Project Title:
Educational Materials for a Laboratory Based Course in Computer Programming for Engineers

National Science Foundation
Course, Curriculum, and Laboratory Improvement
Educational Materials Development Track
Proof of Concept

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Contents

1 Info about PI's .................................................. 3

2 Cover Sheet ....................................................... 3

3 Project Summary .................................................. 0

4 Project Description .............................................. 1
   4.1 Results from Prior Support .................................. 1
   4.2 Project Description: Introduction ............................ 2
   4.3 Project Description: Goals and Objectives .................... 3
   4.4 Detailed Project Plan ....................................... 4
      4.4.1 Class Format: Current Practices ..................... 5
      4.4.2 Detailed Plan ......................................... 7
      4.4.3 Project Time Line ................................... 8
   4.5 Relevant Experience ....................................... 11
   4.6 Evaluation Plan ......................................... 13
   4.7 Dissemination of Results .................................. 15

5 References Cited .................................................. 16

6 Biographical Sketches ........................................... 17
   6.1 P. I.: J. C. Díaz ........................................... 17
   6.2 Advisory Committee Member: Ram Mohan .................... 19

7 Budget and Budget Justification ................................ 21
   7.1 Justification .............................................. 21
   7.2 Budget –Year 1 of 2 ...................................... 23
   7.3 Budget –Year 2 of 2 ...................................... 24
   7.4 Budget –Cumulative ...................................... 25

8 Current and Pending Support .................................... 26
   8.1 Current Support ........................................... 26
   8.2 Pending Support .......................................... 26

9 Facilities, Equipment and Other Resources ....................... 27

10 Appendices ......................................................... 28
   10.1 Specific Examples ........................................ 28
       10.1.1 Snells Law and Functions ............................ 28
   10.2 Sample exercises/quizzes questions ........................ 29
       10.2.1 Coulomb’s Law ..................................... 29
   10.3 Free energy in an ideal Gas .............................. 29
   10.4 Gass Reduced Pressure and temperature ................... 29
1  Info about PI’s
2  Cover Sheet
3 Project Summary

Educational Materials for a Laboratory Based Course in Computer Programming for Engineers. P. I.: J. C. Díaz, Ph.D., The University of Tulsa

Engineering education requires relevant course work in information technology that prepares its graduates to enter a high technology workforce. Criteria for certification of engineering technology programs are to: instruction in one computer language which is commonly used in engineering practice, and experience using programming skills in technical courses appropriate for the discipline. This project will produce educational materials for engineering education to present an algorithmic approach to computer programming making an emphasis in the type of calculations and applications that an engineer would face in their education and practice. The objectives include: Present programming in an object oriented computer language suitable for current engineering practice such as Java or Visual Basic deriving the need for the specific language constructs from calculation requirements in engineering and science applications; Make use of an algorithmic approach that emphasizes the step-by-step approach to programming that enhances logical thinking; Prepare an extensive collection of labs, projects, examples, and typical questions such that the class can be presented over four semesters without repeating labs, projects, or exams; Promote the utilization of programming skills in the engineering curriculum through the instruction in computer languages that can be interfaced with productivity tools; and Expand the use of the Web as a reporting mechanism. The audience for the material are science and engineering majors to prepare them to enter a high technology workforce.
4 Project Description

4.1 Results from Prior Support

The PI received an ILI equipment grant in 1994, NSF Grant 9451656, entitled A Visualization Laboratory for Computational Sciences. The project consisted in integrating a visualization laboratory into an undergraduate computational sciences curricula. The project instrumented a laboratory with Unix workstations with 32-bit graphics accelerators. Associated equipment and software were acquired including disk storage, and AVS a 3-d visualization software. The 32-bit graphics workstations were integrated into the college undergraduate network. Additionally, the project instrumented classroom presentation facility. The majority of the equipment was purchased in 1995.

The workstations laboratory were operational until the Summer of 2000 when the college upgraded the undergraduate laboratories with state of the art workstations. The college also instrumented several other classrooms with current computing equipment. The workstation and the projector in the original classroom presentation facility were also upgraded in 2000.

A lower division and an upper division undergraduate courses begun their incorporation into the lab framework. The typical students enrolled come from a variety of disciplines: Ch. E, Petroleum E., Geoscience, Physics, CS, Mech. Eng., Math. and others.

Our experiences were very encouraging. As freshmen experience the making of their first mpeg animation or the slicing of a cube of data such as the velocity profile on a seismic section, their interest in computing as a tool is significantly enhanced. One course developed a complete set of lectures notes accessible through the Internet, [2], which is
now being used as a text. Another set of lecture notes was developed for an upper division
course, [3], as supplemental material.

