COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e., program, division, etc.)	FOR NSF USE ONLY
Instrumentation & Laboratory Improvement-Instrumentation Project (ILI-IP)	NSF PROPOSAL NUMBER

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/If not in response to a program announcement/solicitation enter GPG, NSF 95-27

GPG, NSF95-27 November 15, 1996

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	FILE LOCATION

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
34-101-1998	☐ A RENEWAL OR ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING ZIP CODE
Youngstown State University	One University Plaza, Youngstown, OH 44555
AWARDEE ORGANIZATION CODE (IF KNOWN): PUBL	
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE	ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING ZIP CODE
PERFORMING ORGANIZATION CODE (IF KNOWN)	

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.D.1 For Definitions) ☐ FOR-PROFIT ORGANIZATION ☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS

TITLE OF PROPOSED PROJECT
Modernization of Instrumentation in a Physical Measurements course

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE
$ 44,112	24 months	September, 1997

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.A.3)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.D.1)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG II.D.10)
- ☐ NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.D.10)
- ☐ HISTORIC PLACES (GPG II.D.10)
- ☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.12)
- ☐ GROUP PROPOSAL (GPG II.D.12)
- ☐ VERTEBRATE ANIMALS (GPG II.D.12) IACUC App. Date ______
- ☐ HUMAN SUBJECTS (GPG II.D.12) Exemption Subsection ____ or IRB App. Date ______
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES ______
- ☐ FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)
- ☐ RESEARCH OPPORTUNITY AWARD (GPG V.H)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
School of Technology	School of Technology Youngstown State University Youngstown, OH 44555
PI/PD FAX NUMBER: 216/742-1567	

NAMES (TYPED)	Social Security No.*	High Degree, Yr	Telephone Number	Electronic Mail Address
PI/PD NAME: Mansour Zenouzi, PE	011-60-2826	Ph.D. 1990	330/742-3741	mzenouzi@cc.ysu.edu
CO-PI/PD: Francis R. Krygowski, PE	279-46-2510	MSME 1972	330/742-3290	ae505@yfn.ysu.edu
CO-PI/PD: Theodore R. Bosela, PE	289-66-4239	Ph.D. 1993	330/742-3286	tbosela@ysub.ysu.edu
CO-PI/PD				
CO-PI/PD				

NOTE: THE FULLY SIGNED CERTIFICATION PAGE MUST BE SUBMITTED IMMEDIATELY FOLLOWING THIS COVER SHEET

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE NSF INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED

CERTIFICATION PAGE

Certification for Principal Investigators and Co-Principal Investigators

I certify to the best of my knowledge that:

(1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and

(2) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of this application.

I understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is a criminal offense (U.S.Code, Title 18, Section 1001).

Name (Typed)	Signature	Date
PI/PD Dr. Mansour Zenouzi	[signature]	November 12, 1996
Co-PI/PD Mr. Francis R. Krygowski	[signature]	November 12, 1996
Co-PI/PD Dr. Theodore R. Bosela	[signature]	November 12, 1996
Co-PI/PD		
Co-PI/PD		

Certification for Authorized Organizational Representative or Individual Applicant

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding Federal debt status, debarment and suspension, drugfree workplace, and lobbying activities (see below), as set forth in the *Grant Proposal Guide (GPG)*, NSF 95-27. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of *Grant Policy Manual* Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Debt and Debarment Certifications (If answer "yes" to either, please provide explanation.)

Is the organization delinquent on any Federal debt? Yes ☐ No XX

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal Department or agency? Yes ☐ No XX

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME/TITLE (TYPED) Dr. Peter J. Kasvinsky, Dean Graduate Studies		[signature]	11/14/96
TELEPHONE NUMBER (330) 742-3091	ELECTRONIC MAIL ADDRESS		FAX NUMBER (330) 742-1580

APPENDIX I

NATIONAL SCIENCE FOUNDATION
Division of Undergraduate Education

PROJECT DATA FORM

The instructions and codes to be used in completing this form begin on the next page.

1. Program to which the Proposal is Submitted: ILI-IP
2. Type of Submission: PR
3. Name of Principal Investigator/Project Director (as shown on the Cover Sheet):
   Dr. Mansour Zenouzi
4. Name of Submitting Institution (as shown on the Cover Sheet)
   Youngstown State University
5. Other institutions involved in the project's operation:
   ______

ATE and CETP only
Preliminary Proposal Number(s) that led to this proposal ______

PROJECT CODES

A. Major Discipline Code: 5 8 Subfields: 56

B. Academic Focus Level of Project: B O

C. Highest Degree Code: B

D. Category Code: __ __

E. Business/Industry Participation Code: __ __

F. Audience Code: __ __ __ __

G. Institution Code: P U B L

H. Strategic Area Code: __ __

Estimated number in each of the following categories to be directly affected by the activities of the project during its operation:

J. Undergraduate Students: 500

K. Pre-college Students: ______

L. College Faculty: 5

M. Pre-college Teachers: ______

N. Total Non-NSF Contribution: $44,113

Project Summary:

The Summary of Proposed Work should be a concise description of the project limited to 22 lines of 12-point (standard pica type) or larger font on plain white paper.

NSF Form 1295 (10/94)

PROJECT SUMMARY

Modernization of Instrumentation in a Physical Measurements Course

The aim of theis proposal is to expand and modernize the laboratory exercises in a Mechanical Engineering Technology course in Physical Measurements.

Currently, the course is predominantly lecture (42 out of 60 contact hours). Although the course material deals with over 50 types of sensors, lab experiments allow practice with only 12 sensors, and data is taken manually, giving students no experience with computer data acquisition.

The objectives of this project are: to acquire a larger number of sensors for use in additional exercises, so students gain practical experience and familiarity with the sensors; to include modern computerized data acquisition equipment and techniques; and to shift the course emphasis as much as possible from passive lecture experience to active experimental experience, while using the strengths of multidisciplinary teams of Electrical Engineering Technology students and Mechanical Engineering Technology students to broaden the knowledge of students from each discipline.

It is hoped that articles resulting from this laboratory development will aid other similar programs in choosing laboratory equipment for such upgrades, and will justify and promote the use of active, versus passive, learning, particularly with multidisciplinary teams.

TABLE OF CONTENTS

NARRATIVE

Modern mechanical systems in both manufacturing and in consumer products are making increasing use of digital controls, and of sensors to monitor the controlled variables This has increased the need for mechanical technicians and technologists to be familiar with electronic sensors and data acquisition. Simultaneously, electrical technicians and technologists need more familiarity with the sensors used to measure properties such as pressure, flow, temperature and strain. Given the practical nature of the Engineering Technology curriculum, it is desirable to provide these students with hands-on experience with as many sensors as possible, and with modern computerized measurement systems. Furthermore, state-of-the-art computerized data acquisition systems can enhance the quality of education by removing the need for tedious, repetitive calculations, thus keeping the student's attention focused on fundamental concepts.

The purpose of this proposal is to upgrade and modernize the Physical Measurement laboratory in the Mechanical Engineering Technology program consistent with the principles stated above.

a. Current Situation:

a.1 The Institution:

Youngstown State University (YSU) is an urban, state-assisted university located in downtown Youngstown, an industrial center in northeastern Ohio, midway between Pittsburgh and Cleveland. YSU is a co-educational, equal opportunity institution with a current enrollment of about 13,000.

YSU is primarily an undergraduate institution, consisting of six colleges and a School of Graduate Studies–The College of Arts and Sciences, the William Rayen College of Engineering and Technology, the College of Fine and Performing Arts, the Williamson College of Business Administration, the College of Health and Human Services, and the

College of Education. Associate, Bachelor's and Master's degree programs are offered in the College of Engineering and Technology.

YSU's primary mission is to provide a wide range of opportunities in higher education, largely, but not exclusively, to the residents of northeastern Ohio and western Pennsylvania. The University is committed to quality in teaching, scholarship, research and public service, and seeks faculty who combine these elements in ways that stimulate excitement and eagerness for learning in students.

a.2 The School of Technology

The School of Technology is one of the seven major departments within the College of Engineering and Technology. The School of Technology offers "two plus two" programs in Engineering Technology. Students in these programs may work toward a two year Associate degree or a four year Bachelor's degree. The Associate in Applied Science degree is offered in Civil Engineering Technology, Drafting and Design Technology, Electrical Engineering Technology, and Mechanical Engineering Technology while the Bachelor of Science in Applied Science degree is offered in Civil Engineering Technology, Electrical Engineering Technology, and Mechanical Engineering Technology. There are eight full-time and approximately 12 part-time faculty members in the School of Technology. Approximately 300 students are enrolled in two-year Associate degree programs and approximately 150 students are enrolled in Bachelor's degree programs.

The Civil, Electrical, and Mechanical Engineering Technology Associate and Bachelor's programs are accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC/ABET). In many states, including Ohio and Pennsylvania, Bachelor degree graduates are qualified to take the Engineer in Training (EIT) exam, and with sufficient work experience, the Professional Engineering (PE) exam.

The Mechanical Engineering Technology program provides students with a broad general education, as well as a strong background in the three principal areas of the major: Design, Manufacturing and Energy Conversion. The curricula for the MET Associate and Bachelor's programs are shown in Appendix B.

a.3 Courses Affected by Proposal

The proposed laboratory improvement will affect the content of five courses. The specific course which will be most affected by the proposed laboratory improvement is MET 700, Physical Measurements. The Physical Measurements course is the basic instrumentation laboratory course in the MET Curriculum. This course is also a required course for students in the Electrical Engineering Technology program.

