Bibliography:

The Complete Problem Solver, http://www.hepumn.edu/~demuth/1251/problem_solving.html.

Heller, Patricia and Heller, Kenneth. (1995). *Workshop #20 Preparing TAs to Teach Undergraduate Courses*, University of Minnesota.

Mayer, R. E. (1983). *Thinking, Problem Solving, Cognition*. W. H. Freeman & Co., New York.

MacMaster. PRS Program: Problem Solving Program Unit 1, Journal of College Science Teaching, May 1984.

Woods, Donald R. (1987). How I Might Teach Problem Solving?, New Directions for Teaching and Learning, 30, 55-71.

Woods, Donald R. PRS Program Unit2: *What is Problem Solving and Background Ideas?*, 2.1-2.3.

Appendix A

PHYSICS (PHYS) COURSES:

PHYS100V Projects (1-2) (FA, SP, SU) Independent study in experimental or theoretical physics for lower division undergraduate students. May be repeated for 2 hours.

PHYS1023 Physics and Human Affairs (FA, SP, SU) The great ideas of physics, together with their philosophical and social impact. Scientific topics include cosmology, relativity, and quantum mechanics. Philosophical and social topics include methods and values of science, problems related to energy sources, and implications of modern weapons. Non-mathematical. Designed for non-science majors. Along with PHYS 1021L, can be used to satisfy a 4-year physical science requirement for a B.A. degree. Students who have received credit in PHYS 2013 and 2033, or 2053 and 2073 cannot also receive degree credit in this course. UNIVERSITY CORE COURSE

PHYS1021L Physics and Human Affairs Laboratory (FA, SP, SU) Laboratory 2 hours per week. Pre- or Corequisite: PHYS 1023. UNIVERSITY CORE COURSE

PHYS1044 Physics for Architects I (FA) The relation between the principles of physics and the practice of building and operating structures. Topics include: The behavior of structures under various loads, the statics and dynamics of fluids, thermal storage, thermal expansion, the greenhouse effect, heat transfer, refrigeration, the energy problem, efficiency in the operation of buildings. One underlying theme is that the self-sufficiency of a building is an important part of architecture. Lecture 3 hours, laboratory 2 hours per week. Corequisite: PHYS 1040L. UNIVERSITY CORE COURSE

PHYS1040L Physics for Architects I Laboratory (FA) Corequisite: PHYS 1044.

PHYS1054 Physics for Architects II (SP) Acoustics, electricity and magnetism, light, and environmental physics. Topics include resonance, acoustical isolation, interference, reverberation time, electrical circuitry with emphasis on power and efficiency, electrical storage, light sources, reflection, refraction, absorption, transmission, color, astronomy (to give perspective to the use of sunlight in architecture), heat, noise, and radioactivity pollution. Lecture 3 hours, laboratory 2 hours per week. Corequisite: PHYS 1050L. Prerequisite: PHYS 1044. UNIVERSITY CORE COURSE

PHYS1050L Physics for Architect II Laboratory (SP) Corequisite: PHYS 1054.

PHYS2013 College Physics I (FA, SU) A non-calculus survey of the principles of physics including mechanics, heat and sound. Lecture 3 hours per week and drill (PHYS 2010D) 1 hour per week. Corequisite: PHYS 2010D and PHYS 2011L. Prerequisite: (MATH 1203 and MATH 1213) or equivalent. UNIVERSITY CORE COURSE

PHYS2010D College Physics I Drill (FA, SU) Corequisite: PHYS 2011L and PHYS 2013.

PHYS2011L College Physics I Laboratory (FA, SU) Laboratory 2 hours per week. Corequisite: PHYS 2010D and PHYS 2013. UNIVERSITY CORE COURSE

PHYS2033 College Physics II (SP, SU) Continuation of PHYS 2013. Topics include electricity and magnetism, light, relativity, quantum mechanics, atomic and nuclear

structure. Lecture 3 hours, drill (PHYS 2030D) 1 hour per week. Corequisite: PHYS 2030D and PHYS 2031L. Prerequisite: PHYS 2013. UNIVERSITY CORE COURSE

PHYS2030D College Physics II Drill (SP, SU) Corequisite: PHYS 2031L and PHYS 2033.

