A MODEL FOR DETERMINING THE EQUIPMENT NEEDED FOR IMPLEMENTING AN ELECTROMECHANICAL TECHNICIAN EDUCATION PROGRAM

By

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INTRODUCTION TO THE PROBLEM

The United States labor market has undergone significant changes during the last few years. New types of industries have been emerging in an era of "new technology." This new era has required many changes in the social and economic institutions of the industrial nations of the world. This rapid rate of change has come about as a result of the tremendous increase in the rate of scientific activity. One result of this changing environment has been the emergence of new occupations in American industry.

A number of new occupations have emerged in the area of Electro-mechanical Technology (EMT). These new occupations are the results of the changing needs for skill and knowledge requirements in our automated society.

One of the new occupations emerging has been that of the Electro-mechanical Technician. This type of technician is trained in a cross-disciplinary program interrelating the electrical and mechanical disciplines. This technician has the capability of performing tasks that are beyond that of the technician trained in a single speciality. A project to develop and test an entirely new educational program in electromechanical technology was conducted at Oklahoma State University during the period of 1968-71.

The electromechanical technology development program resulted from many weeks of study and work by technical teachers, administrators, and a national advisory committee. Curriculum standards and design procedures were derived from a report on a nationwide study, (ERIC-ED-012-372), conducted in 1966-67. The two year EMT development project has been tested by the Technical Education Department at Oklahoma State University as of May, 1971; thus completing the project and making it available to other educational institutions who might wish to adopt the program.

Statement of the Problem

Oklahoma State University has developed and tested a two year electromechanical technology program. The experience and knowledge gained from this program at OSU, should be a basis and guide for other institutions to establish the EMT curriculum.

A newly developed program has to be accepted by other institutions in order for it to be effective. Much evaluation of program requirements and needs must be made before a decision of acceptance or rejection relative to the implementation of the new program is made. One very important factor to be considered when planning a technician education program is, the equipment needed to implement the program. This requires an extensive list of equipment needed for every course. From this equipment list, an expected cost outline for equipment needs can be formulated. This equipment cost, by no means, represents the total cost of the program, but is a substantial part of it.

The problem with which this study is concerned is one of identifying the equipment needed for implementing an electromechanical technician

education program, and also of determining the estimated cost of this equipment. It will serve as a guide to be used by other institutions in planning for an EMT curriculum.

Purpose of the Study

The purpose of this study was to establish a model for determining the equipment needed for implementing an electromechanical technician education program. This model identified the particular type, amount, and estimated cost of laboratory equipment for the EMT program.

Need for the Study

The need for this study is supported by several factors: (a) the demand for programs of this type to be implemented in order to supply the needed electromechanical technicians throughout the United States; (b) the many requests that have been received by Oklahoma State University regarding information about this program; (c) the foreseeable adoption of this curriculum by many institutions in the next few years; and (d) the fact that very little research has been done on electromechanical technology programs.

The electromechanical technology program has been developed, thus leaving the implementation to follow in other institutions. As other institutions begin to consider offering the program, this study will help them in the planning stages. Much information will be needed, and a complete list of equipment and its costs greatly support the needed information. This should save the implementing institutions valuable time in planning for the program.

Limitations to the Study

This study is limited to the two-year post-secondary Electromechanical Technology Developmental Program conducted at Oklahoma State University. The data for the study was based upon the material used in this particular program at OSU, and prepared by the staff at this institution. The equipment list came directly from the text materials that were used in each course of the program.

Assumptions of the Study

The design of the study was based upon the following assumptions:

1. The equipment used in the electromechanical technology developmental program at OSU will be needed by other institutions implementing this program.

2. Other institutions will adopt the complete EMT program.

3. There is a need for information about types, amount, and costs of equipment.

Questions to be Answered

It was felt that the following questions would provide selected information about equipment needed in EMT training programs to educational institutions:

1. What specific types of equipment are needed for each laboratory course in the EMT program?

2. How much of each specific type of equipment is needed to implement a 10 setup, 20 student laboratory?

3. What is the present estimated cost of each item?

4. What is the minimum amount of equipment required to implement this program?

5. What effect does the equipment have upon the scheduling of the courses?

Definition of Terms

Electromechanical Technology (EMT) - That technology which deals with the multidisciplinary aspects of electrical, electronic, and mechanical principles and applications.[1]

Equipment - The machines, tools and supplies required to operate laboratories in the EMT program.