Currently, the course deals with fundamentals of measurement theory, data reduction, basic electronic circuits used with sensors, and the specific sensors used to measure such fundamental quantities as force, strain, temperature, and pressure. Current experiments in the physical measurements course are: Industrial Metrology (micrometers, gage blocks, etc.); Temperature (thermocouples, thermistors, etc.); Strain (resistive strain gages); Fluid Velocity (pitot-static tube); Area Measurement and Statistics (planimeter); and Industrial Proximity Sensors (inductive, capacitive, photoelectric, etc.)

In addition, it is expected that the equipment purchased as a result of this proposal will be used to supplement experiments in other courses. For example, hot film anemometers, flowmeters and pressure transducers could find application in the MET 615 Fluid Mechanics laboratory and the MET 610 Heat and Power Cycles laboratory. Several experiments in the EET 610/611 AC/DC Machines lab may also be revised to utilize the data acquisition and analysis capabilities of the equipment requested in this proposal.

Specific descriptions of the above courses are included in Appendix B.

a.4 Departmental Resources

The Mechanical Engineering Technology program is housed in a newly remodeled building which is shared by three other engineering technology programs and five engineering programs. The Engineering Technology department has eight full-service faculty members and approximately 12 limited service faculty. Most full-service faculty are Registered Professional Engineers, and the limited service faculty are particularly strong at bringing current industrial experience into the classroom.

The department is well supported with equipment. Many laboratories and computer rooms are shared between programs in the College, allowing efficient use of the physical facilities and laboratory equipment. Computer labs currently contain 24 Pentiums, twenty 486 computers, and sixteen 386 computers. Engineering Technology also has eight large classrooms and/or laboratories for its exclusive use, including a computer lab. Dedicated laboratories include fluid mechanics, robotics and numerical control, strength of materials, machine shop, heat transfer, and several electronics labs. In addition, there is a general MET laboratory which is used for various courses (including the Physical Measurements course) and which would house the equipment requested in this proposal.

a.5 The Curricular Deficiency

At present, the Physical Measurements course is taught largely by lecture. Approximately 50 types sensors are discussed in detail [1, 2], but there are only six laboratory experiments, giving students experience with less than a dozen types of sensors. Furthermore, data is collected by hand in the current experiments. There is no experience with data acquisition equipment or software.

Modern industrial practice makes use of a wide variety of sensors and routinely uses computerized data acquisition. Since an aim of the program is to provide realistic experience consistent with current real-world industrial applications, it is very desirable to provide experience with these sensors and systems in this laboratory.

b. The Development Plan

The proposal to upgrade equipment in the MET Physical Measurements laboratory has the following objectives:

- Teach fundamental instrumentation concepts more effectively by providing examples of a wider variety of sensors.
- Provide an understanding of digital data acquisition systems and their operation, including hardware, software, and interfacing.
- Enhance the interdisciplinary nature of the course, allowing Electrical Technology students to take a leadership role in the electronic aspects of experiments, while Mechanical Technology students do the same regarding the mechanical aspects.
- Provide an environment emphasizing active, rather than passive learning, where experiments and lab time will replace some lecture time.

In order to implement this upgrading, it will be necessary to purchase a variety of sensors, both fundamental mechanical ones and sensors suitable for electronic interfacing. It will also be necessary to purchase complete systems that will perform digital data acquisition. The individual components of these systems include personal computers, data acquisition and control software, and all necessary interface boards and apparatus. A graphical software package such as LabView, from National Instruments [3] will be used to provide the user interface. This type of software provides tools for instrument control, data acquisition, and data analysis [4]. Data collection chores can be handled by the software, allowing the students to focus on understanding the underlying principles and the data analysis procedures. Without the acquisition of this equipment, the desired modernization cannot be accomplished.

The first changes in course structure will be the introduction of new experiments to acquaint the students with fundamental circuits used with sensors (filters, bridges, amplifiers, etc.) and digital data acquisition (DAQ) hardware and software.

For example, one experiment will investigate the linearity and response of a Wheatstone Bridge circuit, a ballast circuit, and a voltage divider circuit to varying inputs.

In another experiment, the students will study the frequency response of various filter and signal conditioning circuits, such as high pass, low pass, band pass, and band reject filters. Two input channels of the data acquisition board will be used to observe the input and output waveforms of the various filter networks. A comparison between input and output can be made to evaluate filter performance.

A third experiment will use a signal generator, an oscilloscope, and PC data acquisition hardware and software to gain an understanding of signal levels, resolution and sampling rates.

There will be eight copies of these experiments, enabling the entire class to quickly come up to speed with these topics and use them in subsequent experiments. At the completion of these experiments, the student will understand fundamental measurement circuits, and have hands-on experience using a digital data acquisition system similar to those used in industry.

After these preliminary experiments, the DAQ equipment will be used in other experiments, as described below. Subsequent experiments in this course are run in parallel by several lab groups, so multiple copies of other hardware are not necessary.

Three existing MET 700 experiments will be affected by the equipment requested in this proposal: Temperature Measurement, Strain Measurement, and Fluid Velocity Measurement. These existing experiments will be upgraded to include digital data acquisition and processing techniques.

1. The Temperature Measurement experiment currently involves manually measuring thermocouple voltage as a function of temperature, and using a strip chart recorder to determine response to a step change in temperature. The modified experiment will use a data acquisition system to compare outputs from thermocouples, thermistors and RTDs, as regards linearity and sensitivity. The response to a step change can be better shown using the graphing capabilities of the acquisition software, and direct comparison of the response of the transducers should be possible.

2. The current strain gage experiment is essentially a static test. It is planned to enhance this with a dynamic test, using the Vibrating Beam Test Bed apparatus portion of TecQuipment's SL Systems Laboratory. The TecQuipment's Systems Laboratory is comprised of a Mainframe unit, which provides support and power functions for various experimental modules and test beds, a selection of electronic signal conditioning modules, and the experimental test beds themselves. The TecQuipment Vibrating Beam apparatus includes a cantilever beam fitted with strain gages and temperature instrumentation, and which can be statically deflected or vibrated at various frequencies. This will allow capture of the dynamic strain signals by computer, as well as the investigation of different bridge configurations for their response to strain and their temperature compensation characteristics.

3. The Fluid Velocity experiment is currently limited to the use of a pitot-static tube to examine air velocity at the exit of a free jet. To demonstrate the greater sensitivity of the hot-film anemometer, it will be used to measure the velocity profile of the free jet at a series of axial locations. Calibration of the hot-film anemometer as a function of flow speed, flow direction, and temperature will be incorporated into this experiment, as well as in experiments in the Fluid Mechanics (MET 615) and Heat and Power Cycle (MET 610) courses.

In addition to modernizing existing experiments as described above, there will be new experiments added to the course, to expose the students to a wider variety of sensors than is now possible. These are described below:

1. A new pressure measurement experiment will use equipment to be purchased as part of TecQuipment's Systems Laboratory (as mentioned above). The Pressure Sensing Test Bed, plus suitable interface modules, will be used with the same Mainframe unit described above to demonstrate the response of a bourdon tube gage and a flexible diaphragm to changes in pressure, as sensed by a variable capacitance probe, an LVDT, strain gages and a linear potentiometer.

2. Another new experiment will measure volume rate of flow, by use of an orifice meter and venturi meter in series with a small wind tunnel. By placing the two meters in series, students will perform a direct comparison of the meters' responses. By later installing each meter separately, they will study the effect of measurement system loading. By placing a suitable obstruction in the wind tunnel, the hot wire anemometer will be able to detect the frequency of formation of Karman vortices, thus relating vortex frequency to flow velocity, demonstrating the operating principle of the vortex flowmeter.

3. A third new experiment involves an LVDT and accelerometer used in conjunction with the TecQuipment Vibrating Beam Test Bed, described above. The vibrating beam will allow investigation of displacement, velocity and acceleration measurements using analog and digital integration and differentiation. This will allow comparison of analog and digital signal conditioning, and reinforce basic motion concepts.

4. In a fourth new experiment, the students will investigate the measurement of speed and angular position by absolute and incremental encoders, as well as a resolver. The output of the respective transducers will be read into the personal computer based data acquisition system. Students will become familiar with the encoder coding techniques and waveforms of the various output signals. In addition, a comparison will be made between the actual position or speed and the output of the encoders and resolver to determine the accuracy of the measured quantities.

In addition, the encoders and resolvers will be used for speed measurement in the EET 610 and 611 AC/DC Machines laboratory, demonstrating an alternative to the current use of tachogenerators.

The improvements described in this section will greatly enhance the qualifications of graduates obtaining both the Associate degree and Bachelor's degree at YSU. Thus, the graduates will be better prepared for careers with manufacturing firms, consulting firms, governmental agencies, etc.

c. Equipment

c.1 The Equipment Request

We feel that each piece of equipment requested is critical to the development described. The key components of this project are complete data acquisition systems, comprising personal computers, printers, data acquisition boards, and a software package such as "LabView" from National Instruments. LabView is an example of a general software package for data acquisition (DAQ), monitoring and real-time control. The purchase of 8 such systems will allow the entire class to become familiar with DAQ early in the course; afterward, the systems will be interfaced to various experiments for the remainder of the course, as described above.

The various sensors and support systems were chosen to provide experience with a broad range of sensors, and whenever possible to take advantage of existing experimental equipment of suitable versatility. The TecQuipment Transducer Systems Laboratory units provide this broad range of sensors, and allow running of three experiments with only two Mainframe units, thus saving cost and floor space.

The Cradco C-45 wind tunnel was chosen to compare venturi and orifice meters, in lieu of other commercial units because of it's small tabletop size and low cost, and because most educational volume flow experiments use water as the working fluid. Since the laboratory is dry (no water supply or drain) this was preferred. A standard venturi meter and orifice meter will be purchased to match the wind tunnel.