4.2 Project Description: Introduction.

The University of Tulsa was established in 1894. The student enrollment in the Fall
2000 was near 4,200. The student population is composed of students from most states
including the District of Columbia, and from many foreign countries. The University is
known for its high academic standards.

The College of Engineering and Applied Sciences consists of nine departments: Bio-
sciences, Chemical Engineering, Chemistry and Biochemistry, Electrical Engineering,
Geosciences, Mathematical and Computer Sciences, Mechanical Engineering, Petroleum
Engineering, and Engineering Physics. All of which offer bachelor’s degrees, all but
Physics offer master’s degrees, and six offer the Ph.D.

The high technology workplace demands that graduating engineers be ready to use in-
formation technology tools necessary for productive careers. Engineering programs should
include instruction in one computer language which is commonly used in engineering prac-
tice, [1]. It should also offer experience using programming skills in upper division courses,
[1]. This need has been satisfied by requiring engineers to take computer programming
classes. Many times, the selection has been driven by the programming courses for com-
puter scientists.

It has increasingly become the practice for CS programs to require their majors to
take a year long sequence where programming skills are developed. The examples that are
used often address issues from information sciences such as sorting and searching. These
courses can satisfy the need of a few engineering students who want to complete a minor
in information technology or want a double major in CS. However, these courses do not satisfy the need for the majority of science and engineering students. Many authors have addressed this need by producing textbooks intended to teach programming to science and engineering majors, [8, 9, 10, 11].

NASA announced in September 1999 that the American Mars Climate Orbiter strayed off course and disappeared. They also announced that this accident was partly because of orbiters’ controllers faulty data conversions from English to metric units of measurement. Computer programming languages have become very adept at checking for the correct Type of a variable. A strong typed language such as C++ or Java enforces this. However, both feet and meters use the same representation as floating point numbers. Engineers must be made aware of the need for checking units when using components of computer programs. Moreover, they must be made aware of documenting units in the program units that use them. An object oriented approach can be use to eliminating some of these difficulties. The most important issue in programming is discipline in documentation.

4.3 Project Description: Goals and Objectives

This project will produce educational materials for engineering education to present an algorithmic approach to computer programming making an emphasis in the type of calculations and applications that an engineer would face in their education and practice. The objectives include:

- Present programming in an object oriented computer language suitable for current engineering practice such as Java or Visual Basic. The materials should derive the need for specific language constructs from calculation requirements in engineering and science applications.
• Make use of an algorithmic approach that emphasizes the step-by-step approach to
programming that enhances logical thinking.

• Prepare an extensive collection of labs, projects, examples, and typical questions
such that the course can be presented over four semesters without repeating labs,
projects, or exercises.

• Promote the utilization of programming skills in the engineering curriculum through
the instruction in computer languages that can be interfaced with productivity tools.

• Expand the use of the Web as a reporting mechanism.

The audience for the material are science and engineering majors to prepare them to enter
a high technology workforce.

The two languages come to the surface as potential vehicles for the delivery of the
educational materials are Java and Visual Basic. Java because of the large number of
packages and applications that are available is an interesting possibility. Java is portable
to both Ms-Windows and Unix platforms. Java is a language that can be used to develop
Internet based applications. On the other hand, Visual Basic offers an object oriented
paradigm which can be easily interface with other productivity tools such as spread-sheets
and databases. Visual Basic is used by many computer professionals as a prototyping
language for Ms-Windows applications.

4.4 Detailed Project Plan

At the University of Tulsa, the course CS/ES 2503 Scientific and Engineering Program-
ming is intended to teach science and engineering undergraduates the basic elements of
programming. Before discussing details of the plan for the project, the current class format is discussed.

4.4.1 Class Format: Current Practices

The class is taught in a 2+2 format over the 14 weeks period of a regular term. Two hours of lecture are coupled with a two hour long lab. The lectures are in a large auditorium with instructors console. The two hours lab are held in a computer lab in a small size setting. Faculty, TA’s and SA can provide one-on-one instruction at the critical time of writing programs and making sense of the responses that are returned out by compilers and other program components. There are additional hours of supplemental instruction, mostly by undergraduates, that assist students that may have additional questions with their labs and projects.

The students graded term work consist of 12 Labs, 6 Projects, 2 term and a final, and 3 Basic Skills Quizzes. The term and final exams and the quizzes are offered at the computer lab and it is submitted using Internet driven tools. The students have access to their regular web sources and compilers. The exams include questions that test knowledge of basic computer commands, basic definitions, concepts related to the programming language. They also include questions that test the ability to follow a given program step-by-step, and to organize a given engineering calculation as a step-by-step logical approach.

