Resource for Effective Engineering Physics Laboratory and Project Assignments

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Abstract: Though effective project and laboratory assignments are important in an engineering education, the development of good assignments is impeded by several factors: (i) the present academic reward system does not encourage or promote laboratory development time; (ii) there is no mechanism in place to distribute labs; (iii) there is no mechanism in place to review or recognize appropriate lab assignments. In this paper, we present a resource that addresses the distribution of effective lab assignments. It is a web page that contains lab and project assignments appropriate to an Engineering Physics curriculum as well as links to other resources. We also present a proposal for a national database of lab assignments. This resource will, hopefully, encourage cooperation among universities, provide 3rd party recognition for assignment authors, shorten preparation time for professors at other universities, and lead to more effective assignments for the students.

1. Introduction

Effective laboratory and project assignments are an important element in engineering education. Good laboratory assignments can spark interest in the students, correct conceptual misunderstandings, and help students adjust quicker to the work environment. (If a student has already used specific hardware and software tools in a university lab, then he/she will not need to be trained to use them on the job.)

However, rarely is there incentive or reward for professors to invest time in the development of effective lab assignments. Some of the hindrances to developing good assignments are: (i) it is time-consuming to develop lab and project assignments. There is the planning of the assignment itself and communicating what is expected to the student; often each step must also be clearly stated and described – almost in a tutorial fashion. (ii) One must fit the labs to the available equipment. For example, in a circuits lab, there is the issue of equipment (oscilloscope, waveform generator, power supply, multimeter, breadboad), the specifications and capabilities of each piece of equipment (e.g., bandwidth of scope, digital storage capability, print capability), availability of individual components (resistors, capacitors, inductors, transistors, etc) and number of test stations. (iii) There is no (or only small) tangible reward for development of good labs. Developing good labs takes time and creativity but it does not carry the same weight in academic circles as presenting a paper at a conference. Plus, there is no external (3rd party) recognition that one can put on a dossier/vita.

Another barrier to good assignments is that there is not a formal mechanism for instructors to share or publish good assignments. There is presently not a specific location or repository where instructors can look for good assignments. For example, smaller homework type problems can be obtained from textbooks. But lab and project assignments tend to be longer and more involved; on the low end they take about a week to complete (say 2 – 3 hours in the lab and then the ensuing analysis and write-up) and on the high end some project assignments are designed to take the entire semester (15 weeks) or an entire academic year. In addition, good lab assignments are not tied to a particular textbook (textbooks tend to vary slightly on notation and expected prior knowledge) or piece of equipment but tend to be more general.