Technical Education - Educational programs at the post-secondary level which combine the learning of complex skills with sufficient scientific and technological theory to prepare the technician to provide close support to the scientist and to the engineer throughout the range of scientific and technical work from basic research to industrial production. The programs are normally two years in length and terminate with the associate degree.[1]

CHAPTER II

REVIEW OF LITERATURE

Technology developments of recent years have created a need for a new semiprofessional worker known as the electromechanical technician. This new type of technician is unique in character in that his educational training involves a hybrid model of two very important technologies, electrical-electronic and mechanical.

The purpose of this study was to give a basis for cost evaluation of equipment needed for an electromechanical technician education program. In accomplishing this goal, considerations must be given to equipment needs, selection, specifications, and utilization.

Different ideas on equipment needs and selection in the laboratories and shops of vocational-technical education programs are expressed in the review of literature. The laboratories and shops provide the "heart" of a technician education program. The planning and designing of laboratories "geared" to the needs of students, whose goals are immediate employment in industry, is very essential.

Planning Laboratories and Shops

Good planning in laboratories and shops is a very important phase in the implementation of any successful vocational-technical education program.

Lawson (2) referred to the following important considerations when planning laboratories and shops:

1. Study carefully, available planning guides.

   a. State Departments
   b. Privately Published

2. Become familiar with legal provisions which need to be recognized during initial planning phases.

3. Consider actual type and size of equipment in determining space requirements.

4. Identify the number of auxiliary areas needed (stock and supplies, storage, project storage, and planning).

5. Determine space needed in the area for demonstrations and small-group activities.

6. Complete a layout of equipment and auxiliary areas using plastic models, scale cut-outs, and three dimensional planning, to verify size requirements and tentative arrangements (templates and square paper facilities planning).

7. Consider utility outlets and connections utilizing utility columns, utility walls and/or overhead systems.

8. Consider the location and relation of the laboratory or shop in relationship to the other instructional and non-instructional areas of the complex.

9. Consider uses of the facility by evening classes as well as day school classes.

10. Remember that shop and laboratory equipment should be keyed to the instructional methodology i.e. all students on same project (duplication of equipment) or students follow customer-work method (single piece of equipment for all students.)

11. Realize that instructional order may affect facilities planning, The order in which subjects are offered may need to be studied.

12. Keep in mind that instructional methodology may affect facilities planning:

    a. Closed circuit television facilities
    b. Peripheral layout of laboratory furniture provides greater flexibility than traditional layout.

13. Consider grouping equipment together relative to such factors as:

a. Order of instruction
b. Flow sequences in utilization
c. Quiet areas and noisy areas

14. Establish the pupil-teacher ratio to be applied in the instructional program:

    a. For most shops and technical laboratories the maximum should be 20:1.

15. Anticipate curriculums for the future, recognizing the effect on laboratory or ship layout and size of new processes, new products, and new equipment.

16. Plan to house identified curriculum, but at the same time provide flexibility to accommodate possible future use.

According to the literature, if a mistake is made in planning a shop or technical laboratory, it could be very costly in terms of money, accidents, and public relations. In planning shops and laboratories, the following are important as stated by Campbell (3):

1. Instructional program philosophy, aims, and objectives will determine space, items taught, materials, etc.

2. Students--type, age, and stage of development.

3. Teachers--age, vitality, stamina, training, experience, personality, teaching techniques, etc.

4. Type of laboratory--materials handled, items taught, and storage.

5. Service lines and facilities--heating, power, ventilation, and maintenance.

6. Teacher efficiency--a shop or laboratory should be designed so that the teacher has maximum supervisory and instructional potential.

7. Expansion to meet change.

8. Learning materials--tools, equipment, machines, and supplies should be considered.

9. Internal and external traffic--visitors, normal traffic of instruction, and emergency traffic.

10. Keys to better laboratory planning:

a. Design laboratories under the direct responsibility of the chief school administrator and policy maker. Insist on competent planning by experts (hiring top consultants is cheaper in the long run).
b. Build for maximum flexibility and expansion.
c. Plan around the teacher.
d. Make multiple use of areas.