PHYS2031L College Physics II Laboratory (FA, SP) Laboratory 2 hours per week. Corequisite: PHYS 2030D and PHYS 2033. UNIVERSITY CORE COURSE

PHYS2053 University Physics I (FA, SP, SU) Introduction to the principles of mechanics, wave motion, temperature and heat, with calculus. Lecture three hours per week and practicum two hours a week (included in PHYS 2051L). Pre- or Corequisite: MATH 2554. Corequisite: PHYS 2051L. UNIVERSITY CORE COURSE

PHYS2053H Honors University Physics I (FA) Introduction to the principles of mechanics wave motion, temperature and heat, with calculus. Lecture three hours per week and practicum two hours a week (included in PHYS 2051M). Pre- or Corequisite: MATH 2554. Corequisite: PHYS 2051M. UNIVERSITY CORE COURSE

PHYS2051L University Physics I Laboratory (FA, SP, SU) The laboratory includes a practicum component integrating it with the lecture (PHYS 2053) and meets twice a week for two hours at each meeting. Corequisite: PHYS 2053. UNIVERSITY CORE COURSE

PHYS2051M Honors University Physics I Laboratory (FA) The laboratory includes a practicum component integrating it with the lecture (PHYS 2053H) and meets twice a week for two hours at each meeting. Corequisite: PHYS 2053H. UNIVERSITY CORE COURSE

PHYS2073 University Physics II (FA, SP, SU) Continuation of PHYS 2053. Topics covered include electricity, magnetism, light and geometric optics. Lecture three hours per week and practicum two hours per week (included in PHYS 2071L). Pre- or Corequisite: MATH 2564. Corequisite: PHYS 2071L. Prerequisite: PHYS 2053. UNIVERSITY CORE COURSE

PHYS2073H Honors University Physics II (SP) Continuation of PHYS 2053H. Topics covered include electricity, magnetism, light and geometric optics. Lecture three hours per week and practicum two hours per week (included in PHYS 2071M). Pre- or Corequisite: MATH 2564. Corequisite: PHYS 2071M. Prerequisite: PHYS 2053 or PHYS 2053H. UNIVERSITY CORE COURSE

PHYS2071L University Physics II Laboratory (FA, SP, SU) The laboratory includes a practicum component integrating it with the lecture (PHYS 2073) and meets twice a week for two hours at each meeting. Corequisite: PHYS 2073. UNIVERSITY CORE COURSE

PHYS2071M Honors University Physics II Laboratory (SP) The laboratory including practicum meets twice a week for two hours at each meeting. Corequisite: PHYS 2073H. UNIVERSITY CORE COURSE

PHYS2093 University Physics III (FA) A continuation of PHYS 2053 and PHYS 2073. Topics include waves, physical optics, thermodynamics, kinetic theory, and an introduction to quantum mechanics. Lecture 3 hours per week and practicum 2 hours per week (included in PHYS 2091L). Corequisite: PHYS 2091L and MATH 2574. Prerequisite: PHYS 2073.

PHYS2091L University Physics III Laboratory/Practicum (FA) The laboratory includes a practicum component integrating it with the lecture (PHYS 2093) meets twice a week for two hours at each meeting. Corequisite: PHYS 2093.

PHYS220V Introduction to Electronics I (1-18) (FA, SP, SU) Individualized, self-paced laboratory instruction in electronics requiring no previous electronic experience. Topics include basic DC and AC electronics fundamentals. May be repeated for 2 hours. Pre- or Corequisite: MATH 1203 or MATH 1285.

PHYS306V Projects (1-3) (IR) Individual experimental or theoretical research problems for advanced undergraduates.

PHYS3113 Analytical Mechanics (SP) Newton's laws of motion applied to particles, systems of particles, and rigid bodies. Introduction to Lagrange's equations and expansions. Prerequisite: PHYS 2073 and MATH 2574.

PHYS320V Introduction to Electronics II (1-4) (FA, SP, SU) Individualized, self-paced laboratory instruction in electronics, covers topics including semiconductor devices, electronic circuits, and digital techniques. May be repeated for 4 hours. Prerequisite: PHYS 220.

PHYS3414 Electromagnetic Theory (SP) Electrostatics including dielectric, magnetostatics and magnetic materials. Maxwell's equations, radiation theory, and wave propagation. Prerequisite: PHYS 2073 and MATH 2574.

PHYS3544 Optics (FA) Elements of geometrical, physical, and quantum optics. Lecture 3 hours, laboratory 2 hours. Corequisite: PHYS 3540L. Prerequisite: PHYS 2073 or MATH 2564.

PHYS3540L Optics Laboratory (FA) Corequisite: PHYS 3544.

PHYS3603 Introduction to Modern Physics (FA, SP, SU) An introduction to the basic ideas of 20th century physics, with an emphasis on those that form the foundations of modern technology: quantum theory and its application to atomic, nuclear, optical and condensed matter physics. No credit is given toward a B.S. degree in physics. Prerequisite: PHYS 2033 and (MATH 2043 or MATH 2554).

