UNDERGRADUATE INSTRUCTIONAL IMPROVEMENT PROGRAM
Instructional Scientific Equipment - ISEP

1. Title of Project: ELEMENTARY SURVEYING IMPROVEMENT
   (Limit to 70 letters and spaces)

2. a. Name of Institution: Santa Barbara City College
   b. Location: City Santa Barbara, State California, Zip Code 93109
   c. Grant to: Santa Barbara Community College District

3. a. Type of Institution: Public X Private □ Consortium □
   b. Institution's opening FTE undergraduate fall enrollment as reported in Fall Enrollment in Higher Education, 1975, National Center for Educational Statistics, NCES #76-135 9079
   c. Highest Degree Offered in Science by Campus Submitting this Proposal (Check One)
      □ Associate X Baccalaureate □ Master □ Doctor □ Other (specify)

4. a. Major Discipline Code: (Enter Only One Code): EN
   b. Field of Science and Engineering Code: Primary AQ59 (Surveying) Other ND54

5. a. Amount Requested from NSF: $8,400
      (Round to nearest $100)
   b. Amount to be provided in matching funds: $8,400
      (Round to nearest $100)

6. Number of students to be affected over a 5-year period: 225

7. From 6, the number expected: a. to terminate scientific studies with the Associate
   Degree 30 b. to terminate scientific studies with the Baccalaureate
   Degree 120 c. to continue scientific studies beyond the Baccalaureate
   Degree 40 d. to enter pre-college teaching careers 15

8. Are funds for any part of the project proposed herein being requested in another proposal to NSF or some other Federal Agency? □ No X If yes, explain below.

9. Project Director:
   a. Name: (Prof., Dr., Mr., Ms., etc.) Frederic W. Schuler
   b. Mailing Address (Academic)
      Department Physics and Engineering
      Institution Santa Barbara City College
      City, State Santa Barbara, CA 93109 Zip
   c. Social Security No. 2
   d. Phone: Office (805) 965-0581 (Ext. 453)
      (Incl. Area Code) Home (805) 687-1492
   e. Signature: [Signature]
   f. Date: 2/27/78

10. Authorized Institutional Representative:
    a. Name: (Prof., Dr., Mr., Ms., etc.) Glenn G. Gooder
    b. Title: Superintendent/President
    c. Mailing Address:
       Santa Barbara City College
       721 Cliff Drive
       Santa Barbara, CA 93109
    d. Signature: [Signature]
    e. Date: 2/28/78

1. See reverse side of this page and page 6
2. See Comments regarding Social Security account number disclosure, page 5.
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**State Sales Tax (6%)**

939.97

**Shipping Costs**

(Group I, II at 10. per item
Group III, V at 3. per item)

Total

16,756.22

**NSF Grant Matching Funds**

8,400.00

15,666.25
ABSTRACT

The one-semester elementary surveying course taught in the engineering department of Santa Barbara City College, while now showing growth, has not undergone changes in teaching methods in the last ten years. Meanwhile, practices in the field have changed greatly with the availability of much more precise instrumentation. The availability of inexpensive pocket computers, including programmable ones, is nearly universal, and these instruments have become an integral part of the basic equipment of the surveyor and engineer. This proposal incorporates the use of pocket computers for learning the basic trigonometry and for simplifying computations. Then the emphasis is to be shifted from computation to extension of the range and types of measurements: (1) by making measurements of model polygons in the laboratory, (2) by making field measurements of low precision with range finders and tripod compass, (3) by making field measurements of intermediate precision, using existing equipment, tapes and transits, and finally, (4) by making field measurements of high precision, using tapes and theodolites with optical read-out of angles. Thus the study of the principles of metrology, surveying, and errors can be covered in an expanded manner, still consistent with an elementary course.
NARRATIVE

A. The Present Situation

1. History of the Present Surveying Course

   Santa Barbara City College has offered a one semester elementary surveying course, taught once a year for many years. This course has been a basic course in the engineering program. While the engineering program has suffered decreases in enrollment during the period 1970-75, the surveying enrollment remained fairly constant. It has been increasing since 1975, as has the enrollment in the other engineering classes. In fact, due to the limited equipment available, we have had to restrict the enrollment to 30 students the last three years and the class has been closed before the end of the registration period. For the school year 78-79, for the first time, we will offer the surveying class in both fall and spring, and we anticipate about 45 students to be enrolled over the year.