The three basic skills quizzes test the ability of the students to be able to write compilable code that works as expected in an exam environment. Thus the questions have to be simple yet significant. The skills tested by the quizzes are:

1. The students ability to write a simple program that performs an engineering/science
type of calculation that requires simple input and simple output.

2. The students ability to write a subprogram or function which computes a given formula for a certain set of arguments, and returns the values of certain variables. No input/output except through the argument list.

3. The students ability to write a program that invokes a subprogram whose calling sequence is provided, change of units are required, and generally file input/output is required.

The quizzes are administered so passing is at a 90%. Up to four attempts are allowed. Each succeeding attempt carries a increasing penalty. After four failed attempts, the grade assigned is 60% of the highest grade obtained. The first quiz has a 98% passing result history, the second shows a 94% and the third shows a 90% passing rate. Over 50 Attendance is taken daily and counted as 1% of the total possible points. Additionally, Journals in the form of short attitudinal surveys coupled with short paragraph questions are expected for every lab, project, exam, quiz, and week of lectures. These have been collected over a period of two to three years. This information has been used effectively to adjust the lecture format and pace. In the last year, the Journals have been served by Webct, an Internet based tool that allows anonymous survey. Yet, it also provides the list of those students that have submitted Journals. Hence, completing the Journals is used also as a small fraction of the total grade.

The labs are assigned to be completed by the most part on the 2 hrs lab. The projects are of similar difficulty level as the labs. They are generally designed to reinforce concepts discussed in class by providing additional experience. Other projects make emphasis on computer related issues such as incorporating the use of scanner, the production of
animations from data generated by engineering simulations, and publishing of all the class reports in a more permanent storage provided by the university. Examples of student’s work can be found at:


4.4.2 Detailed Plan

The project involves the recasting of the course around a new programming language using object oriented paradigm. The new paradigm requires that new issues be address from the outset, and that other regular programming constructs be presented perhaps in a new order. Hence, the plan for achieving the objective of writing the set of educational materials must be organized along a time table.

Two key components are the formation of the Advisory Committee which will represent the engineering disciplines involved and the hiring of the Graduate and Undergraduate Assistants.

The core of this group are representatives of Chemical and Mechanical Engineering which together represent over 65% of the class enrollment. Petroleum engineering has also been asked to participate since they account for another 20% of the enrollment. Engineering physics has a very low enrollment and their needs generally parallel those of ME and PE. The students from EE, the other engineering discipline at TU, generally take the regular CS sequence as most of them tend to emphasize computer engineering and digital electronics. The regular CS courses are most suitable to them. The science majors taken together account for less than 15% total enrollment and generally use this class as an elective rather than a required course as is the case with the engineering programs.
Mechanical Engineering has already indicated their members. Assistant Professor R. Mohan will serve on the Advisory Committee. He is currently an PI on an NSF curriculum grant and understand the important role of the advisory committee.

4.4.3 Project Time Line

The project is slated to start in January of 2002. The time-line below provides for particular check-points based on this assumption.

**Fall 01:** The advisory committee meets to review objectives and evaluation plan. The language platform is discussed and a recommended selection is made. A GA is recruited.

**January 02:** Final selection of language platform is made. GA is hired to begin work. A first UA is identified and hired.

**Spring 02:** The PI and GA re-tools one or two of of the more significant of the current labs and corresponding implementation in new platform. They are evaluated by the UA for complexity, readability, etc. Next, particular attention is placed at this time on the introductory lessons that involve issues with the new paradigm. While this material is being developed, the UA is looking for sample science and engineering calculations for future labs, projects, exercises, and test questions. As new whole lessons are written, the UA will read and criticize them for accessibility and comprehension. A third of the lessons will be completed by the end of the Spring term.

**1st Half of Summer 02:** The PI and GA finish the first draft of the complete set of lecture notes. The labs at this time will parallel those of the current version with the appropriate modifications to account for the new language paradigm.

The materials are produced as web pages, printed suitable for photocopying, and as
CD’s for distribution to the summer students.

**2nd Half of Summer 02:** First trial run. The PI offers the course as a summer class in the 2nd regular summer session. The GA assist the PI in this trial run. The GA attends the lab sessions to provide additional observations to the efficacy of the materials. The GA also reviews the submitted materials for further observation. Evaluation of the material and its effect on students is gathered. The materials are modified to respond to student responses and PI and GA observations.

**Summer-Fall Interim:** The materials are cleaned up and produced as web pages, printed suitable for photocopying, and as CD’s for distribution to the students for Fall 02 classes. Evaluation data and efficacy of prototype are compiled.