PHYS3601L Modern Physics Laboratory (FA, SP, SU) Experiments illustrating the development and concepts of modern physics. No credit given toward a B.S. major in physics. Prerequisite: PHYS 3603.

PHYS3614 Modern Physics (FA, SP, SU) Introduction to special relativity, statistical physics, quantum physics, and a survey of nuclear and particle physics. Review of thermal radiation, photon, and wave mechanics.

PHYS3923H Honors Colloquium (IR) Covers a special topic or issue, offered as part of the honors program. No more than 3 hours may be offered toward fulfillment of the requirements for the B.S. or B.A. degree in Physics. May be repeated. Prerequisite: honors candidacy (not restricted to candidacy in physics).

PHYS399VH Honors (1-6) (FA, SP, SU) Independent study for physics students enrolled in the honors program. Prerequisite: junior standing.

PHYS400V Laboratory and Classroom Practices in Physics (1-3) (FA, SP, SU) The pedagogy of curricular materials. Laboratory and demonstration techniques illustrating fundamental concepts acquired through participation in the classroom as an apprentice teacher. Prerequisite: PHYS 3114 and PHYS 3414.

PHYS4073 Introduction to Quantum Mechanics (FA) A survey of quantum mechanics from the wave mechanical point of view. Required course for B.S. Physics majors. Prerequisite: PHYS 3614 and MATH 3404.

PHYS4103 Physics in Perspective (SP, Odd years) Human implications of physics, including life's place in the universe, the methods of science, human sense perceptions, energy utilization, societal impacts of technology, and the effect of physics on modern world views. No credit given toward a B.S. major in physics. Prerequisite: PHYS 3603 or PHYS 3614.

PHYS4113 Physics in Perspective (SP, Odd years) Human implications of physics, including life's place in the universe, the methods of science, human sense perceptions, energy utilization, societal impacts of technology, and the effect of physics on modern world views. Credit allowed for only one of PHYS 4113 or PHYS 4103. Prerequisite: PHYS 3614.

PHYS4203 Physics of Devices (SP, Even years) Principles of physics applied in a selection of technologically important devices in areas including computing, communications, medical imaging, lasers, and energy utilization. Students will utilize technical journals. No credit given toward a B.S. major in physics. Prerequisite: PHYS 3603 or PHYS 3614.

PHYS4213 Physics of Devices (SP, Even years) Principles of physics applied in a selection of technologically important devices in areas including computing, communications, medical imaging, lasers, and energy utilization. Students will utilitize technical journals. Credit allowed for only one of PHYS 4203 or PHYS 4213. Prerequisite: PHYS 3614.

PHYS4333 Thermal Physics (SP, Even years) Equilibrium thermodynamics, statistical physics, and kinetic energy. Prerequisite: PHYS 3614.

PHYS462VL Modern Physics Laboratory (1-3) (FA) Advanced experiments, projects, and techniques in atomic, nuclear, and solid state physics.

PHYS4713 Solid State Physics (SP) Crystal structure, diffraction and symmetry. Lattice vibrations, elasticity and optical properties. Electronic structure, band theory, transport and magnetism. Course emphasizes applications and current topics in semiconductors, optics and magnetism. Corequisite: PHYS 3414 and PHYS 4333. Prerequisite: PHYS 3614.

PHYS4734 Introduction to Laser Physics (SP) A combined lecture/laboratory course covering the theory of laser operation, laser resonators, propagation of laser beams, specific lasers such as gas, solid state, semiconductor and chemical lasers, and laser applications. Prerequisite: PHYS 3414 and PHYS 3544.

PHYS4754 Introduction to Applied Nonlinear Optics (FA) A combined lecture/laboratory course. Topics include: practical optical processes, such as electro-optic effects, acousto-optic effects, narrow band optical filters, second harmonic generation parametric amplification and oscillation, and other types of nonlinear optical spectroscopy techniques which are finding current practical applications in industry. Prerequisite: PHYS 3414 and PHYS 3544.

PHYS4774 Introduction to Optical Properties of Materials (SP) A combined lecture/laboratory course covering crystal symmetry optical transmission and absorption, light scattering (Raman and Brillouin) optical constants, carrier mobility, and polarization effects in semi-conductors, quantum wells, insulators, and other optically important materials. Prerequisite: PHYS 3414 and PHYS 3544.