Equipment Selection

Equipment for vocational-technical education must provide both the opportunity and the environment for learning. With expanded programs and large numbers of new institutions emerging in the near future, much help is needed in planning for equipment needs.

Gallington and McManus (4) states that:

> For years architects, teachers and administrators have determined the furniture, fixtures, and equipment needs for new vocational-technical schools. Most of the time, these busy people find that the manufacturers' catalog is the fastest way to locate equipment to meet the expenditure limits of their budgets. However, catalogs are just one of the many classes of services needed. The catalog is unsatisfactory and impractical for todays school planning, because it does not describe nor cater to educational objectives. Todays school-equipment needs are becoming very sophisticated; architects, teachers, and administrators are very busy and uninformed.

According to the study above, educational specialists from equipment manufacturers should organize to do a better job in supplying schools with the most reliable information, about school, shop and laboratory equipment. Too often, the supplier will "oversell" or "undersell" a school board on equipment purchases. Education planners should project a true picture of optimum equipment specifications for meeting specific needs and objectives.

Cook and Miller (5) explained:

> Before any laboratory can be furnished with equipment it is necessary to have some background as to what will be taught. Adaptations can be made in equipment when such things as money, time, and ability, enter into the picture. Much wasted equipment sits idle in cabinets and on shelves across the nation. This practice tends to cause administrators to take a closer look at what is being purchased and why.

This study shows some reference should be made, as to what type of program is going to be offered during the equipment selecting. Textbooks, programs of study, curriculum outlines, and other sources, should be considered. This helps to bring about wise utilization of equipment which is a very important factor in equipment selection.

The problem of equipment selection can be enhanced by the idea of "clustering" as explained by Blake and Larson (6).

> Clustering can be thought of as grouping into a complex, the laboratory and equipment for use of all related topics. The advantages of the cluster idea would be:
>
> 1. nonduplication of laboratories
> 2. common storage space may be used by more than one lab
> 3. instructional materials could serve more cases

Appropriate Equipment

Selecting appropriate equipment for a specific laboratory setup requires extensive consideration by administrators, teachers, and professional consultants.

Holloman (7) stated:

> Each item of equipment must be:
>
> 1. appropriate to serve instructional and/or administrative uses reasonably expected to exist in institutions, providing programs of the same educational level and type as the institution selecting the equipment item and,

2. appropriate to serve the administrative purpose for which it is selected, or to serve reasonable needs of the instructional program for which it is selected.

Equipment standards are expressed specifically in sums of money. They are determined and fixed by the State Board of Education with professional assistance from advisory committees; as specified by the 1963 Vocational Education Act for advisory assistance in the development and operation of vocational-technical education programs, and re-emphasized in the 1968 amendments to this Act. The standard are based on the amount of money sufficient to purchase the quality and quantity of equipment deemed adequate to equip each specific facility, room, program, or space for operation, at a stated minimum level of service or occupancy during any one hour of use.

The study further emphasizes that the problem of selecting items for the list of appropriate equipment, should be entrusted largely to persons professionally competent in the area in which the equipment will be used. This does not mean to depend upon the discretion of one person, no matter how professionally competent he may be. Experience indicates that individual discretion exercised unchecked, will too often result in either extravagance or waste. Where the selection made by a presumably competent professional person is reviewed by a jury of his professional peers, the best interest of the system will be served, particularly where the selection affects several other institutions.

Securing Quality Equipment

The goal of all school systems should be to obtain the best product, at the best price. One of the best ways to achieve this goal is to seek competitive bidding on equipment items needed. This is the type of procedure used by many schools to achieve this goal.

In the publication How to Get the Quality you Specify, (8) the following are emphasized in obtaining this goal:

1. Write a good specification:

The specification that is tight rather than loose, tends to assure the owner of greater value. The specification should spell out what is needed and wanted, or is of the same degree of educational use, and the same durability, and low maintenance as the product specified.