TSI's FlowPoint velocity transducer system will be used as a data acquisition tool with the above tabletop wind tunnel. TSI's hot–wire anemometer is a common industry–standard system for measuring mean and fluctuating components of fluid velocity.

The encoders and resolvers were selected to reflect current real–world industrial applications. Encoders are instructive as being among the most common digital sensors. The models chosen are typical industrial equipment.

c.2 Equipment on Hand for the Project

The following equipment is currently on hand and available for use in the Physical Measurements and MET 610 MET 615 courses:

Equipment Description	Quantity
Tektronix Digital Oscilloscopes	4
Solomat Multifunctional Instrument	2
Fluke Digital Multimeters	6
D/C Power Supplies	5
Rubicon thermocouple indicators	2
Solomat digital thermocouple indicators, with 4 probes	2
Pitot-static tube with well manometer	1
Dead weight pressure gage calibrator	1
Strip chart recorders	2
Dimensional metrology toolkit (micrometers, gage blocks, calipers, etc.)	1
Starrett Data Collector system, hardware and software	1
Dual trace digital storage Tektronics oscilloscope	1
Strain gage indicators, with switch and balance units	2
Industrial proximity sensor kits (inductive, capacitive, Hall effect, etc.)	2
Thermoline electric high-temperature furnace ($0.6ft^3$)	1

Other major equipment owned by the department, but not directly pertinent to this project, are listed in Appendix A.

c.3 Equipment Maintenance

Operation and minor maintenance of the proposed equipment will be the responsibility of the School of Technology. For the 1996-97 academic year, the Department has budgeted a total of $9,360 for supplies, with additional funds for student lab assistants.

Maintenance beyond the capability of the department is handled by YSU's Electronics

Maintenance Service, which has six technicians qualified to maintain highly sophisticated scientific instruments and a budget over $300,000. Mechanical maintenance for the College of Engineering and Technology is handled by a staff of four technicians.

Past history indicates that the funds available and the procedure used are ample to maintain the equipment in proper operating condition.

d. Faculty Expertise

The authors of this proposal are well qualified to implement the project described. We have extensive experience in selecting, installing and operating a wide range of laboratory instruments.

Dr. Mansour Zenouzi, a faculty member in the School of Technology—Mechanical Engineering Technology, is the Principal Investigator for the proposed project. Dr. Zenouzi has been on YSU's faculty since 1990. His previous experience includes eight years of teaching and research at Northeastern University, which included lecturing and supervising laboratory sessions in a Measurement and Analysis course at Northeastern University. Dr. Zenouzi has been involved in laboratory development during his graduate training. He designed and developed a laboratory incorporating a fully automated micro-computer based data acquisition system and hot film anemometry. Additionally, he has industrial experience and is a registered Professional Engineer in the state of Ohio.

Mr. Frank Krygowski has been coordinator of the Mechanical Engineering Technology Program since 1982. He has been on the faculty of the School of Technology—Mechanical Engineering Technology program for 15 years. During the course of his tenure, Mr. Krygowski has periodically taught all of the Mechanical Engineering Technology courses affected by this proposal, and is familiar with the course content. He has industrial experience in Plant Engineering and Robotics, and is a registered Professional Engineer in Ohio and Pennsylvania.

Dr. Theodore R. Bosela has been on the faculty of the School of Technology for the past 7 years. He has taught the electrical machines, power distribution, power transmission, and programmable logic controls courses in the Electrical Engineering Technology program. In addition, he has been Director of the School of Technology since July 1, 1996. Dr Bosela has approximately 7 years of industrial experience in the electrical power utility and consulting industry, and is a registered professional engineer in Ohio and Pennsylvania.

e. Evaluation and Dissemination Plan

To assess the effectiveness of this course development, it is proposed to survey students at the end of the course, to have them self-evaluate their knowledge of the characteristics of various sensors, sensor interfacing, and data acquisition, as well as their level of interest in the course material. By administering this questionnaire to students in the present version of the course, then to students in the revised course, any improvements in the students' impressions should be obvious.

The results of this program will be disseminated to the scientific and engineering communities by submitting papers to the American Society for Engineering Education and the American Society of Mechanical Engineers for presentation at various local and national meetings or for publication in educational journals.

Bibliography

[1] Holman, J.P., "Experimental Methods For Engineers," 6th Ed., McGraw Hill, 1994.

[2] Dally, J.W., Riley, W.F., and McConnell, K.G., "Instrumentation For Engineering Measurements," 2nd Ed., John Wiley & Sons, 1993.

[3] LabView Instrumentation and Reference Catalog, 1996 Edition, National Instruments Corporation, Austin, Texas, 1996.

[4] Eaton, j.K. and Eaton, L., "LabTutor: A Friendly Guide to Laboratory Computer Interfacing and LabView Programming," Oxford U. Press, 1995.

Mansour Zenouzi
School of Technology
Youngstown State University
Youngstown, OH 44555

EDUCATION:

Ph.D. Mechanical Engineering, Northeastern University, Boston, MA, 1990.
M.S. Mechanical Engineering, Tufts University, Medford, MA, 1981.
B.S. Mechanical Engineering, University of Science and Technology, Tehran, Iran, 1976.

PROFESSIONAL EXPERIENCE:

YOUNGSTOWN STATE UNIVERSITY, School of Technology

Associate Professor, Sept. 1995–present.
Assistant Professor, Sept. 1990–Sept. 1995.

- Taught Thermodynamics, Air Conditioning Principles, Fluid Mechanics, Heat and Power Cycles, Applied Finite Element Method, Physical Measurements, BASIC, and Dynamics.

NORTHEASTERN UNIVERSITY, Mechanical Engineering Department

Instructor, 1983–Sept. 1990

- Taught Heat Transfer, Thermodynamics I and II, Fluid Mechanics, Statics, and Dynamics.

Teaching/Research Assistant, 1982–1983.

- Lectured and supervised laboratory sessions in Measurement and Analysis, Heat Transfer, Internal Combustion Engines, and Mechanics of Materials.
- Designed and developed a laboratory incorporating the Beckman gas analyzer and a fully automated micro-computer based data acquisition/processing and graphic facility for the experimental setup of a study on "NO_x Reduction in a Fixed and Fluidized Bed Coal Combustion."

EFB INC.,Woburn, MA

Engineering Consultant, Summer 1987

- Studied the flow field characteristics of the "2500 cfm Electrified Filter Bed unit" and provided a final report.

LEHIGH UNIVERSITY, Mechanical Engineering Department

Research/Teaching Assistant, 1981–1982.

- Investigated flow-induced vibrations through the use of hot film anemometer, pressure transducer, high speed video recording, and Laser Doppler Velocimetry (LDV).
- Lectured and conducted Heat Transfer and Fluid Mechanics Laboratories.

TUFTS UNIVERSITY, Mechanical Engineering Department

Teaching Assistant, 1980–1981.

- Assisted Instructor in Numerical Methods Course.

HAIMEX CO. (Subsidiary of HAIMEX Company in Frankfurt, Germany)

Design Engineer, 1976–1979.

- Responsible for HVAC systems design for Estimated heating and cooling loads and designed HVAC/plumbing systems for large institutional, industrial, and commercial facilities.

AWARDS:

- Distinguished Professorship Award for Scholarship, YSU 1995-96.
- YSU Research Professorship for the 1994-95 academic year.
- Received the National Science Foundation travel grant to attend the NATO Advanced Study Institute in Izmir, Turkey, June 21–July 2, 1993.
- Support for research from the YSU Research Council grant and the YSU Faculty Development Grant.

PROFESSIONAL AFFILIATIONS & ACTIVITIES:

- Registered Professional Engineer in the State of Ohio.
- Member of ASME, ASHRAE, Phi Beta Delta, and the Advanced Energy Systems Analysis Technical Committee of ASME.
- Contributing editor of a symposium proceedings entitled "Thermodynamics and the Design, Analysis and Improvement of Energy Systems," AES-Vol. 35, presented at the 1995 *International Mechanical Engineering Congress and Exposition*, San Francisco, California, November 12–17, 1995.
- Co-edited a symposium proceedings entitled "Thermodynamics and the Design, Analysis, and Improvement of Energy Systems," AES-Vol. 33, presented at the 1994 *International Mechanical Engineering Congress and Exposition*, Chicago, Illinois, November 6–11, 1994.
- Chaired and co-chaired technical sessions sponsored by the Advanced Energy Systems Division of ASME at the 1994 and 1995 IMEC&E.
- Served as a reviewer for Advanced Energy Systems, Solar Energy Engineering, and Electrical and Electronic Packaging Divisions of ASME, for the Intenational Heat and Mass Transfer Conference, and for ASHRAE.

PUBLICATIONS:

Ramadhyani, S., Zenouzi, M., and Astill, K. N., "Combined Natural and Forced Convective Heat Transfer in Spherical Annuli," *ASME Journal of Heat Transfer*, Vol. 106, pp. 811–816, 1984.

Zenouzi, M. and Yener, Y., "Simultaneous Radiation and Natural Convection in Vertical Slots," Developments in Radiative Heat Transfer, (S.T. Thynell, *et al.*, Eds.), HTD–Vol. 203, pp. 179–186, ASME 1992.

Zenouzi, M. and Yener, Y., "Thermal Stability of Radiating Fluid in a Vertical Slot," *Stability of Convective Flows*, (P.G. Simpkins and A. Liakopoulos, Eds.), HTD-Vol. 219, pp. 1-7, ASME 1992.