2. Deficiencies of the Present Course

   Through the years the course has remained a straightforward, traditionally taught, basic surveying course. Emphasis has been made on measurements with tape and transit, and at least until this current year, on teaching trigometric functions and the sine law and cosine law of oblique triangles as in a trigonometry class, with computations carried out by trigonometric table, logarithms, and the slide rule. The computations have been fairly time-consuming so that only a small number of surveying assignments are carried out.
Meanwhile small, economical pocket computers are available, much more convenient to use than trigonometric tables and logarithms. Programmable computers are now well within the price range that students can consider, and those using magnetic card memories are priced so that the school can consider them as part of their instructional equipment stock. The precision of surveying equipment has improved, also, with the introduction of laser-beam and infra-red tacheometers, and optical read-out of angles. Students need to be taught the underlying principles of the use of these new tools.

The whole course offers potential of revision, from the basic teaching of trigonometric concepts and computation to the field measurements. In fact, Jack C. McCormac, in his new book, Surveying, (Prentice-Hall, Inc., 1976, p. 267) says: "...surveyors who are not taking advantage of electronic computers or programmable desk or pocket calculators are actually endangering their professional futures."

This year seven Texas Instruments SR-40 pocket computers have been available to the students, although no formal effort has been made to teach them how to use the SR-40. Such instruction is available in another engineering course, Numerical and Graphical Analysis, and will also be available in a five week evening course starting the fifth week of the semester. Of course, the instruction manuals are available so that students can learn on their own.
B. Project Description

1. New Directions

The objectives of this proposal are:

- To bring the full power of non-programmable pocket computers into play in this course.
- To teach trigonometry from basic definitions and as key sequences of the computer.
- To make model measurements "in the small" in the laboratory, studying the principles of metrology, surveying, and errors and carrying out surveying computations as key sequences using the computers.
- To go out in the field and carry out measurements at different levels of precision, including the less precise measurements using small range-finders and spirit level instruments, intermediate measurements with transits, and more accurate measurements with the theodolite.
- To return to the laboratory, carry out computations of field work with the pocket computers and to learn to write programs and use programmable computers for the problems already studied.

These steps are broken down into eight parts, called the "Key Elements of the Course," and follow in the next section. It is to be emphasized that through the simplification of computation we can consider expanding the range of measurements, still consistent with an elementary course. It is through this increased range of measurements that the student will become more aware of significant figures, averages, and
errors as well as the range of precision of his measuring equipment. While these concepts are here presented in the context of a surveying course it is also noteworthy that they are applicable in many other areas of engineering and science.

2. The Key Elements of the Course

1) **Basic Metrology: Lengths and Angles**

   Students will measure lengths and angles using model polygons (triangles, quadrilaterals, pentagons, hexagons) with sides less than 5 inches in length, engraved on black anodized aluminum plate (3/8" thick). Students will measure lengths using three levels of precision (engineer's triangular rule, vernier caliper, and dial caliper) and angles using two levels of precision (protractor and vernier protractor).

2) **Scale Drawings**

   Students will construct scale drawings of the model polygons using protractors and engineer's triangular rule, exploring different scales of the rule.

3) **Triangulation**

   Students will analyze the model polygon data using pocket computers, like the Texas Instruments SR-40 or TI-30.

4) **Basic Trigonometry**

   Those students requiring the basic trigonometric background will be taught the definitions of trigonometric functions and inverse trigonometric functions and the law of sines and the law of cosines for oblique triangles.
5) **Trigonometry by Pocket Computer**

Students will be taught the analysis of triangles with the pocket computer, rather than traditional trigonometric tables. They will be taught how to decimalize angles given in degrees-minutes-seconds, so as to input the decimal angle, and how to get inverse functions.