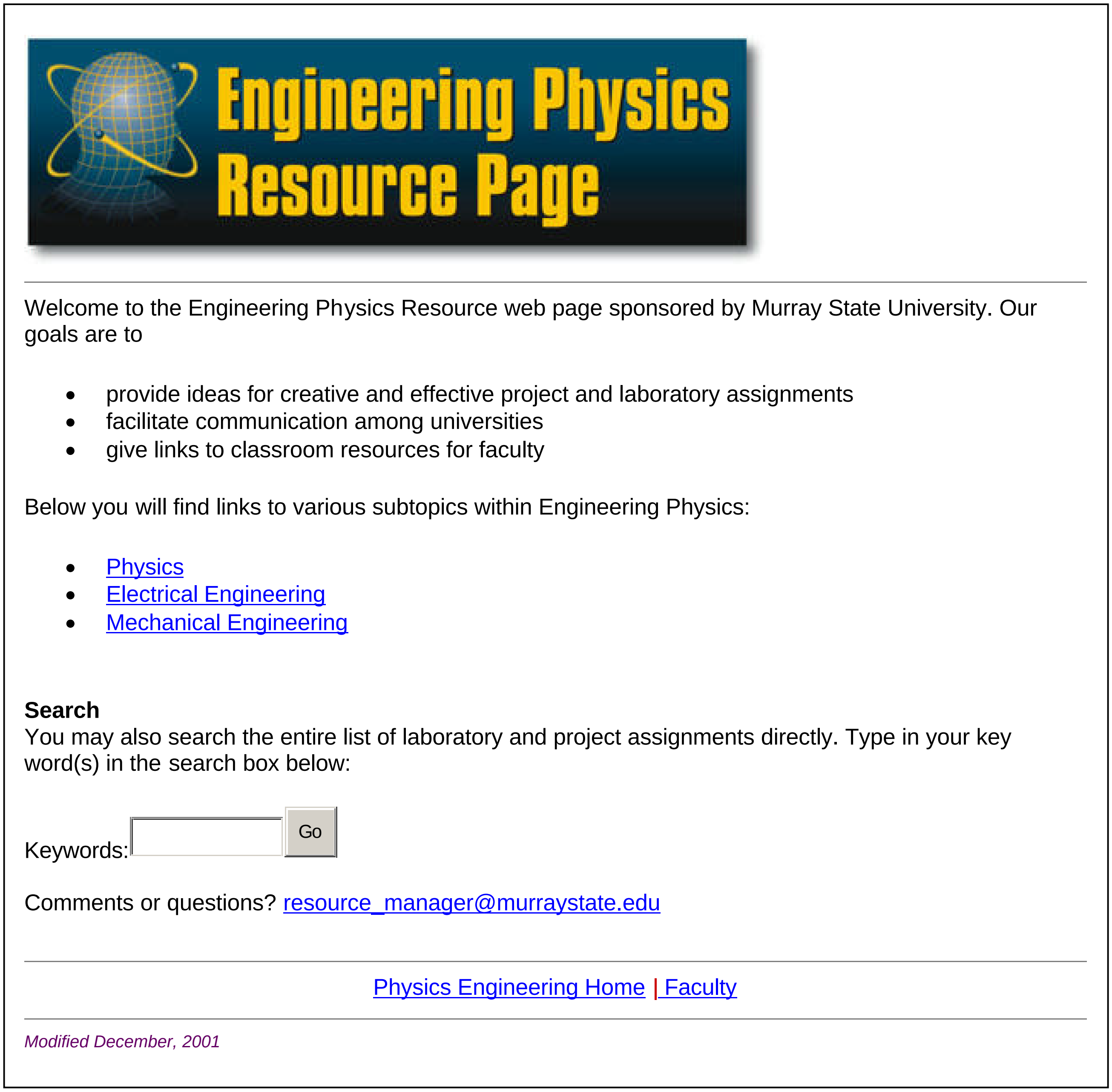
The ABET-accredited Engineering Physics program at Murray State University combines elements of Physics, Mechanical Engineering, and Electrical Engineering. There are lab sections associated with five of the courses and major projects in four other courses in the curriculum. Thus, every semester professors are either recycling and updating old lab assignments and projects or trying to dream up new and different assignments. But must each professor "reinvent the wheel" and develop all the assignments himself/herself? This creates a picture of each professor or institution acting like an isolated "Lone Ranger" in the development of significant assignments. Based on similar degree programs, one can assume there are other universities who have developed labs and projects for similar courses in the Engineering Physics area. The American Institute of Physics states that there are 770 degree-granting physics departments in the United States.[1] A check of the ABET web page shows that there are over 225 accredited programs in Electrical Engineering and Mechanical Engineering and 17 accredited Engineering Physics programs.[2] There should be a mechanism to share laboratory and project assignments among the universities.

The hope is to allow professors access to assignments developed by professors at other universities. In this way, clever and creative assignments can have a wider impact and the preparation time for the isolated professors can be reduced. This paper describes a possible solution to help distribute or share effective assignments.

2. Solution: Engineering Physics resource web page

The Murray State Physics and Engineering department has started a lab resource web page. (The web page is presently only available on an internal Murray State server and is not yet viewable to the general public.) The web page includes lab and project assignments that MSU faculty have developed for its Engineering Physics program, as well as links to other useful sites.

A snapshot of the main page is shown in Figure 1. The intent of the main page is (a) to be simple and thus download quickly, (b) provide a search capability, and (c) provide a jump off point to the main subsections.