**Fall 02:** The advisory committee meets to review evaluation data and makes recommendations.

Fall 02 trial run. The PI offers class as a regular fall offering. The GA attends one of the lab sessions to provide additional observations to the efficacy of the materials. The GA coordinates with the TA to identify barriers. The PI and GA works on a new set of labs and projects which test the same concepts but represent different areas of application. A new UA is hired to review all the materials and specially the new ones as they are developed. The UA continues to look for relevant science and engineering calculations for future labs, projects, exercises, and test questions.

Evaluation of the materials continues. The materials are refined to respond to student responses and the PI’s and TA’s observations.

**December 02:** The refined materials which now include the newly defined labs and projects, are produced as web pages, printed suitable for photocopying, and as CD’s for
distribution to the students for Spring 03 classes. Fall trial evaluation data and efficacy of prototype are compiled.

**Spring 03:** The advisory committee meets to review evaluation data and makes recommendations.

Spring 03 trial run. The PI offers the course as a regular spring offering. The GA attends one of the lab sessions for observation on the impact of the new set of labs and projects. The GA coordinates with the TA to identify barriers. The PI and GA work on a further set of labs and projects which test the same concepts but represent different areas of application. A new UA is hired to review the materials and specially as new ones are developed. The UA continues to look for sample science and engineering calculations for labs, projects, exercises, and test.

Evaluation of the materials continues. The materials are refined to respond to student responses and The PI’s and TA’s observations.

**1st Half of Summer 03:** Plans for national dissemination through adoption and adaptation will be made based on current experience with the prototype. A proposal to this end will be drafted.

As one last set of labs, projects, exercises are written, the whole collection of materials is cleaned up and reviewed.

The materials are produced as web pages, printed suitable for photocopying, and as CD’s for distribution to the summer 03 students.

**2nd Half of Summer 03:** Summer 03 trial run. The PI offers the course as a summer class in the 2nd regular summer session. The GA assists the PI in this trial run. The GA assist with the lab sessions to provide further observations. Evaluation of
the material and its effect on students continued to be gathered. Few modifications are expected but they will be updated to respond to student input and the PI’s and GA’s observations.

The PI and the GA write a draft report analyzing the evaluation data for the several stages of the project. This may be used as a Master’s report for the GA which graduates in Summer 03.

**Summer-Fall Interim:** The materials are now at a final stage requiring minor updates. They are produced as web pages, printed suitable for photocopying, and as CD’s for distribution to the students for Fall 03 classes. Evaluation data and efficacy of prototype are compiled.

**Fall 03:** The advisory committee meets to review evaluation data and makes recommendations.

Fall 03 trial run. The PI offers class as a regular Fall offering. The PI works with the TA to identify remaining barriers. The processes for collection of evaluation of data have been automated and data is gathered on the final version.

**December 03:** At this point the material should represent a fully-realized set of educational materials that is readily transportable to prepare mainstream engineering students. The advisory committee meets to review evaluation data and makes final recommendations. The PI writes a final report.

### 4.5 Relevant Experience

At the University of Tulsa, the course CS/ES 2503 Scientific and Engineering Programming is intended to teach science and engineering undergraduates the basic elements of programming. This course had used Fortran as the language platform until 1998 when it
was changed to C++. In 1992, the PI completed a full set of web-accessible lecture notes for the predecessor of this course using Fortran with a short section on Matlab. Some of these materials derive the need for specific language constructs from calculation requirements in engineering and science applications. In addition to being web based materials, a hard copy with a ring-bind was made available for purchase at the bookstore. More recently copies have been made available for reproduction at a local Kinko’s.

The course objective has been to teach programming to engineers making an emphasis in the type of calculations and applications that an engineer would face in their education and practice. Basic web-authoring tools for lab and project report writing using raw html constructs, were introduced into the course at that time. This became the standard way to report results of labs projects and include graphics. It is significant part of the course now.

The materials have evolved incrementally over the years with corrections, revisions, and new sections. In 1998, the language platform for this course was changed to C++. The PI revised all the materials explaining the concepts using C++ but retaining some of the Matlab sections. The C++ materials have continued to evolve since.

Computer programming languages have been created, evolved, matured, and changed significantly over the last 30 years. A major point of teaching a brief coverage of programming in Matlab has been to illustrate that the basic constructs in one language are similar to those in another although the syntax may be different. Thus, illustrating that the basic programming skills are portable beyond these languages; and preparing them to learn new languages as they become available in the future.

Fortran had been an effective language to introduce programming concepts because it
is easy to learn and most importantly it is easy to identify and correct errors. While a large number of researchers continue to use Fortran and it remains the language of choice for high performance computing, it is no longer a major language in engineering day to day practice. Extremely few upper division undergraduate engineering courses still do use it.