2. Qualified bidders:

Exclude bidders who have proven to be unreliable or incapable. Samples should be thoroughly checked against the specified requirements before, or immediately after, the bidding.

3. Compare for value, not just price:

The rule must be the lowest responsible bid meeting the specifications, not the lowest dollar bid. Consider educational function, flexibility of use, durability, as well as price.

4. Give the award to the supplier or distributor, who shows himself capable of delivering the product, fully meeting the specifications:

Make sure the vendor delivers as per agreement under penalty of price adjustment, replacement of substandard materials and components, or rejection of the entire order.

Whenever a specification for equipment, materials, or supplies is written it is the basis for purchasing according to Lawson (9). The main requirements on any specification is that it must be a definite, clear-cut description of the item needed for the purpose identified.

Coverdill (10) states that a well written specification needs to provide:

1. Scope--nature and purpose of equipment.
2. Date of delivery
3. Description--minimum specific requirements.
4. Specific requirements.
5. Accessories
6. Noncompliance--statement of noncompliance and exceptions.
7. Delivery--how and where.

A study of post-secondary electronics programs by Wright (11) found that in specifying equipment needed for an educational program, it is most likely to be used by others if it is complete, concise, and

meets an important criteria of inventory forms; that it requires a minimum of time to complete.

Summary

Laboratories and equipment for technician programs must meet high standards of quality, since the overall objectives of this type of program rely on valid laboratory experience. The specialized courses in technical education require well equipped laboratories and are a necessity for a successful program.

In equipping laboratories, variety and quality of equipment are more important than quantity. Inferior equipment may not show the principles being studied or may not be sensitive enough to provide reliable data or experience. Good planning and good equipment can cost the same as poor planning and poor equipment in the long run.

When specifying laboratory equipment, the need for each item should be well established. This helps to achieve good utilization and economy. The appropriate equipment should be selected with the proper specifications, and then the desired quality specifications can be met.

Selection of the equipment should be done by technical specialists who administer and teach in the programs. Visits to well-equipped laboratories, and consulting assistance by practitioners in the field help to provide information about realistic laboratories.

Technical education is laboratory oriented by nature of its objectives. This special characteristic places heavy emphasis upon laboratory equipment for its success. Appropriate equipment and good utilization of that equipment, are necessary criteria for a successful technical education program.

CHAPTER III

METHOD AND PROCEDURE

The review of literature suggests reasons for developing equipment lists for use in laboratory planning. The literature also gives several different views and methods of approaching the problems of developing equipment lists.

This study was concerned with the development of a complete and concise model of equipment needed to implement an electromechanical technology program.

Data Collection

Students have been enrolled for the last two years in the Oklahoma State University Electromechanical Technician Program. This new program has been developed, along with the instructional material, at this institution under the supervision of the Technical Education Department. The educational program has been under constant review of the department, and whenever possible, there have been changes made to better the curriculum material.

Table I shows the curriculum outline for the EMT program used in this study. The outline designates between laboratory and non-laboratory courses. This study deals with only the laboratory courses. Materials for the six non-laboratory courses are not mentioned in this study.

TABLE I

CURRICULUM OUTLINE FOR ELECTROMECHANICAL TECHNOLOGY

			T	L	C
		FIRST YEAR			
		FIRST SEMESTER			
PH	1104	Unified Physics I (Fluids)	3	2	4
ET	1104	Electricity	2	4	4
ME	1104	Mechanical Drives	2	4	4
GE	1111	*Technical Report Writing	1	0	1
MA	1103	*Algebra and Trigonometry	3	0	3
EM	1202	Electromechanical Devices	1	3	2
			12	13	18
		SECOND SEMESTER			
EM	2103	Controls I (Motor Controls)	2	3	3
MA	1203	*Calculus and Analytic Geometry	3	0	3
PH	1204	Unified Physics II (Optics)	3	2	4
ET	1204	Electronic Amplifiers	2	4	4
ME	1204	Mechanical Linkages	2	4	4
			12	13	18
		SECOND YEAR			
		FIRST SEMESTER			
GE	2103	*Social Science I	3	0	3
ET	2103	Digital Electronics	2	2	3
ME	2203	Machines	2	2	3
IT	2103	Transducers	2	2	3
IT	2203	Controls II (Automatic Controls)	2	3	3
GE	2213	*Communications Skills I	3	0	3
			14	9	18
		SECOND SEMESTER			
GE	2203	*Social Science II	3	0	3
EM	2214	Electromechanical Fabrication	2	6	4
EM	2204	Controls III (Servomechanisms)	3	3	4
ET	2213	Electronic Communications	2	2	2
ME	2103	Materials	2	2	3
			12	13	17

*These courses are considered non-laboratory courses.