Zenouzi, M., Tangborn, A., Taslim, M., and Methghalchi, M., "Implementation of Design in Teaching of Engineering Thermodynamics," *Thermodynamics and the Design, Analysis, and Improvement of Energy Systems,* (H.J. Richter, Ed.), AES-Vol. 30/HTD-Vol. 266, pp. 241-247, ASME 1993.

Zenouzi, M., Yener, Y., and Tangborn, A., "Numerical Modeling in Heat Transfer By Spectral Methods," in *Mathematical Modelling Courses for Engineering Education*, (Y. Ersoy, A.O. Moscardini, Eds.), Series F Computer and Systems Sciences, Vol. 132, pp. 221-236, Springer-Verlag, Berlin, 1994.

Tangborn, A., Zenouzi, M., Yener, Y., "Numerical Simulation of Heat Transfer problems by Spectral Methods," Proceedings of the *Tenth International Heat Transfer Conference*, (G.F. Hewitt, Ed.), Vol. 2, pp. 467-472, IChemE, UK, 1994.

Zenouzi, M., Mankarios, E., Song, H., and Metghalchi, M., "An Automotive Air Conditioning System Using LiBr-H_2O Absorption Refrigeration Cycle," *Thermodynamics and the Design, Analysis, and Improvement of Energy Systems,* (R.J. Krane, Ed.), AES-Vol. 33, pp. 339-346, ASME 1994.

Zenouzi, M., Mankarios, E., and Metghalchi, M., "Dynamic Simulation of a Solar Powered Lithium Bromide–Water Absorption Cooling System with Refrigerant/Absorbent Storage Tanks," *Solar Engineering 1995*, (W.B. Stine, *et al.*, Eds.), Vol. 2, pp. 1259-1266, ASME 1995.

Patwardhan, A., Ataai, M., and Zenouzi, M., "A Mathematical Model of the Immobilized Metal Affinity Chromatography for Protein Separations: Simulation of Loading and Elution Conditions," *Advances in Heat and Mass Transfer in Biotechnology,* (L.J. Hayes, Ed.), HTD-Vol. 322/BED-Vol. 32, pp. 61-68, ASME 1995.

Patwardhan, A., Zenouzi, M., and Ataai, M., "Designing Efficient Loading and Elution Strategies for IMAC Separations: Purification of Human Interleukin 1β from *E. coli* cell Extract as a Model System," *Recent Advances and Future Opportunities in Separations Technology,* Vol. 1, pp. 418-424, AIChE 1995.

Francis R. Krygowski
School of Technology
Youngstown State University
Youngstown, OH 44555

Education: BE in ME Youngstown State University, 1970
MS in ME Youngstown State University, 1972

Work Experience:

1980 to present: Youngstown State University, Youngstown Ohio - Associate Professor, School of Engineering Technology, College of Engineering and Technology. Since 1982, Coordinator of the Mechanical Engineering Technology program. Responsible for course and curriculum development, textbook choices, purchase of laboratory equipment, hiring of limited service faculty, industrial relations through the Industrial Advisory Committee, course scheduling, and general administration of the program.

Courses currently taught include Elements of Engineering Technology including computer programming), Mechanics (both statics and dynamics), Machine Design, and Robotics Technology. Other courses recently taught include Fluid Mechanics, Thermodynamics, Physical Measurements, Advanced Drawing and Manufacturing Techniques.

1990 - 1991: Packard Electric Corp., Warren, Ohio - Manufacturing Development Engineer (while on sabbatical from YSU): Responsibilities included: complete revision of robot programming software for three industrial robots, and software enhancements for a fourth, using the VAL-II/V+ robot programming language; writing of robot support manuals for use by engineers and technicians, operators and maintenance workers; research into failure of small stamping press frames; and development work on flexible part orientation and feeding systems.

1973 - 1980: Coosa Valley Tech, Rome, Georgia - Coordinator of the Mechanical Engineering Technology program. Teaching and administrative duties similar to the current position at YSU.

1972 - 1973: Union Carbide Corp., Cartersville, Georgia - Plant Engineer. Responsibilities included: Noise abatement program in the plant; design of an automated carton turnover mechanism; miscellaneous steel structural design; supervision of construction projects.

1970 - 1972: Youngstown State University, Youngstown, Ohio - Awarded graduate assistantship. Duties included research and computer program coming under an NSF grant, and teaching engineering classes.

Work Experience (cont.):

1966-1968 Summers: Commercial Intertech, Youngstown Ohio - Hydraulics Laboratory Technician. Duties included setup, monitoring and data collection for endurance tests of hydraulic pumps, valves and cylinders.

Public service projects include work on committees for local, regional and state (ODOT) agencies related to facilities for non-motorized (bicycle and pedestrian) transportation, and membership on the Board of Trustees of Poland Municipal Forest.

Publications include "The M.E.T. Robotics Technology Laboratory at Youngstown State University", 3rd place award at the American Society for Engineering Education regional conference in Akron, OH., and "Anodized Rim Stiffness: Bending vs. Compression vs. Spray Paint", published in Bike Tech, a national circulation magazine of bicycle technology. Presentations include "Getting Started with Computer Bulletin Boards - The Edge of the Internet" for the ASME.

Member of the American Society of Mechanical Engineers and Society of Manufacturing Engineers, Robotics International. Registered professional engineer in Pennsylvania.

Theodore R. Bosela

Youngstown State University
School of Technology
Youngstown, Ohio 44555

EDUCATION

University of Pittsburgh
Ph.D. in Electrical Engineering conferred May, 1993.

University of Akron
Master of Science in Electrical Engineering conferred January, 1985.

Youngstown State University
Bachelor of Engineering conferred March, 1981.

EXPERIENCE

Youngstown State University
Director of School of Technology, July 1, 1996 to present. Duties include administration of the School of Technology.

Assistant Professor, September 1993 to present, Instructor, September 1989 to August, 1993. Duties include teaching of AC and DC Electrical Machines, Power Systems, Electronics, and Electrical Systems Design to Electrical Engineering Technology Students.

Schneider Engineers Inc.
Senior Electrical Engineer, May 1989, to September, 1989. Duties included preparation of corporate design standards and specifications for electrical power transmission distribution and substation facilities.

University of Pittsburgh
Teaching Fellow in Electrical Engineering, September, 1988 to April, 1989. Assisted in teaching FORTRAN and electrical machines to engineering students.

Mosure and Syrakis Co.
Manager of Electrical Engineering, May, 1987 to January, 1988. Responsible for the design and project management of electrical systems for commercial, industrial and institutional facilities.

Pennsylvania Power Company
District Engineer, December, 1985 to August, 1986 and February, 1987 to May, 1987. Responsible for operation of Zelienople District Engineering department. Performed voltage flicker analysis of large motor starting, voltage drop calculations, ensured that overhead and underground line extensions were engineered and designed in accordance with company policy.

Transmission Planning Engineer, August 1986 to February, 1987. Analyzed impact of large load increases on the transmission system, performed line outage and contingency analyses, prepared construction budget for transmission facilities.

Distribution Planning Engineer-A, October, 1984 to December, 1985. Performed load studies for facility expansion planning, transformer economic analysis and life cycle costing, distribution construction budget preparation, harmonic analysis of distribution circuits.

Distribution Engineer-B, May, 1984 to October, 1984 and October, 1982 to August, 1983. Investigated voltage and TV/Radio interference complaints on customer premises, performed voltage flicker calculations, protective device coordination studies of various distribution circuits, design of overhead and underground line extensions and new customer services.

Electrical Application Engineer-B, November, 1981 to October, 1982. Performed calculation of protective relay setting for coordinated protection of transmission and distribution lines, designed installation of supervisory control and data acquisition system for remote substation locations, performed protective coordination studies of transformer and capacitor installations.

Substation Design Engineer-B, July, 1981 to November, 1981. Performed substation terminal equipment loadability study to determine equipment capability under continuous, short time and emergency conditions.

<u>University of Akron</u>
Teaching Assistant August, 1983 to May, 1984. Assisted in teaching Sophomore Engineering students basic electrical circuits and electronics.

<u>Youngstown State University</u>
Teaching Assistant January, 1981 to June, 1981. Assisted in teaching Senior Electrical Engineering students basic communications circuits and electrical machines.

<u>John Bosela Construction Company</u>
General Construction Laborer, June 1976, to June, 1981.

OTHER

Registered Professional Engineer - Ohio and Pennsylvania
Member of IEEE
Member of ASEE

Past recipient of NSF ILI Grant, July, 1990, "Automated Data Acquisition and Control of AC and DC Machines Lab". NSF Grant No: USE-9052292.

SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY			
PROPOSAL NO.	DURATION (MONTHS)	Proposed	Granted
AWARD NO.			