In the late 80’s, C++ became the language of choice for computer professionals. In the 90’s engineering disciplines began to see an influx of younger faculty members that had used C or C++ in their graduate research work and were interested in using it in their courses. However, C++ is much more difficult to learn and to teach. Understanding of significant computer language concepts such as passing-by-value versus passing-by-address and C++ pointers are required to write basic code. In balance, coverage of advanced topics and relevant applications had to be sacrificed in order to cover these topics correctly. There was no room left to cover modern object oriented concepts. Moreover, the use of C++ in upper division engineering courses has been extremely limited and restricted to few topical courses. Significantly however, few upper division engineering students do talk about using the concepts learned in the class to write good Visual-Basic code for some of their other course worked. The portability of programming concepts has indeed work. But we must move the language vehicle to one closer to actual engineering practice which is more accessible pedagogically and is likely to be used systematically in the engineering curriculum.

4.6 Evaluation Plan

There are two types of project outcomes to evaluate: effects on students, and quality of materials. Does the set of materials represent a course that is practically teachable?
There are five effects of the courses on students: attitudes, basic skills, problem solving, the ability for step-by-step logical thinking, and the use of programming skills in advanced classes. The first four of these can be evaluated within the scope of one term.

The evaluation needs to be accomplished without increasing the already heavy sampling required from the students. The current plan call for use of Webct to provide the vehicle for evaluation providing a secure environment for the data and instruments. Webct is password accessible only.

Detailed attitudinal surveys are planned to become part of the first and last lab. They will be administered as the first and last lab journals using Webct survey tool which provides anonymity and automatic tabulation of the results. A modification of the Maryland Physics Expectation (MPEX) survey is being contemplated, [4]. The validity of the results will reflect the strength of the instrument. Hence, careful wording and consultation with the Advisory committee will be essential, [5, 7].

Data available from the previous version of the course will be used to compare those specific items with the new version of the materials. Data is available on basic skills, problem solving and step-by-step logical thinking from previous course versions for comparison. Where data is not available from the previous version, such as new concepts, an 80% passing expectation will be used to measure the effectiveness of the materials.

The use of programming skills in advanced classes is a more difficult task to accomplish because the students are no longer part of the class. Juniors and Seniors that have taken the previous version will be selected at random and they will be requested to complete a confidential attitudinal survey designed to test the impact of the class on later programming use and ability. The same instrument will be use to test the students that
have gone through the trial runs when they become Junior and Seniors. Collecting of this data is expected to take about 2 years beyond the end of the project. But it may be possible that within the time-line of the project, a few student will begin to come to the upper level courses that may provided a glimpse of the impact before completion of the project.

4.7 Dissemination of Results

The dissemination audience is comprised of the instructors of courses in computer programming for engineers. These should be associated with college or universities that have engineering programs.

Once the materials are up on the web, they can be accessed and used. A special web page will gateway the materials, will be made available. It will contain detailed information on how to obtain a copy by downloading it, or receiving a CD. A counter to monitor the utilization of the material will be maintained.

The major vehicle for dissemination consist of oral presentations at the American Society of Engineering Education (ASEE) conferences followed up by publications in their journals and magazines. Participation at topical conferences of the ChE Society and the AME society are also contemplated. Another society avenue is the ACM educational conference where instructors for engineering programming courses may attend.

The materials will continue to be updated based on experiences every year or so. The updates will be indexed so users can keep up with current versions.
5 References Cited

References


6 Biographical Sketches

6.1 P. I.: J. C. Díaz

Education

Rice University, Houston, TX, MA 1974, Ph.D 1975, Universidad de los Andes, Bogotá, Colombia, Licenciado en Matemáticas 1970.

Graduate and Post-Doctoral Supervisors

J. C. Díaz Post-Doctoral Supervisor: G. Fairweather, Colorado School of Mines

Current Position

Professor of Computer and Mathematical Sciences, 1994-present; Director of the Center for Parallel and Scientific Computing, 1987-present; The University of Tulsa, Tulsa, Oklahoma.

Sketch

Dr. Díaz has worked on various aspects of numerical analysis and numerical software development since he joined the Math. Faculty at Kentucky in 1975, and visited the Computer Science department at the University of Toronto in 1978-79.

Dr. Díaz has worked with various aspects of reservoir simulation since he joined Mobil Research and Development in 1981. His major interests have been on developing robust and parallel preconditionings for Krylov space iterative methods for reservoir simulation, and on adaptive grid refinement techniques for fluid flow in porous media. Since arriving in Oklahoma in 1984 and visiting Argonne National Laboratory several summers since 1985, he has been interested in various aspects of parallel processing issues including programming environments and languages, computer architectures, and mapping of numerically intensive algorithms onto parallel architectures.