T = Theory - hours per week; L = Laboratory - hours per week; C = Credit - hours per semester.

The material from which the data came was the finished product of much hard and tedious work done by OSU staff members. The equipment list came directly from the manuals of each laboratory taught in this program. The specifications of each piece of equipment was listed along with the number required to implement a 10 setup, 20 student laboratory. Two students were assumed for each setup or bench. Also included in the study was the estimated cost of each piece of equipment.

The equipment list, which came from the manuals of each laboratory course, was arranged in a matrix form to show the amount of equipment required in each course. The list also identified the equipment that was used in more than one course.

From the equipment list an educator interested in implementing a program of this type should be able to use this list for selection of equipment. This should allow him to check-off the equipment he already has on hand and leave him with a list of equipment he needs to purchase. This should provide an excellent way of saving money on excess equipment purchases and also help to utilize the equipment to its fullest extent.

Appendix A contains the equipment specifications and cost of each item. This is an estimated cost and should not be considered as absolute. Cost of items vary according to suppliers and quality. Equipment of a different price and quality may be used, but the equipment specifications in this list should be considered as a minimum requirement.

Arrangement

Information from data collection produced a master list of equipment needed for the EMT program. From this master list the equipment

may be selected in various quantities to meet the needs of each individual program. Arrangement and selection of the equipment should show advantages and disadvantages of using the same equipment for several different courses.

One arrangement would be to have enough equipment to supply each course with its own specific equipment. This would be considered an ideal situation. It would take a unique institution to be able to afford the capital outlay necessary for this type of arrangement.

Another arrangement, and a much more practical one, would be to purchase the minimum amount of equipment required to implement the program. This situation would call for using a particular piece of equipment in all courses in which it was required, but to the extent where it did not interfere with the scheduling and equipment utilization in a program of this type. From the data collected a minimum amount of equipment for implementing the program may be selected readily from the matrix list.

Other selections may be made anywhere between the maximum and minimum arrangements described above. The amount of equipment one selects depends upon how much existing equipment the school has acquired, capital available, and how well the courses can be scheduled to utilize the equipment. If proper care is not exercised, large amounts of money can be invested in new equipment that sits idle most of the time. This emphasizes the fact that careful consideration should be given to the selection of equipment, and to the utilization of that equipment.

The results of this study will provide the educator with a quick and easy guide to selecting equipment for the EMT program. Information

will be available for him to equip a program in a selected manner. The responsibility will be up to the educator to wisely select and utilize the equipment to its greatest extent.

CHAPTER IV

RESULTS

Table II of this study shows the complete laboratory equipment list for the Electromechanical Curriculum Development Program at Oklahoma State University. The specifications and estimated cost of each unit of equipment are given in Appendix A.

The list includes sufficient equipment for a 10 setup, 20 student lab in each course that contains a laboratory. A matrix form was used for the master equipment list to be more concise, and to show the equipment that was used in more than one laboratory setting.

Each item of Table II was numbered so that the specifications and cost could be given in an orderly fashion in Appendix A. The item number in Table II corresponds to the same item number in Appendix A, which gives the item specification and its estimated unit cost. This made referring to a particular piece of equipment much easier.

In Table II each item is numbered and has a corresponding item name. Directly across from each item is the quantity that is required by each laboratory course. Quite often items are repeated in several different courses and sometimes in different quantities.

The items are arranged in the order as they appeared in the laboratory courses. As each new laboratory course was begun, the equipment used in that particular course was put down under item name. If a piece of equipment was used in one of the preceding courses it was not

repeated under item name, but was marked across from where it was used the first time. This made the list more concise and not as lengthy as it would have been if the equipment had been repeated each time it was used.