ORGANIZATION
Youngstown State University

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Dr. Mansour Zenouzi, PE

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF-Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted By NSF (If Different)
1. Dr. Mansour Zenouzi				$	$
2. Francis R. Krygowski					
3. Dr. Theodore R. Bosela					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) 8 computer data acquisition boards & software, $10,360; 8 Pentium P5-150 computers, $21,600; 2 TecQuipment SL1 Mainframes, $11,110; 1 Hotwire anemometry system, $12,230					
TOTAL EQUIPMENT				$86,725	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ ____ 2. TRAVEL ____ 3. SUBSISTENCE ____ 4. OTHER ____					
( ) TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER Equipment assembly and shipping cost				$ 1,500	
TOTAL OTHER DIRECT COSTS				$ 1,500	
H. TOTAL DIRECT COSTS (A THROUGH G)				$88,225	
I. INDIRECT COSTS (SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS					
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$88,225	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECT SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 88,225	$

M. COST-SHARING: PROPOSED LEVEL $44,113	AGREED LEVEL IF DIFFERENT $		
PI/PD TYPED NAME & SIGNATURE* Dr. Mansour Zenouzi	DATE 11/13/96	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION	
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet / Initials-ORG

NSF Form 1030 (7/95) *Supersedes All Previous Editions* *SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B

ILI-IP DETAILED BUDGET (EQUIPMENT LIST)

Item (Descriptive name, probable brand & model)	How Many	Unit Price (List)	Unit Price (Discounted)	Total Cost (Discounted)
1. Scientific and Computing Equipment				
IBM-compatible Pentium computers (Gateway P5-150)	8	$3,000	$2,700	$21,600
Ink jet color printers (HP 660-C)	8	$ 575	$ 390	$ 3,120
DAQ Class Pack/Win data acquisition packages (hardware and software)	8	$1,295	$1,295	$10,360
5B Series Backplane w/ 5VDC 5A power supply	8	$ 360	$ 360	$ 2,880
CB50LP 50-pin connector blocks & cables	8	$ 70	$ 70	$ 560
NBI 50/C cable 1M	8	$ 30	$ 30	$ 240
Thermocouple Modules 5B47	2	$ 205	$ 205	$ 410
Strain Guage Modules 5B38	2	$ 180	$ 180	$ 360
Current/voltage Modules 5B30	2	$ 150	$ 150	$ 300
RTD Modules 5B34	2	$ 150	$ 150	$ 300
Pressure & Vibrating Beam/Strain Gauge Experiments, to consist of:				
TecQuipment (TQ) SL1 Mainframe	2	$5,555	$5,555	$11,110
TQ-SL10 Pressure Sensing Test Bed	1	$4,913	$4,913	$ 4,913
TQ-SL10 Vibrating Beam Test Bed	1	$4,626	$4,626	$ 4,626
TQ-SL101 Phase Shifter	2	$ 417	$ 417	$ 834
TQ-SL102 Phase Sensitive Detector	2	$ 417	$ 417	$ 834
TQ-SL103 Differential Amplifier	2	$ 387	$ 387	$ 774
TQ-SL05 Bridge Network	2	$ 387	$ 387	$ 774
TQ-SL106 Low Pass Filter	2	$ 179	$ 179	$ 358
TQ-SL115 Capacitance Transducer	1	$ 579	$ 579	$ 579
TQ-SL118 Constant Current Generator	1	$ 537	$ 537	$ 537
TQ-SL31 Diaphragm Gauge	1	$ 625	$ 625	$ 625
TQ-SL100 Differential Current Amplifier	1	$ 431	$ 431	$ 431
TQ-SL104 Charge Amplifier	1	$ 423	$ 423	$ 423
TQ-SL114 Analogue Thermocouple	1	$ 514	$ 514	$ 514

Detailed Budget (Continued)

Item (Descriptive name, probable brand & model)	How Many	Unit Price (List)	Unit Price (Discounted)	Total Cost (Discounted)
Fluid Velocity Experiment, to consist of:				
TSI 2 channel Flowpoint 1500-2SH hot wire anemometer system	1	$10,900	$10,360	$10,360
TSI single sensor file probe pkg.	1	$ 850	$ 850	$ 850
TSI single sensor probe support	2	$ 190	$ 190	$ 380
TSI locking and protecting shield	2	$ 220	$ 220	$ 420
Air velocity calibration	1	$ 250	$ 240	$ 240
Cradco wind tunnel, model C-45	1	$ 1,495	$ 1,495	$ 1,495
Venturi meter	1	$ 900	$ 900	$ 900
Orifice meter	1	$ 250	$ 250	$ 250
Rotational Position Experiment, to consist of:				
Absolute optical encoder with mating connector- Allen Bradley	2	$ 1,095	$ 1,095	$ 2,190
Incremental optical encoder with current source output - Allen Bradley	2	$ 479	$ 479	$ 958
Industrial resolvers - Allen Bradley	2	$ 620	$ 620	$ 1,240
2. Construction of Equipment:				-0-
3. Equipment Assembly:				$ 1,000
4. Safety Equipment:				-0-
5. Shipping Costs:				$ 500
6. Required Taxes:				-0-
		Total project cost:		$88,225
		Non-NSF contribution (Including any overmatch)		$44,113
		NSF request:		$44,112

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Mansour Zenouzi, Francis Krygowski, Theodore Bosela

Other agencies (including NSF) to which this proposal has been/will be submitted: None

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Appendices

APPENDIX A

List of Other Major Departmental Equipment

Equipment Description	Quantity
General Electric industrial robots (models P-55 and P-60)	2
Adept One industrial robot	1
Allen Bradley SLC-100 programmable logic controllers	5
Technovate fluid mechanics test benches with associated equipment	2
Technovate impact of a jet apparatuses	2
Technovate venturi flow apparatuses	2
TecQuipment pipe friction loss apparatus	1
Rotary drum viscosimeter	1
Precision Scientific kinematic viscosity apparatus	1
Vega industrial hydraulic and pneumatic test benches, with components	5
Boyle's & Charles Law experimental apparatus	5
Jet 1325 metal working lathes (manual control)	5
Bridgeport Series One milling machine (manual control)	1
Boxford shaper (manual control)	1
Rockwell - Delta vertical band saw (manual control)	2
Rockwell - Delta drill presses (manual control)	2
Burke - Cincinnati horizontal milling machine (manual control)	1
Universal testing machine	1
Tektronix Analog Oscilloscopes	12
AC/DC Analog Voltmeters, Ammeters, Wattmeters	6
Hewlett Packard signal generators	6
Hampden Motor Generator Test Set	5
Labtech Notebook with associated DAQ Boards	2

Computer lab, with 18 IBM 386 personal computers and 5 printers.

Appendix B

Descriptions of Courses Affected
and
Curriculum

MET 700 - Physical Measurements

1995 Catalog Data: MET 700. Physical Measurements. Practice in the use and selection of instruments measuring pressure, temperature, strain, force and flow rate including the interpretation of data and the fundamentals of Statistical Quality Control. Three hours lecture and three hours laboratory per week. Prereq.: EET 625 and ECON 624 or MATH 714 4 q.h.

Textbook: Holman, Experimental Methods for Engineers, 5th ed, McGraw - Hill, 1989

Reference: Beckwith & Buck, Mechanical Measurements, Addison-Wesley, 1981

Offering Frequency: Winter-Night, Summer-Night

Enrollments : Average class size is approximately 30
Class is required of all MET and EET majors

Goals: To introduce students to the general principles of industrial measurement and data reduction, including the fundamentals of Statistical Quality Control, and to familiarize them with a range of sensing devices and techniques for measuring various physical quantities.

Prerequisites by topic:

1. Mathematical statistics.
2. Fundamentals of electricity and electronics.
3. Fundamentals of stress and strain.

Topics:

1. Basic concepts of measurement (3 class hours)
2. Analysis of data, curve fitting and SQC (6 class hours)
3. Electrical devices and systems (5 class hours)
4. Displacement and area measurement (2 class hours)
5. Pressure measurement (3 class hours)
6. Flow measurement (3 class hours)
7. Temperature measurement (3 class hours)
8. Force, torque and strain measurement (3 class hours)
9. Tests (2 class hours)

Computer usage:

1. Students are introduced to a computer program used for curve fitting of experimental data.

2. Students make use of a department-written program to obtain immediate feedback in a laboratory experiment involving machinists tools.

Laboratory projects:

1. Metrology: Students learn the use of a variety of machinists measuring tools with the aid of a computer program. Requires use of micrometers, vernier calipers, gage blocks, dial gages, snap gages, etc. Report required. (1 week)

2. Temperature measurement: Students measure temperature using thermocouples, plotting voltage versus temperature. Students measure response time of the thermocouple system to a step change in temperature. Requires use of voltage balancing potentiometer, digital temperature display unit, strip chart recorder. Report required. (2 weeks)

3. Strain measurement: Students measure longitudinal and lateral strain in a cantilever beam, comparing measured strain with nominal predicted strain and with limits predicted by uncertainty analysis. The response of the system to a step change is also observed. Requires use of strain gages, digital strain indicator, and storage oscilloscope. Report required. (2 weeks)

4. Area measurement: Students measure a variety of areas using a polar planimeter. Statistics procedures are used to evaluate the effects of random human errors in tracing. Requires use of polar planimeter. Report required. (2 weeks)

5. Fluid velocity measurement: Students measure the distribution of air velocity across the exit area of an industrial blower. Requires use of Pitot-static tube and differential manometer. Report required. (2 weeks)

6. Industrial proximity sensors: Students determine the response of six types of industrial proximity sensors to a variety of materials. Requires use of inductive and capacitive proximity sensors, reed switch, Hall effect sensor, and two optical sensors. Report required. (1 week)

MET 610 - Heat and Power Cycles

1995 Catalog Data: MET 610. Heat and Power Cycles. A continuation of Thermodynamics, including the study of heat transfer, the Rankine cycle, the Otto cycle, the Deisel cycle, and the performance of pumps and heat exchangers. Three hours lecture and three hours laboratory per week. Prereq.: MET 605, MET 615 4 q.h.

Textbooks: Cengel & Boles, *Thermodynamics, an Engineering Approach*, McGraw-Hill, 1989
Mott, *Applied Fluid Mechanics*, 3rd ed., Merrill, 1990
Mikhailov, *Heat Transfer Solver*, Prentice-Hall, 1991

References: Moran, *Fundamentals of Engineering Thermodynamics*, Wiley, 1988
Ozisik, *Heat Transfer; a Basic Appoach*, McGraw-Hill, 1985

Offering Frequency: Spring every year

Enrollments : Average Class size is approximately 30
Class is required of all MET majors

Goals: To demonstrate the applications of the principles of thermodynamics, including their use in various power cycles and pumps. To introduce the fundamentals of heat transfer, and to demonstrate their application in heat exchangers.