He has worked as a consultant for Amoco Production Company for several years investigating parallel processing issues in functional language semantics for the description of reservoir simulators, application of massively parallel processing to iterative methods, developing domain decomposition techniques for faulted basin evolution, developing mathematical models for primary hydrocarbon migration, and more recently he worked on algorithms for the palinspastic reconstruction of seismic sections.

Extracurricular Activities in SMET Programs

Professor Diaz serves as the TU lead coordinator for the Oklahoma LS-AMP-SMET program at TU. Recently TU was upgraded to a full participant institution in the alliance.
The TU program was started on its own in 2000. Additional funding was obtained from the Zarrow Families foundation, a local private foundation, which has allowed the program to grow. Professor Díaz directed an intense residential summer bridge program for SMET students in the 2000 and 2001 summers. The summer internship program now includes 15 undergraduates conducting research in several SMET fields, and the academic year scholars program includes about 27 students participating in various levels of undergraduate research.

Professional Experience

1994-present: The University of Tulsa, Professor of Computer and Mathematical Sciences
1994 Sum & Fall Universidad de Valladolid, Iberdola Profesor Visit. Matemática Apl. y Comp.
1988-present: The University of Tulsa, Director, Center for Parallel and Scientific Computing
1987-1994: The University of Tulsa, Assoc. Prof. of Computer and Mathematical Sciences
1985-89: Argonne Nat. Lab., Summer Faculty Visitor
1984-87: University of Oklahoma Assoc. Professor of Computer Science
1981-84: Mobil R. & D. Senior Research Mathematician
1978-79: University of Toronto Visiting Associate Professor of Computer Science
1975-81: University of Kentucky Assistant Professor of Mathematics
1974-75: University of Kentucky Postdoctoral Fellow Mathematics

Selected Publications


List of Doctoral and Post-Doctorals supervised by J. C. Díaz.

C. G. Macedo, Jr., Ph.D. 1990 (IBM, Brasil); J. D. F. Cosgrove, Ph.D. 1992 (Cameron U, Oklahoma); R. P. Bording, Ph.D. 1996 (PGS Inc., Houston); M. Komara, Ph.D. 1996 (Exxon-Mobil, Ivory Coast); L. Chu, Post-Doctoral, 1991-93 (Petrofina, Houston).
6.2 Advisory Committee Member: Ram Mohan

Education

University of Kerala (India), Bachelor of Science in Mechanical Engineering (1984); University of Kentucky, Master of Science (1992) and Doctor of Philosophy (1996) in Mechanical Engineering.

Current Position

Associate Professor Mechanical Engineering Department, The University of Tulsa, 1996-present.

Professional Experience


- The University of Tulsa, Mechanical Engineering Department, Associate Professor (2001-present), Assistant Professor (1996-2000).

- Associate Director (1998-2001), and Co-Principal Investigator (1996-1998), Tulsa University Separation Technology Projects, Industry/University Cooperative Research Group (JIP); Fifteen to Twenty Private Sector Partners in the Oil and Gas Sector.

Significant Publications


Current Research Activities

Co-Principal Investigator; "NSF/CRCD: Multiphase Transport Phenomena Curriculum"; The National Science Foundation, Michigan State University, The University of Akron, and The University of Tulsa; $625,000, 1999-2001.


Co-Principal Investigator, Tulsa University Separation Technology Projects, Cooperative Industry University Research Group (JIP); $255,000 per year.

Graduate and Undergraduate Curricula

Independently developed 4 courses (2 undergraduate and 2 graduate courses) during the past 5 years, which are new for the Mechanical Engineering program at The University of Tulsa.
1. Manufacturing Processes (ME 3063).
2. Quality Control and Manufacturing Technology (ME 4323 / ME 6523).
3. Advanced Manufacturing Processes (ME 7863).

Developed an Internet-based course on Multiphase Transport Phenomenon (MTP) jointly with Professor Ovadia Shoham of The University of Tulsa Petroleum Engg., Professor Charles Petty of Michigan State University and Professor George Chase of University of Akron as a part of the Combined Research and Curriculum Development (CRCD) project sponsored by National Science Foundation (NSF).

Awarded TAU BETA PI Professor of the month award during April 1997 for teaching excellence.