PHYS4794 Lightwave Communication (SP, Odd years) A laboratory based course on light propagatioin in planar and fiber waveguides, optical coupling, operation principles of semiconductor lasers, detectors, and LEDs, hands-on experience with applications in communication systems. Prerequisite: PHYS 3414 or ELEG 3703.

PHYS4803 Mathematical Physics (IR) Development of mathematics used in advanced physics, including tensors, matrices, group theory, special functions and operators. Prerequisite: MATH 2574.
PHYS498V Senior Thesis (1-6) (FA, SP, SU)

PHYS4991 Physics Senior Seminar (FA, SP, SU) Student mastery of the principles of physics are assessed by means of research paper writing and an examination chosen by the faculty. The research paper may be used to satisfy the Fulbright College writing requirement. (Required of all B.S. and B.A. physics majors in their last year.)

Appendix B

Student demographics of undergraduate physics classes at the University of Arkansas based on Fall 1999 enrollment after official drop date.

CLASS NUMBER	COLLEGE OR SCHOOL	DEGREE	MALE	FEMALE	TOTAL	% SCHOOL	%MALE	% FEMALE
PHYS1023	Agriculture		4	3	7	2%		
Physics in Human Affairs	Architect		1	0	1	0%		
	Arts and Sciences	Art	1	2				
		Criminal Justice	5	6				
		Communication	6	8				
		Computer Science	16	8				
		English	8	20				
		Math	1	2				
		Music	5	1				
		Law	0	1				
		Other	76	72				
		TOTAL	118	120	298	81%		
	Business		37	23	60	16%		
TOTAL			160	146	366		44%	40%
PHYS1044	Agriculture	Interior Design	0	16	16	16%		
Physics for Architects	Architect		41	37	78	80%		
	Business		3	0	3	3%		
TOTAL			44	53	97		45%	55%
PHYS2013	Agriculture		11	9	20	11%		
College Physics I	Arts and Sciences	Biology	35	24				
		Computer Science	3	0				
		English	4	1				
		Math	0	1				
		Other	14	16				
		Pre-Med.	13	11				
		TOTAL	69	53	122	68%		
	Business		9	3	12	7%		
	Education		9	16	25	14%		
TOTAL			98	81	179		55%	45%
PHYS2053	Agriculture		1	1	2	1%		
University Physics I	Arts and Sciences	Biology	3	3				
		Chemistry	5	5				
		Other	9	7				
		Computer Science	4	0				
		English	2	2				
		Math	3	3				
		Physics	5	0				

		TOTAL	31	20	51	26%		
	Engineer		121	23	144	73%		
TOTAL			153	44	197		78%	22%
PHYS2073	Agriculture		0	1	1	1%		
University Physics II	Arts and Sciences	Other	5	3				
		Physics	1	0				
		TOTAL	6	3	9	6%		
	Engineering		121	22	143	93%		
TOTAL			127	26	153		83%	17%
PHYS2093	Arts and Sciences	Other	2	0	2	12%		
University Physics III		Physics	8	5	13	76%		
		TOTAL	10	5	15			
	Engineer		2	0	2	12%		
TOTAL			12	5	17		71%	29%
PHYS3544	Arts and Sciences	Physics	2	1	3	50%		
Optics	Engineer		3	0	3	50%		
TOTAL			5	1	6		83%	17%
* Other - represents all degrees with less than 1% of the total college or school population.								

Appendix C

Sample Lab Syllabus

Course Name: College Physics I Lab
Course Number: PHYS 2013L
Course description: College Physics I Laboratory (FA, SU) Laboratory 2 hours per week. Corequisite: PHYS 2010D and PHYS 2013.

Lab Instructor: Stephen R. Skinner
Office: PHYS 246
Phone: (501) 575-6059
E-mail: sskinne@comp.uark.edu
Office Hours: To be announced after the first day of class.

Welcome to College Physics Lab. This lab is worth one credit hour and carries a separate grade from College Physics, PHYS 2013. This lab is designed to help reinforce the physical concepts and laws discussed in the lecture part of this course. Attending lab does not take the place of attending class. Passing the lab does not mean that you will pass the class and vice-versa.

This lab is designed so that the students work together in groups of three or four, depending on the lab and space available. You will be able to complete the lab in the time allotted. Even though you work in groups the lab reports are not to be done as group projects. Please write reports individually.