Prerequisites by topic:

1. Algebra, trigonometry, calculus, and units of measurement.
2. Elements of thermodynamics.
3. Principles of fluid flow for incompressible fluids.
4. Ability to program in BASIC or another high level programming language.

Topics:

1. Review of thermodynamics (3 class hours)
1. Gas power cycles: Carnot, Otto, Diesel, Brayton, etc. (6 class hours)
2. Vapor power cycles: Carnot, Rankine, cogeneration, etc. (4 class hours)
3. Pumps: design, selection, performance (3 class hours)
4. Introduction to heat transfer (2 class hours)
5. Heat conduction (3 class hours)
6. Convection (3 class hours)
7. Heat exchangers: Classification, thermal analysis (3 class hours)
8. Radiation (1 class hours)
9. Tests (2 class hours)

Computer usage:

1. Students will write at least one BASIC program related to the course material.

2. Students will solve a variety of problems in heat transfer using the Heat Transfer Solver software package.

3. Students will use a department written software package to perform heat transfer calculations for the heat exchanger laboratory exercise.

Laboratory projects:

1. Pump performance: Determine the performance of a centrifugal pump, by measuring discharge pressure, discharge flow, and input torque versus pump speed. Requires use of pump apparatus, tachometer, and other measuring tools. Report required. (1 week)

2. Lumped system analysis: Determine the film coefficient for convective heat transfer of a hot object cooling in air. Requires use of thermocouples, and strip chart recorder. Report required. (1 week)

3. Heat exchanger: Determine the effectiveness of a concentric tube heat exchanger as a function of flow rate for both parallel and conterflow conditions. Requires use of heat exchanger, rotameter, thermocouples and thermocouple potentiometers. Report required. (2 weeks)

4. Field trip: Technical tour of YSU power plant in the company of an operating engineer. (1 week)

5. Thermodynamic film series (1 week)

6. Problem session. (4 weeks)

MET 615 - Fluid Mechanics

1995 Catalog Data: MET 615. Fluid Mechanics. Fundamental concepts: fluid statics; the basic laws of fluid mechanics and their application to incompressible flow in pipes and channels; dimensional analysis, fluid measurements. Prereq.: MET 516 3 q.h.

MET 615L. Fluid Mechanics Laboratory. Tests and applications of concepts covered in MET 615. Three hours laboratory per week. Concurrent with MET 615. 1 q.h.

Textbook: R. Mott, *Applies Fluid Mechanics*, 2nd ed., Merrill, 1979

Reference: Granet, *Fluid Mechanics for Engineering Technology*, Prentice Hall, 1981

Offering Frequency: Fall-Day, Winter-Night

Enrollments : Average Class size is approximately 25
Class is required of all MET and CET majors

Goals: To introduce the fundamentals of fluid statics and fluid dynamics, including pressure, buoyancy, Bernoulli and energy conservation, pipe friction, and open channel flow. To enable students to analyze and predict fluid flow.

Prerequisites by topic:

1. Algebra, trigonometry, and units of measurement.
2. Statics and dynamics
3. Ability to program a computer in the BASIC programming language.

Topics:

1. Fundamental concepts and fluid properties (3 class hours)
2. Fluid statics (5 class hours)
3. Energetics of steady flow (3 class hours)
4. Fluid dynamics applications (4 class hours)
5. Incompressible flow in pipes (5 class hours)
6. Dynamic forces (3 class hours)
7. Open channel flow (3 hours)
8. Tests (4 class hours)

Computer usage:

1. Students will write at least one BASIC program related to the course material.

2. Students will use computer software for curve fitting for laboratory reports.

Laboratory projects:

1. Introductory project: determination of the relation of wave speed to liquid depth. Curve fitting. Requires use of flow tank. Report required. (1 week)

2. Measurement of fluid viscosity and specific gravity. Requires use of rotating drum viscosimeter and Wesphal balance. Report required. (1 week)

3. Measurement of kinematic viscosity variation with temperature. Requires use of Cannon-Fenske tubes in temperature-controlled bath. Report required. (1 week)

4. Measurement of flow discharge from an orifice, evaluation of discharge coefficient. Requires use of flow bench with orifice tank. Report required. (1 week)

5. Measurement of flow and pressure in a venturi. Requires use of flow bench and venturi with manometers. Report required. (1 week)

6. Measurement of frictional losses in piping systems. Requires flow bench and board-mounted piping system with manometers. Report required. (1 week)

7. Measurement of impact force of a jet of liquid. Requires flow bench with impact of jet apparatus. Report required. (1 week)

8. Measurement of flow discharge over a weir. Requires flow bench with weir plates. Report required. (1 week)

9. Problem sessions. (2 weeks)

Youngstown State University
College of Engineering & Technology

Last Update

MECHANICAL ENGINEERING TECHNOLOGY
Associate Degree Program

Effective FALL, 1995

NAME________________________ DATE__________ SOC. SEC. #________________

FIRST YEAR

First Quarter	Hrs.
*MATH 513 Intensive Inter Algebra	4( )
***STECH 505 Elements of Engr Technology	4( )
CHEM 501 Introduction to Chemistry	4( )
CHEM 510L Introduction to Chemistry Lab.	1( )
MECH 501 Engineering Drawing	3( )
	16( )

Second Quarter	Hrs.
MATH 520 Trigonometry	4( )
***MET 515 Mechanics 1	4( )
ENGL 550 Basic Composition 1	4( )
**Social Studies Elective	4( )
	16( )

Third Quarter	Hrs.
MATH 570 Calc for Engr Tech 1	5( )
MET 516 Mechanics 2	4( )
***CET 604 Properties & Strength of Matls.	4( )
ENGL 551 Basic Composition 2	4( )
	17( )

SECOND YEAR

Fourth Quarter	Hrs.
MATH 670 Calc for Engr Tech 2	4( )
MET 615 Fluid Mechanics	3( )
MET 615L Fluid Mechanics Lab	1( )
CET 607 Solid Mechanics	4( )
MET 630 Manufacturing Techniques	3( )
MET 630L Manufacturing Techniques Lab	1( )
	16( )

Fifth Quarter	Hrs.
MET 605 Thermodynamics	4( )
PHYS 502 Fundamentals of Phy 2	3( )
PHYS 502L Fund of Phys 2 Lab	1( )
MET 606 Machine Design 1	4( )
DDT 605 CAD Technology 1	4( )
HSC 590 Strategies Hlth/Well	3( )
	19( )

Sixth Quarter	Hrs.
MET 610 Heat and Power Cycles	4( )
MET 607 Machine Design 2	4( )
MET 620 Tool Design	3( )
****SPCH 651 Comm for Business & Professions	3( )
**Social Studies Elective	4( )
	18( )

(Advisor initial if not req'd or completed)
EPT: EDUC 510A___ EDUC 510B___ ENGL 520___ ENGL 540___
HS DEF: ENGL____ MATH____ SCI____ SOC SCI____
FOR.LANG____ F&PA____

TOTAL CREDIT HOURS — 102

*Or Math 505, Inter Algebra (5 q.h.) - same content as Math 513 with more contact hours.
**Social Studies Elective - select courses from geography (excluding physical geography), history, political science, psychology, sociology, economics, or black studies.
***"C" or better required to serve as prerequisites.
****Or SPCH 652 (4 q.h.)

TRANSFER CREDIT EVALUATION

(K) designates courses completed by transfer credit from________________________.

Evaluated by____________________, date__________. Total Q.H. (K)________________.

Remarks:____.

Youngstown State University
College of Engineering & Technology

Last Update	

MECHANICAL ENGINEERING TECHNOLOGY
Bachelor's Degree Program

Effective FALL, 1995

NAME____________________ DATE__________ SOC. SEC. # ________________

THIRD YEAR

Seventh Quarter	Hrs.
MATH 770 Calc for Engr Tech 3	4( )
EET 625 Electrical Systems 1	4( )
ECON 624 Economics & Social Stats 1	4( )
ENGL 743 Prof/Tech Comm	5( )
HPES Activity Course	1( )
	18( )

Eighth Quarter	Hrs.
♦Computer Elective	4( )
EET 725 Electrical Systems 2	4( )
MET 700 Physical Measurements	4( )
Social Studies Elective	4( )
HPES Activity Course	1( )
	17( )

Ninth Quarter	Hrs.
MATH 785 Matrix Alg & Num Methods	4( )
MET 720 Mechanisms	4( )
MET 715 Fluid Power Systems	4( )
PHYS 503/L Fund of Phys 3/Lab	4( )
HPES Activity Course	1( )
	17( )

FOURTH YEAR

Tenth Quarter	Hrs.
CET 800 Building Systems	4( )
MGT 725 Fundamentals of Management	4( )
MET 820 Machine Systems	4( )
MET 810 Manufacturing Systems Anal	4( )
	16( )

Eleventh Quarter	Hrs.
MGT 789 Operations Management 1	4( )
MET Elective (700/800 level)	4( )
MET Elective (700/800 level)	4( )
*Humanities Elective	4( )
	16( )

Twelfth Quarter	Hrs.
Free Elective	4( )
MET 860/L Robotics Technology/Lab	4( )
MET 830 Advanced Tool Design	4( )
*Humanities Elective	4( )
	16( )

TOTAL CREDIT HOURS — 100
TOTAL HOURS 4 YEARS — 202

MET Electives - Choose two from: MET 812 Numerical Controls, MET 840 Mechanisms 2, MET 850 Air Conditioning Principles & Practices, MET 870 Appl. Finite Element Method.
♦Computer Elective - select from CET 705, CIS 601, CIS 602
*Humanities Elective - a sheet listing courses which satisfy the humanities requirement is available in the departmental main office.