Industrial Traineeship Programs

Besides developing the above courses for academia, developed and conducted 5 different short courses and workshops for petroleum industry in recent years jointly with Dr. Ovadia Shoham, Professor of Petroleum Engineering, The University of Tulsa.
7 Budget and Budget Justification

7.1 Justification

Senior Personnel
The PI will devote 1.1 mos each Summer 2002 and 2003 to develop new educational
materials for the laboratory based course. Further, the PI expects to be assigned to teach
the class during the Fall and Spring of the 2002-2003 academic year at which time the
revised materials will be used. Further, the PI expects to spend nearly 5% during the
academic year on project related issues. Subject to enrollment, the PI anticipates offering
the course during the 2002 and 2003 Summer sessions.

Graduate and Undergraduate Assistants
A Graduate Assistant will be employed by the grant for three terms and two summers.
The aim is to recruit a CS student that can complete a Master’s degree in the allotted
period. The GA will develop labs and projects in the selected platform language. The
GA will also assist to ensure the quality of all sample code presented in the lecture notes.

One Undergraduate Assistant will be recruited each term to help in identifying labs
and projects, and to help review the material produced by the PI and the GA from the
point of view of readability by typical target engineering undergraduate student. The
UG’s will likely be students in the target disciplines that have already taken previous
version of the course. The UG’s and the GA both will produce the CD version of the
educational materials for distribution.

Equipment
The equipment consist of a PC workstation that would serve as the workstation for the
GA and as depository for the different material related for the course. It should have
significant disk capabilities. It should include a heavy duty CD writer to be used to
produce versions of the educational materials for distribution to the students enrolled in
the class.

Below is the specification of the equipment as if it were to be purchased May 2001.
This specification is given here to illustrate the minimal required components and the
actual price at the time the proposal was written. The actual brand and configuration
will be determined at the time of purchase.
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</tr>
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<td>Catalog</td>
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<td>Processor</td>
<td>Intel Xeon processor, 1.40GHz</td>
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<td>Memory</td>
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<tr>
<td>Graphics Card</td>
<td>GeForce 2 GTS, 32MB NVGAGP</td>
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<tr>
<td>Hard Drive</td>
<td>18GB Ultra 160/M SCSI, 1 inch (10,000 rpm)</td>
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<td>Monitor</td>
<td>17” Dell 1701FP</td>
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<tr>
<td>Operating System</td>
<td>Microsoft Windows 2000 Professional</td>
</tr>
<tr>
<td>CD Read–Write Drive</td>
<td>20/48X IDE CD–ROM and 12X/8X/32X CD Read–Write ROMRW</td>
</tr>
<tr>
<td>Sound Card</td>
<td>Creative Labs Sound SB512 – 313–7355</td>
</tr>
<tr>
<td>Speakers</td>
<td>harman/kardon 19.5 Speakers</td>
</tr>
<tr>
<td>Keyboard</td>
<td>Enhanced Performance, USB keyboard,</td>
</tr>
<tr>
<td>Mouse</td>
<td>Logitech Club PS/2</td>
</tr>
<tr>
<td>Floppy Drive</td>
<td>3.5” 1.44MB Floppy Drive</td>
</tr>
</tbody>
</table>

**Cost-Sharing**

The PI’s Department Chair and Collegiate Dean at University of Tulsa have agreed to cost-share the equipment portion of the budget on a 1-1 ratio.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>NSF</th>
<th>TU</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC Workstation</td>
<td>1,747</td>
<td>1,747</td>
<td>3,494</td>
</tr>
</tbody>
</table>

**Supplies-Travel**

Miscellaneous supplies also include Tel charges, software packages, blank CD’s for experimentation and distribution, etc. Travel includes modest expenses for travel to Engineering and CS Education conferences to present the results of the project.
7.2 Budget –Year 1 of 2
7.3 Budget – Year 2 of 2
7.4 Budget – Cumulative
8 Current and Pending Support

8.1 Current Support

- J. C. Díaz,
  *LS Oklahoma Alliance for Minority Participation in Science, Mathematics, Engineering, and Technology (LSOKAMP-SMET)*. PI for the University of Tulsa, National Science Foundation, $30,000, November 2001 to May 2002.
  Time commitment PI: .5% Academic Year Only.

- J. C. Díaz,
  *Implementation of a Science Enrichment Program at Whittier Elementary School*, for the University of Tulsa Chapter of the Hispanic Honor Society, Phillips Petroleum Foundation, and other Foundations.
  $13,000, January 1992 to Present.
  Time commitment PI: .18 Mos. Academic Year Only.