Engineering Physics Resource Page

Welcome to the Engineering Physics Resource web page sponsored by Murray State University. Our goals are to

- provide ideas for creative and effective project and laboratory assignments
- facilitate communication among universities
- give links to classroom resources for faculty

Below you will find links to various subtopics within Engineering Physics:

- Physics
- Electrical Engineering
- Mechanical Engineering

Search
You may also search the entire list of laboratory and project assignments directly. Type in your key word(s) in the search box below:

Keywords: Go

Comments or questions? resource_manager@murraystate.edu

Physics Engineering Home | Faculty

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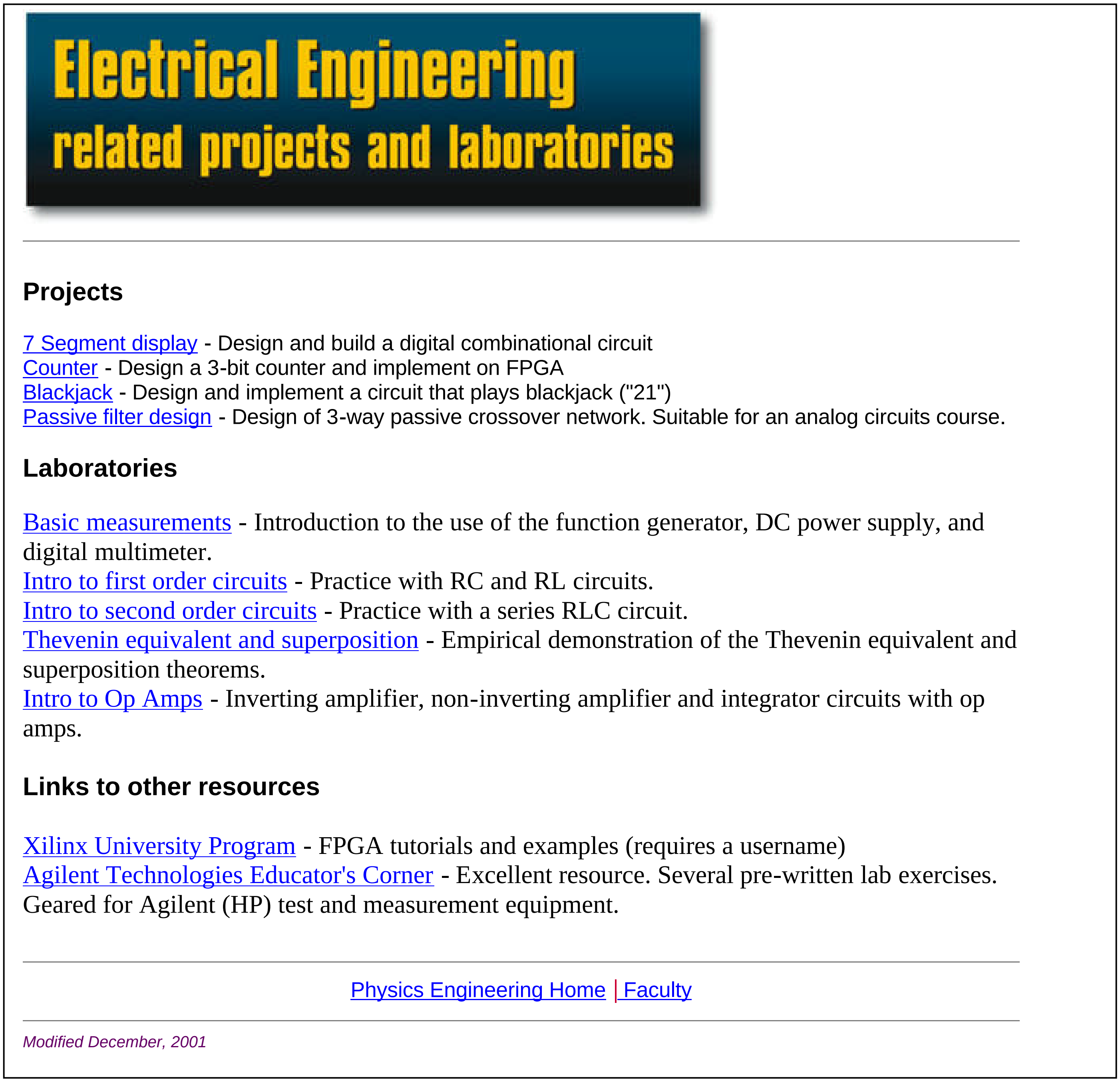
Figure 1: Snapshot of the main web page Engineering Physics Resource Page at Murray State University

The resources are broken down into three subsections: a Mechanical Engineering section, an Electrical Engineering section, and a Physics section. The user can select one of those sections (similar to yahoo.com) or enter keywords into a search that looks for relevant assignments in all three of the subsections.

A draft of the Electrical Engineering resource page is shown in Figure 2.