TRANSFER CREDIT EVALUATION

(K) designates courses completed by transfer credit from____________________.

Evaluated by________________, date________. Total Q.H. (K)____________.

Remarks:____________________________________.

Youngstown State University
College of Engineering & Technology

Last Update

ELECTRICAL ENGINEERING TECHNOLOGY
Associate Degree Program

Effective FALL, 1995

NAME________________________ DATE__________ SOC. SEC. #________________

FIRST YEAR

First Quarter — Hrs.

STECH 505 Elements of Engr Technology... 4( )
ENGL 550 Basic Composition 1............ 4( )
HSC 590 Strategies Hlth/Well............ 3( )
*MATH 513 Intensive Inter Algebra........ 4( )
DRAWING/CAD Elective.................... 4( )
19( )

Second Quarter — Hrs.

EET 501 Circuit Theory 1................ 3( )
EET 501L Circuit Theory 1 Lab........... 1( )
ENGL 551 Basic Composition 2............ 4( )
MATH 520 Trigonometry................... 4( )
**Social Studies Elective................ 4( )
16( )

Third Quarter — Hrs.

EET 502 Circuit Theory 2................ 3( )
EET 502L Circuit Theory 2 Lab........... 1( )
MATH 570 Calc for Engr Tech 1........... 5( )
PHYS 501 Fundamentals of Phys 1......... 4( )
***SPCH 651 Comm for Business & Professions 3( )
16( )

SECOND YEAR

Fourth Quarter — Hrs.

EET 503 Circuit Theory 3................ 3( )
EET 503L Circuit Theory 3 Lab........... 1( )
EET 605 Electronics 1................... 3( )
EET 605L Electronics 1 Lab.............. 1( )
EET 620 Digital Fundamentals............ 3( )
EET 620L Digital Fundamentals Lab....... 1( )
MATH 670 Calc for Engr Tech 2........... 4( )
16( )

Fifth Quarter — Hrs.

EET 600 Measurements.................... 3( )
EET 600L Measurements Lab............... 1( )
EET 606 Electronics 2................... 3( )
EET 606L Electronics 2 Lab.............. 1( )
EET 610 Direct Current Machines......... 3( )
EET 610L Direct Current Machines Lab.... 1( )
PHYS 503 Fundamentals of Phys 3......... 3( )
PHYS 503L Fund of Phys 3 Lab............ 1( )
16( )

Sixth Quarter — Hrs.

EET 607 Electronics 3................... 3( )
EET 607L Electronics 3 Lab.............. 1( )
EET 611 Alternating Current Machines.... 3( )
EET 611L Alt Current Machines Lab....... 1( )
EET 645 Microprocessor Systems 1/LAB.... 4( )
ECON 530 Principles I................... 4( )
16( )

(Advisor initial if not req'd or completed)
EPT: EDUC 510A___ EDUC 510B___ ENGL 520___ ENGL 540___
HS DEF: ENGL____ MATH_____ SCI_____ SOC SCI_____
FOR.LANG_____ F&PA_____

TOTAL CREDIT HOURS — 99

*Or Math 505, Inter Algebra (5 q.h.) - same content as Math 513 with more contact hours.
**Social Studies Elective - select social studies courses from geography (excluding physical geography), history, political science, psychology, sociology, economics, or black studies.
***Or SPCH 652 (4 q.h.)

TRANSFER CREDIT EVALUATION

(K) designates courses completed by transfer credit from_________________________.

Evaluated by______________________, date__________. Total Q.H. (K)________________.

Remarks:____.

Youngstown State University
College of Engineering & Technology

Last Update

ELECTRICAL ENGINEERING TECHNOLOGY
Bachelor's Degree Program

Effective FALL, 1995

NAME________________________ DATE__________ SOC. SEC. #________________

THIRD YEAR

Seventh Quarter	Hrs.
EET 720 Pulse Circuit Design/Lab	4( )
CET 604 Properties/Strength of Matls	4( )
♦Computer Elective	4( )
MATH 770 Calc for Engr Tech 3	4( )
	16( )

Eighth Quarter	Hrs.
EET 730 Logic Systems Design/Lab	4( )
HPES Activity Course	1( )
MATH 785 Matrix Alg & Num Methods	4( )
MET 630 Manufacturing Techniques	3( )
MET 630L Manufacturing Techniques Lab	1( )
**Science Elective	4( )
	17( )

Ninth Quarter	Hrs.
EET 710 Networks/Lab	4( )
EET Elective (700/800 level)	4( )
ECON 624 Econ & Social Stats 1	4( )
****Humanities Elective	4( )
*Social Studies Elective	4( )
	20( )

FOURTH YEAR

Tenth Quarter	Hrs.
EET 745 Microprocessor Systems 2/Lab	4( )
EET Elective (700/800 level)	4( )
CET 800 Building Systems	4( )
ENGL 743 Prof/Tech Comm	5( )
HPES Activity Course	1( )
	18( )

Eleventh Quarter	Hrs.
EET 810 Electrical Systems Design	4( )
EET Elective (700/800 level)	4( )
HPES Activity Course	1( )
MET 700 Physical Measurements	4( )
MGT 725 Fundamentals of Mgt	4( )
	17( )

Twelfth Quarter	Hrs.
EET 820 Power Transmission	4( )
****Humanities Elective	4( )
MGT 789 Operations Management 1	4( )
***Technical Elective (700/800 level)	4( )
	16( )

TOTAL CREDIT HOURS — 104
TOTAL HOURS 4 YEARS — 203

♦Computer Elective - select from CET 705, CIS 601, CIS 602
*Social Studies Elective - select social studies courses from geography (excluding physical geography), history, political science, psychology, sociology, economics, or black studies.
**Science Elective - select from chemistry (excluding chemistry 500) or physics (excluding physics 500).
***Technical Elective - select course from CET, EET, or MET programs.
****Humanities Elective - a sheet listing courses which satisfy the humanities requirement is available in the departmental main office.
EET Electives - choose any three of the following, 2 of which must be 800 level, EET 750/L Ind. Control EET 780/L Com. Sys. Fund.; EET 845/L Micro. Sys. 3; EET 850/L Integ. Cir. Appl.; EET 870 Proc. Cont. Te

TRANSFER CREDIT EVALUATION

(K) designates courses completed by transfer credit from________________________.

Evaluated by____________________, date__________. Total Q.H. (K)________________.

Remarks:____.

EET 610 - Direct Current Machines
Winter Quarter 1992

1993 Catalog Data:	EET 610: Direct Current Machines, Credits 3. Construction and principles of operation of DC motors and generators; characteristics, efficiency, control, and associated equipment; specialized DC machines. Prerequisite: EET 502.
	EET 610L: Direct Current Machines Laboratory, Credit 1. Experiments with direct current machinery, characteristics, operation, efficiency, control. Three hours per week. Taken concurrently with EET 610.
Textbook:	Charles I. Hubert, *Electric Machines - Theory, Operation, Applications, Adjustment, and Control*, Merrill Publishing Co., 1991.
Textbook: (Supplemental)	*LABTECH NOTEBOOK* software manual.
Reference:	Robert L. Boylestad, *Introductory Circuit Analysis*, 6th Edition, Merrill Publishing Co., 1990.
Coordinator:	S. R. Gardner, Prof. of Engineering Technology
Goals:	Introduce students to characteristics of magnetic circuits as applied to electric machinery. Provide an understanding of the characteristics and operation of Direct Current motors and generators, and single phase transformers. Emphasize use of equivalent circuit approach in the solution of problems.

Prerequisites by topic:

1. Fundamental laws and theorems of circuit analysis
2. Problem solving and report writing skills
3. Complex phasor algebra
4. Concepts of active, reactive and apparent power
5. College level geometry, algebra, trigonometry, and differential calculus

Topics:

1. Magnetic circuits, reluctance, permeability, and hysteresis, magnetization curves, electromagnetically induced voltages (generator action), electromagnetically produced forces (motor action). (3.0 class hours)

Continued on next page

2. Principles of DC machines, flux distribution, construction, armature windings, function of commutator, armature reaction, brush shifting, function of interpoles and compensating windings. (3.0 class hours)
3. Induced voltage and voltage regulation of separately-excited shunt generator. (1.0 class hour)
4. Basic DC motor, developed torque, speed regulation, general speed equation, reversing direction of rotation. (2.0 class hours)
5. Speed control of basic DC motor, dynamic behavior during speed adjustment. (2.0 class hours)
6. Shunt, series, and compound connections of DC motors, effect of saturation on DC motor performance. (3.0 class hours)
7. Dynamic braking, plugging, and jogging, standard terminal markings and connections of DC motors. (2.0 class hours)
8. Characteristics of self-excited shunt, compound and series generators, load voltage characteristics, generator paralleling. (3.0 class hours)
9. Transformer theory of operation, construction, cooling methods, nameplate data. (2.0 class hours)
10. Transformer no-load characteristics, leakage reactance, voltage regulation, efficiency. (3.0 class hours)
11. Transformer open- and short-circuit test procedures, determination of equivalent circuit parameters, percent and per unit impedances. (2.0 class hours)
12. Exams (4 class hours)

Computer usage:

1. Several of the lab experiments require the students to use *LOTUS 123* spreadsheet to perform calculations and to generate graphic display of data.