8.2 Pending Support

- J. C. Díaz,
  *Summer 2001 Academic Prefreshmen Bridge Program for SMET students*,
  Oklahoma State Regents for Higher Education
  $12,000, June 2001 to August 2001.
9 Facilities, Equipment and Other Resources

The network infrastructure is in place to support the project. The University operates a campus-wide fiber optic data network which is connected to the Internet. All faculty offices, and undergraduate laboratories have access to the network. The College of Engineering and Natural Sciences has three MS-Windows PC undergraduate laboratories and one Unix based which are accessible for all students in the college. Additionally each department maintains a MS-Windows PC laboratory for their own students. The PI’s currently has in his office a Sun Unix workstation and a Dell MS-Windows PC that supports the PI’s work.
10 Appendices

10.1 Specific Examples

We present a brief highlighted summary of a lesson to illustrate the nature of the presentation. The assessment of this lesson leads to the presentation of another set of language constructs.

10.1.1 Snell’s Law and Functions

A presentation of Snell’s law leads to the discussion of functions in the programming language:

Problem Snell’s law provides a general relationship for scattering of waves (such as light and sound) incident from one medium (such as air) into another medium (such as water).

Model Snell’s law describes the geometry of scattering of the incident wave. Snell’s law states that the ratio of the sine of the angle against the normal line to the velocity of the medium is the same for both incident and transmitted mediums. The angles are measured against a normal line to the interface.

\[ \frac{\sin(\theta_i)}{V_i} = \frac{\sin(\theta_t)}{V_t} \]

where \( V_i, V_t \) are the incidence and transmitted velocities, the angle \( \theta_i \) is both the incidence and reflection angles, and the angle \( \theta_t \) is the transmission angle.

Algorithm The problem is to determine the transmission angle \( \theta_t \) given the medium velocities and the incident angle. For each of the cases considered we have three input values:

1. the incidence angle \( \theta_i \),
2. the incidence velocity, \( V_i \), and
3. the transmitted velocity, \( V_t \).

Mathematically speaking the transmitted angle \( \theta_t \) is a function of three arguments the incidence angle \( \theta_i \), the incidence velocity, \( V_i \), and the transmitted velocity, \( V_t \).

\[ \theta_t = f(\theta_i, V_i, V_t) = \arcsin((\sin(\theta_i) * V_t/V_i)) \]

Implementation The C++ language has a vehicle to express a function such as 10.1.1, it is the function subprogram. Functions is a powerful programming concept that allows to write large and complex programs.
Assessment  The discussion carefully uses examples where the incidence velocity is greater than
the transmitted velocity. The following lecture, the program that was developed
earlier is shown to produce the wrong numbers. Light from water to air, or sound
from air to water will quickly produce wrong results. This leads to the discussion
of critical angles which in turn leads to if statement.

10.2  Sample exercises/quizzes questions.

10.2.1 Coulomb’s Law

Coulomb’s law relates the energy of interaction between a pair of ions and the distance
between their centers and their numerical ion charges. The energy interaction in joules $E$
between a pair of ions is given by

$$ E = 2.31 \times 10^{-19} \frac{Q_1 Q_2}{r}. $$

Where $r$ is the distance between the ion centers in nm, and $Q_1$ and $Q_2$ are the numerical
ion charges.

Write a main() program that receives as input the distance between the ion centers
and the numerical ion charges, and outputs the energy interaction. The input is from the
file Coulomb.txt. The results are sent to the file EnergyInter.txt.

10.3  Free energy in an ideal Gas

The free energy in an ideal gas depends on the pressure and the temperature of the gas.
The free energy $G$ of a gas at $P$ atm pressure is given by:

$$ G = G^0 + RT \ln(P). $$

Where $G^0$ is the free energy of the gas at a 1 atm pressure, $T$ is the temperature, and $R$
is the gas constant.

Write a function to compute the free energy in an ideal gas would take in as arguments
the pressure, the free energy of the gas at a 1 atm pressure, the temperature, and the gas
constant and return the free energy.

10.4  Gass Reduced Presure and temperature

The gas reduced pressure and temperature are functions of the the pressure, temperature,
and the gas gravity. The C++ function gasRdcPT calculates the gass reduced temperature
and pressure is declared as:

```cpp
void gasRdcPT( float Press, float Temp, float Gas_g,
               float & P_g, float & T_g);
```
where $\text{Press}$ is the pressure in (psia), $\text{Temp}$ is the temperature in (oR), $\text{Gas}\_g$ is the gas gravity, $P\_g$ is the gas reduced pressure, and $T\_g$ is the gas reduced temperature.

Write a C++ main() program that reads the temperature from the file \texttt{TempCent.txt} in (oC), the pressure from the file \texttt{PressPsia.txt} in (psia), and the gas gravity from the file \texttt{GassGrv.txt}. The program invokes the \texttt{gasRdcPT()} function and outputs the values of gas reduced pressure to the file \texttt{GasRdcP.txt} and gas reduced temperature to the file \texttt{GasTdcT.txt}.
Letters of Support