Electrical Engineering related projects and laboratories

Projects

7 Segment display - Design and build a digital combinational circuit
Counter - Design a 3-bit counter and implement on FPGA
Blackjack - Design and implement a circuit that plays blackjack ("21")
Passive filter design - Design of 3-way passive crossover network. Suitable for an analog circuits course.

Laboratories

Basic measurements - Introduction to the use of the function generator, DC power supply, and digital multimeter.
Intro to first order circuits - Practice with RC and RL circuits.
Intro to second order circuits - Practice with a series RLC circuit.
Thevenin equivalent and superposition - Empirical demonstration of the Thevenin equivalent and superposition theorems.
Intro to Op Amps - Inverting amplifier, non-inverting amplifier and integrator circuits with op amps.

Links to other resources

Xilinx University Program - FPGA tutorials and examples (requires a username)
Agilent Technologies Educator's Corner - Excellent resource. Several pre-written lab exercises. Geared for Agilent (HP) test and measurement equipment.

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Figure 2: Snapshot of the Electrical Engineering resource page with the three categories of projects, laboratories and links to other resources.

Each subsection groups the resources into three categories. The first category contains assignments suitable for projects. That is, assignments students can do on-their-own with minimal equipment. The second category contains laboratory assignments. These assignments require instruments or components that are likely only available in a laboratory. The third category is links to other pertinent resources. (The Other Resources links are collections of tutorials and assignments maintained on other servers. An example of an Other Resources link would be the American Journal of Physics web page.)

Each link is annotated with a brief description to facilitate the search and selection of pertinent assignments. In addition, there will be a search capability (not shown); the user will be able to search the projects and laboratories categories (which are mostly original assignments developed by Murray State University professors) for assignments based on key words.

As more assignments are added, the categories will be broken down even further for quicker searching. For example, the Electrical Engineering assignments could be divided into subcategories analog, digital, programming, and other. The analog subcategory could be further divided into circuits (only passive components are required), electronics (utilize active components such as diodes, transistors, and op amps), VLSI, and instrumentation. The Mechanical Engineering assignments could be divided into subcategories such as statics, dynamics, materials, thermodynamics, and other.

3. National database

The web resource page at Murray State University is one step towards a national database of lab assignments.[3] A proposed laboratory distribution methodology is shown in Figure 3.

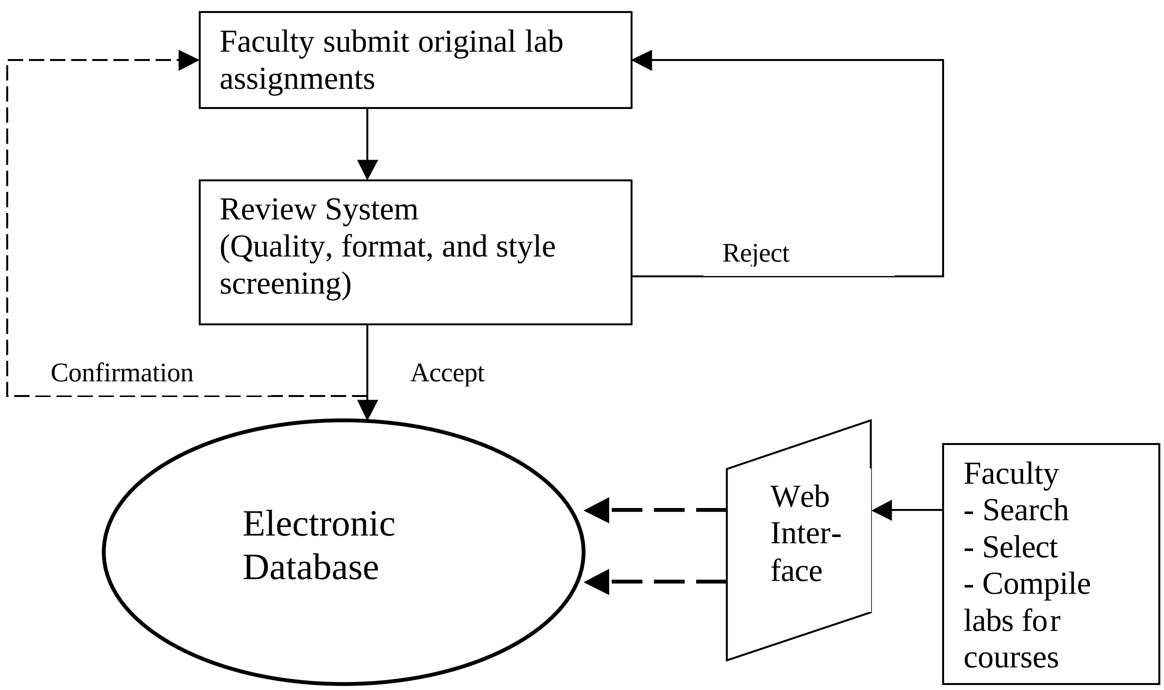

Figure 3: Outline of a proposed national database of laboratory and project assignments.

