| **TESTS** | **Friday -- problem-solving quiz & conceptual questions (usually multiple choice) every three weeks.** |

# The End

**Please visit our website for more information:**

**http://groups.physics.umn.edu/physed/**