Grading Scale: Your grade will be based on the completion of 10 labs, five quizzes, and a lab final. Each lab is worth 10 points. The 10 points will be distributed differently for each of the 10 labs and the distribution will be discussed prior to lab. You will have five pop quizzes during the semester worth 3 points each. The quizzes will be given at the beginning of the class. The purpose of these quizzes is to make sure that you are prepared for lab. If you are not prepared for the lab then your understanding of the physical concepts covered in the lab may not improve. The lab final will be given on the last day of labs and is worth 35 points. You may only use your graded lab reports on the lab final.

LAB REPORTS (10 POINTS)	= 100 POINTS	67 % OF GRADE
Lab quizzes (3 points)	= 15 points	10 % of grade
Lab Final (35 points)	= 35 points	23 % of grade
TOTAL points	= 150	

150 – 135 points = A
134 – 120 points = B
119 – 105 points = C
104 – 90 points = D
89 – 0 points = F

Make-up Policy: You will only be able to make up one missed lab during the semester. There will be a make-up day at the end of the semester, the week before the lab final. You are required to submit a lab report for the make-up lab. If you know that you are going to be missing a lab, please try to attend another section during the week if circumstances allow.

Weather Policy: Lab will meet unless the University of Arkansas officially closes.

Lab Report Format:
All lab reports should include the following:

- **Purpose –** This is a statement, no longer than three sentences, that describe the reason this experiment is to be performed. **Ex:** *This experiment will show that the capacitance of a parallel plate capacitor increases with the area of the plates and when you insert a dielectric with a dielectric constant greater than that of air.*
- **Theory –** This presents in detail the physical concepts that covered by this experiment. This part of the lab must be well written. Include physical laws, diagrams, graphs, and equations when referenced
- **Apparatus –** This section is a list of the materials used in the experiment.
- **Procedure -** Like the instructions for baking a cake, the procedure is an important part of any experiment. The procedure is important because, for your results and conclusions to be factual and believable, someone else must be able to follow your procedures and arrive at the same results.
- **Data –** This section contains all of the recorded measurements that you need in order to compute your results. The data should be contained in well-organized and labeled charts. You must also define all variables used in the experiment. This is similar to the homework and includes all constants.
- **Data-analysis –** This section requires that you show all of your work. This means that you will need to neatly copy all of your scratch work. Show all steps that are necessary. You will also include a well-labeled chart showing all of your results.
- **Conclusion -** In this section you will discuss all of your results. If you had to calculate a number to make a conclusion then you need to discuss the limits of precision and accuracy.
- **References –** A list of resources that you used to complete the lab report. Please use the referencing techniques of the APA format.

Questions pertaining to the course or lab: Please contact me at any time if you have questions pertaining to the course or the lab. You can contact me at the above phone number or by e-mail: sskinne@comp.uark.edu.

Appendix D

Guidelines for Lab Instructors

1. **Practicing the Lab** – Practice the complete lab prior to instructing the lab. Check with the Laboratory Curator concerning lab schedules.

2. **Pre-lab Check** - Always do a pre-lab check. This means that the TA will need to arrive a few minutes earlier than the students. Check each lab station for proper equipment and check the equipment to see if it is functioning properly. If a piece of equipment is not working properly, notify the lab curator so that it can be taken care of before lab starts.

3. **Equipment Function** - Be familiar with the proper function of each piece of equipment. If the TA is not sure how a piece of equipment functions, contact the lab curator for proper operating instructions. The proper function of equipment should have been discussed at the lab meeting.

4. **Hazardous Material and Safety Equipment** - Always be alert to the presence of hazardous material and lab equipment that requires safety precautions and equipment such as chemicals, mercury thermometers, radioactive samples, lasers, shock or burn hazards, etc. If the TA has any questions about the handling of hazardous material contact the lab curator. Each lab is provided with a simple first aid kit. The kit is located in the cabinet under the sink in each lab room.

5. **Checking Out Equipment** - Several labs will require students to present a picture ID when checking out equipment. For security reasons, keep the IDs on you at all times. When the students return equipment in proper working order, they get their IDs back. Please follow this guideline.

6. **Broken Glass** - If a piece of glassware breaks during the lab, clean it up immediately. A broom and dustpan are available in the lab curator's office. Notify the lab curator so that the broken piece can be replaced.

7. **Equipment Breakage Forms** - "Equipment Breakage Forms" are located in each of the lab rooms in red notebooks. Should a piece of equipment break:
    - Fill out the top part of 2 forms.
    - Give the first copy to the student who broke the equipment.
    - Give the second copy to the Lab Curator.

Appendix E

Appendix F

Problem Solving Strategies[2]

[2] Strategies are borrowed from *Workshop #20 Preparing TAs to Teach Undergraduate Courses* by Patricia and Kenneith Heller.