For the database/resource to be successful, it would need input from faculty at several institutions. The process starts with faculty from different universities creating laboratory assignments. The submitted assignments can be designed to conform to a style standard set forth by the overall review organization. (The review organization could be an individual entity such as a university or a national organization such as the ASEE or IEEE.) The style standard might require sections such as: goals of the assignment, skills developed/learned, prerequisite background required, equipment (hardware/software) required, problem statement, time involved (pre lab, during lab, post lab), expected results, follow-up questions, etc. The review organization that develops the standard would be a committee operating under the auspicies of the ASEE or similar organization. Faculty that develop the labs then submit their assignments to the review organization which insures the quality and originality of the assignment and enforces the style standard. This system is analogous to the peer review system for journal paper submission.

Current technology exists to make the review process a completely paperless system. Typically, the lab assignments are created in an electronic format and would be submitted to the review board electronically. The review "editor" would then electronically send the write-ups to two (or so) reviewers. If accepted, the assignments would be stored electronically in the database.

Accepted laboratory and project assignments are stored in an electronic database that is accessible through a web-based interface. The web interface allows faculty at other institutions to select assignments pertinent to their courses and curriculum. A search capability would be built in that allows an instructor to quickly narrow down the possible number of assignments; a user could search based on assignment goals, required equipment, required knowledge or some other criteria. The instructor could download the assignments him/her self or work through an independent publisher to compile and publish a lab manual.

Benefits of national assignment database
Encourages cooperation among universities
Shortens preparation time for professors
Third party recognition for assignment authors
Allows for external feedback on the labs
Will encourage better lab assignments (access to quality assignments, feedback and possible improvements to existing assignments)

The laboratory and project assignment distribution system that is proposed will benefit all the involved parties. The original faculty authors will receive recognition in the form of feedback from the unbiased review board. If the review board accepts the lab exercise, then it is external confirmation of the thought, creativity, and work put into developing the assignment. In addition, the author would receive feedback on his/her assignments (both from the review board as well as others who might use the lab) so that the assignment could be modified or improved.

Faculty at other universities would have access to a database of innovative assignments. Since the database is online, it can be searched for assignments that are relevant based on one or more of several criteria. This would greatly decrease preparation time for faculty. It would also lead to better learning assignments for the students.

There are several issues that would have to be addressed before a national database resource became fully functional. The biggest issue is copyright and plagiarism concerns. Many good assignments are variations on previous assignments, so how much "variation" is enough to warrant a good review? Is the material in national database copyrighted? If so, who owns the copyright and can other professors then download the assignments and use them in their own classes? If not, what protections are there for the original author(s)? There are, to our knowledge, three possible solutions: (a) the material in the national database is not copyrighted; (b) the material is protected by copyleft, which allows others the freedom to copy and modify the material; (c) the material is protected by full copyright protection. The best solution needs to be debated and decided within the national community.

Another issue is where would the national database "reside" and who would be responsible for maintaining it and keeping it current. One suggestion is that there be a charge to the people who use the database to support the maintenance and upkeep. It is our belief that the database would be more widely used if it were free and we would thus look for other avenues (such as the NSF) for the required funding.

It is presumed that the review board and the overall national database would be governed by the ASEE or some other national body (e.g., ACM, IEEE, ASME). The proposed system will allow the national body to build a laboratory infrastructure. This infrastructure will foster a cooperative environment among universities. It will also impose a certain "quality control" on the assignments since the assignments will be in a standard format and reviewed for overall quality and depth. This will lead to an overall improvement in laboratory instruction in the universities.

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References:

1. American Institute of Physics, AIP Report, AIP Pub No R-394.7, September 2001.

2. www.abet.org

3. Robert F. Hodson and James M. Hereford, "Infrastructure for Laboratory Distribution", IEEE Microelectronics Systems Education, July 1997.

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