6) **Computer Key Sequences for Polygon Analysis**

Students will be taught how to describe their steps of polygon analysis in pocket computer language of key sequences, after learning the operations, calculator hierarchy (algebraic hierarchy), use of parentheses, memories, and trigonometric keys (of the SR-40 or TI-30).

7) **Measurements in the Field at Different Levels of Precision**

The ease, rapidity, and precision of computation made possible by the pocket computer will mean that more time can be spent on the principles of metrology and surveying. More measurements on polygons can be made and analyzed, so that the student can be exposed to a variety of instruments offering different levels of precision.

The laboratory measurements, at this stage, will be extended to field measurements, at different levels of precision:

(a) by making measurements of low precision with range finders and tripod compass
(b) by making measurements of intermediate precision, using existing equipment, with tapes and transits, and, finally,

(c) by making measurements of higher precision, using tapes and theodolites with optical angle read-out. Students will construct scale drawings. The polygons will be analyzed.

8) **Computer Programming by Magnetic Card**

After the above measurements are analyzed by pocket computer, the students will be taught the use of the programmable pocket computer (Texas Instruments TI-59) to re-analyze any of the previously obtained data, ranging from the engraved polygons to the field data. They will be taught as much of the full capability of the computer as is required. They will review the pocket computer language, key sequences, programming, edit programs, check programs, and use magnetic cards.
C. The Equipment Request

The equipment request is divided into five groups and each group is related to a key element in Section 4 above.

Group I: High Precision Instruments ("Key Element", number 7)

2 Theodolites and tripods, (Budget Items a,b)

Group II: Low Precision Instruments ("Key Element", number 7)

2 Spirit Level Instruments and tripods
   (Budget Items c, d)

2 Small Rangefinders (Budget Item e)

2 Tripod Compasses (Budget Item f)

Group III: Programmable Magnetic Card Computers ("Key Element", number 8)

5 Texas Instruments TI-59 (Budget Item g)

Group IV: Model Polygon, Gauges, and Protractors
   ("Key Element", number 1)

4 Anodized aluminum plate (1/4" x 18" x 18")
   (Budget Item h)

4 Dial gauge calipers (Budget Item i)

4 Precision Vernier Protractors (Budget Item j)

Group V: Support Computers ("Key Element", number 3)

5 Texas Instruments TI-57
D. Present Equipment on Hand

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E. Maintenance of Equipment

The Physics/Engineering Department has a full-time laboratory technician who is responsible for the maintenance of equipment on hand. Specialized equipment, such as surveying instruments that need repair or maintenance that is outside the capability of the technician, is sent to Surveyors Service Company, Costa Mesa, California.

F. Faculty

Dr. Frederic Schuler, Chairman of the Engineering and Physics Department, received his PhD degree from the University of Wisconsin in 1949, with a major in Physical Chemistry and a minor in Mathematics. He has had 17 years of industrial experience, as a senior research associate, and as a supervisor, doing research and development work in high vacuum technology,
vacuum deposited thin magnetic films, photosensitive glass and pyrocerams, and high temperature electrochemical batteries. He has been 11 years at Santa Barbara City College and taught the engineering courses: Engineering and Society, Design and Problem Solving, Design Graphics, Numerical and Graphical Analysis, Vector Mechanics: Statics as well as the general physics and mechanics course for engineers and physicists. He will assist in the planning and preparation of the detailed course of study outline and will either instruct the students on the use of the hand held computer directly in the course or through the separate mini-course concept, to be held parallel to the surveying course.

Mr. Joseph Connell received his Bachelor of Civil Engineering Degree from the University of City of New York, School of Technology, in 1957 and his Master of Arts Degree from the University of California, Santa Barbara in 1972. He is a Registered Civil Engineer and Licensed Professional Engineer. He has taught the surveying course at Santa Barbara City College for ten years.