2. A data acquisition system has been purchased that interfaces a personal computer to the Motor/Generator sets in the lab. The system runs the *LABTECH NOTEBOOK* software package that acquires raw data, and writes this data to a file that is compatible with *LOTUS 123*.

Laboratory projects:

1. Introduction to *LOTUS 123*. The students use the spreadsheet package to perform various calculations and produce graphic display of data. Requires submission of completed spreadsheet and graphic display of certain DC shunt motor characteristics. (1 week)

2. Introduction to the Hampden Motor/Generator test set. Requires submission of answers to questions pertaining to the test set. (1 week)

Continued on next page

3. Supervisory control and data acquisition system. The students are introduced to the *LABTECH NOTEBOOK* software package that will be used in several of the experiments to perform data acquisition functions. Requires performance of tutorial. (1 week)

4. Input signal scaling board. The students are introduced to the scaling board that is used to convert or scale all measured quantities to a level suitable for input to the computer using *LABTECH NOTEBOOK*. Requires submission of test results and design of several resistive scaling networks. (1 week)

5. DC shunt motor characteristics. The torque versus armature current and speed versus load characteristics are studied by testing a DC shunt motor under load. Report required. (1 week)

6. DC series motor characteristics. The speed versus armature current characteristics and speed regulation are studied by testing a DC series motor under load. Report required. (1 week)

7. DC shunt motor speed control. The use of armature voltage control and field current control are investigated. Report required. (1 week)

8. DC shunt generator saturation curve. The induced voltage versus field current characteristic of a shunt generator is obtained. Report required. (1 week)

9. DC generator load characteristics. The terminal voltage versus load current characteristics of series and compound generators are obtained by test. Report required. (1 week)

EET 611 - Alternating Current Machines
Spring Quarter 1993

1993 Catalog Data:	EET 611 Alternating Current Machines, Credits 3. Transformer construction design; standards, operational characteristics; three-phase transformers; alternators; induction, synchronous, and single-phase motors. Prerequisites: EET 503, 610.
	EET 611L: Alternating Current Machines Laboratory, Credits 1. Experiments with transformers, alternators; induction and synchronous motors. Three hours per week. Taken concurrently with EET 611.
Textbook:	Charles I. Hubert, *Electric Machines - Theory, Operation, Applications, Adjustment, and Control*, Merrill Publishing Co., 1991.
Textbook: (Supplemental)	*LABTECH NOTEBOOK* software manual.
Reference:	Robert L. Boylestad, *Introductory Circuit Analysis*, 6th Edition, Merrill Publishing Co., 1990.
Coordinator:	S. R. Gardner, Prof. of Engineering Technology
Goals:	Introduce students to characteristics of polyphase transformers, polyphase and single-phase induction motors, synchronous motors, and synchronous alternators. Emphasize use of equivalent circuit approach in the solution of problems.

Prerequisites by topic:

1. Fundamental laws and theorems of circuit analysis
2. Problem solving and report writing skills
3. Complex phasor algebra
4. Balanced three phase circuit analysis techniques
5. Concepts of active, reactive and apparent power in single and three phase circuits
6. College level geometry, algebra, trigonometry, and differential calculus

Topics:

1. Transformer polarity, terminal markings, autotransformer connections, buck-boost transformers. (1.5 class hours)

Continued on next page

2. Parallel connections, load division between paralleled transformers. (1 class hour)
3. Transformer inrush current, excitation current harmonics. (1 class hour)
4. Three-phase connections, harmonic suppression in three-phase connections, instrument transformers. (1.5 class hours)
5. Principles of induction motor action, rotating magnetic field, motor construction. (1 class hour)
6. Induction motor operating characteristics; synchronous speed, slip, induced rotor voltages and currents, rotor frequency, rotor equivalent circuit. (2 class hours)
7. Induction motor air gap power, mechanical power developed, developed torque, and torque speed characteristics. (2 class hours)
8. NEMA performance parameters of three-phase induction motors. (1 class hour)
9. Wound rotor induction motor characteristics, torque versus slip, speed control. (2 class hours)
10. Locked rotor inrush current, effect of unbalanced voltages, insulation class. (1 class hour)
11. Induction motor tests, per-unit values of induction motor parameters. (1 class hour)
12. Single-phase induction motors: Quadrature field theory, phase splitting circuits, resistance start and capacitor start split phase motors, capacitor start-capacitor run motors, shaded pole motors. (1 class hour)
13. Reversing single-phase induction motors, NEMA standard ratings for single-phase induction motors, operation of three-phase induction motors from single-phase lines. (1 class hour)
14. Synchronous motors: construction, starting methods, developed torque, equivalent circuit, characteristic "V-curves", losses and efficiency. (2 class hours)
15. Using synchronous motors to improve system power factor. (2 class hours)
16. Synchronous generators: construction, loading and countertorque, frequency, power factor. (2 class hours)
17. Parallel operation of synchronous generators: paralleling procedure, division of active and reactive load, safe shutdown procedure. (2 class hours)
18. Synchronous generator testing, losses, efficiency, and cooling. (1 class hour)
19. Exams (4 class hours)

Computer usage:

1. Several of the lab experiments require the students to use *LOTUS 123* spreadsheet to perform calculations and to generate graphic display of data.
2. A data acquisition system has been purchased that interfaces a personal computer to the Motor/Generator sets in the lab. The

Continued on next page

system runs the *LABTECH NOTEBOOK* software package that acquires raw data, and writes this data to a file that is compatible with *LOTUS 123*.

Laboratory projects:

1. Single-phase transformer polarity, open-circuit test, short-circuit test, load test. Determination of equivalent circuit parameters. Report required. (1 week)
2. Transformer third harmonic distortion characteristics, waveform of excitation current. Report required. (1 week)
3. Squirrel cage induction motor speed versus load, and power factor versus load characteristics. Report required. (1 week)
4. Wound rotor induction motor torque versus slip characteristics and speed regulation. Report required. (1 week)
5. Split phase induction motor power factor versus load characteristics. Report required. (1 week)
6. Split phase capacitor motor power factor versus load characteristics. Report required. (1 week)
7. Synchronous motor characteristic "V-curves". Report required. (1 week)
8. Synchronous alternator open- and short-circuit characteristic curves, determination of synchronous impedance, and load characteristics. Report required. (1 week)
9. Problem session (2 weeks)

APPENDIX C

Information on Past Graduates

Number of Graduates:	1991	1992	1993	1994	1995
Associate's Degree (MET)	11	8	13	23	[illegible]
Bachelor's Degree (MET)	13	20	11	17	[illegible]
Associate's Degree (EET)	24	16	17	26	[illegible]
Bachelor's Degree (EET)	41	25	34	21	[illegible]
TOTAL	89	69	75	77	[illegible]

SAMPLE DESTINATIONS OF M.E.T. GRADUATES:

Companies which have recruited on campus for M.E.T.'s include:

AMC Engineering
Bailey Controls
Johnson Controls
National Security Agency
Owens-Corning Fiberglass
U.S. Navy
Babcock & Wilcox
Dowell Schlumberger
LTV Steel
North Star Steel
Parker Hannifin Corporation
USS/Division of USX Corporation

Companies which have recruited or hired M.E.T. graduates include:

Haenny, Barolol & Grover
M.S. Consultants
Youngstown State University
Glen Smith Ind.
Glowe-Smith Industries
Brainard Rivet
Boardman Molded Products
KRK Management
WRM
New Castle Industries
Liberty Industries
Venture Plastics
H.L. Libby Corp.
Simmers Co.
Aerolite Extrusiions
Paltech
Taylor-Winfield
Roth Brothers
Mahoning Valley Riggers
TF Industries
Winkle Electric
Commercial Intertech
F.A.P. Industries
Linde Hydraulics
NRM Steelastics
Pfitzenmaier & Jarionski, Inc.
Vertex Development
Michigan Hanger Co.
Fab-Art, Inc.
Therm-O-Disc
Firestone Research
HB Consultants
Gormac Custom Manufacturing
Emco Maier Corp.
Konwal Co.
Aquatech
Harbison-Walker Refractories
National Refractories
Kessler Products
Campbell Soup Co.
Erelind Steel Fabrication
Youngstown Welding & Engineering
United Service Co.

Initial job titles for Associate Degree M.E.T. graduates included the following:

- Project Supervisor
- Estimator
- Technician
- Tool Foreman
- Design/Draftsman
- Lab Technician
- Mechanical Engineer
- Senior Designer
- Maintenance Supervisor
- Manager-Technical Development
- QC Technician
- Process Engineer
- Draftsman
- Engineer
- Project Engineer
- Application Engineer
- Process Technician
- CAD Draftsman/Designer
- General Supervisor
- Project Engineer
- CAD Engineer
- Mechanical Designer

Initial job titles for Bachelor's Degree M.E.T. graduates included:

- Engineer
- CAD Design Engineer
- QC Engineer
- Materials Engineer
- Project Engineer
- Process Engineer
- Senior Tool Designer
- Plant Engineer
- R & D Technician
- Management Associate
- Automation Engineer
- Project Manager
- Maintenance Supervisor
- Applications Engineer
- Engineer Trainee
- Engineering Technician
- Damage Consultant
- Component Engineer
- Operations Manager
- Director of Facilities
- Design Engineer
- Senior Manufacturing Engineer
- Associate Engineer
- Designer
- QC Supervisor
- Engineer, R & D
- Product Engineer
- Mechanical Engineer
- Tooling Engineer
- Development Engineer
- NC Programmer
- Manufacturing Engineer
- Industrial Engineer
- Technical Supervisor
- Tool Designer
- Research Technician
- Methods Engineer
- Detail Engineer
- Director, Maintenance
- Metallurgist