Under item name in this list there are 207 pieces of equipment. Many of these items are single items but 37 of these items are component kits containing various items. The 207 item names require a maximum of 5,956 items, not counting the items in the kits, to operate a 10 setup, 20 student laboratory for the 16 electromechanical courses in the study.

A minimum amount of equipment may be selected from the equipment list. This would include 3,804 items from the list. The equipment selected could be used to equip one large multipurpose laboratory. This type of laboratory may not be feasible due to the problem of course scheduling.

TABLE II

EQUIPMENT REQUIRED FOR A 10 SETUP, 20 STUDENT LABORATORY

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE														
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
1	Hydraulic Student Bench	10										10					
2	Student Tool Kit	10															
3	Flow Meter	20											10				
4	Component Kit	10															
5	Container, 5 Gal.	10											10				10
6	10 Qt. Graduated Container	10															
7	Stroboscope	10	10	10	10	10			10			10	10		10		
8	Meter Stick	10										10					
9	Dial Caliper	10			10				10								
10	16 Gal. Tank	10															
11	Thermometer	20			10												
12	Steam Generator	10															
13	1000 ml. Beaker	10															
14	225 ml. Beaker	10															
15	Beaker																30
16	Electric Component Kit	10															
17	DC Power Supply	10	10		10	10	10	10		10		10	10	10	10	10	10

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE															
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
18	Dual Channel Strip Chart Recorder	10	10		10	10					10		20				
19	5 Lb. Wts.	100															
20	Bunsen Burner	10										10					10
21	Ring Stand	10										10					
22	Kundts Tube Apparatus	10															
23	Stool	20	20	20	20	20		20	20	20	20	20	20		20	20	20
24	Portable Chalkboard	1		1		1			1			1					
25	Demonstration Sliderule	1	1	1	1	1		1	1	1	1	1	1		1		1
26	Storage Cabinet	4	4		4	4				4	4	4	4		4	4	4
27	Student Component Kit		10														
28	Dual Regulated Power Supply		20			20		10		20	10	10	20			10	
29	Sine/Square Wave Generator		10		10	10		10		10		10	10		10	10	
30	Resistance Decade Box		10			20										10	
31	Thermocouple Meter		10	10	10							10					
32	Multipurpose Meter		20	20		20				10		10				10	10
33	Dynamometer	10	10	10	10								10				
34	Oscilloscope		10	10	10	10	10	10		10		10	10		10	10	
35	AC Relay		50														
36	Transformer				10								10				
37	Series Motor		10		10	10							10		10		
38	PM Motor		10		10	10							10				
39	Low Voltage Power Supply		10		10												
40	AC Motor		10		10												
41	AC Milliameter		10		10												

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE														
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
42	Wattmeter		10		10												
43	DC Current Meter Movement		10		10												
44	Variac		10		10	10		10				10	10		10		
45	Student Tool Kit		10		10	10		10				10				10	
46	Work Bench		10	10	10	10		10	10	10	10	10	10		10	10	10
47	Magnetic Chalkboard		1		1	1		1				1				1	
48	Precision Mechanical Drives Kit			10					10								
49	Precision Mechanical Breadboard Kit			10													
50	DC Motor Control			10		10			10								
51	Tool Kit			10		10			10								
52	Student Component Kit (Electrical)				10												
53	Student Component Kit (Mechanical)				10												
54	Spring Balance				10							10					
55	DC Relay				10							10					
56	Student Tool Kit				10												
57	Student Component Kit (Electrical)					10											
58	Student Component Kit (Mechanical)					10											
59	Synchronous Motor					10											
60	Induction Motor					10											
61	Tool Kit					10											
62	Incremental Motor					10							10				
63	Pulse Generator					10											
64	Chart Recorder					10							10				
65	He-Ne Laser						10										

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE														
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
66	Optical Bench & Support Platform						10										
67	Optical Kit						10										
68	Mechanical Breadboard						10						10		10		
69	Clip Leads																90
70	Electronics Kit							10									
71	Field Effect Meter				20		10	20		10		10	10		20	10	
72	Resistance Substitution Box							20		30					10		
73	Capacitor Substitution Box		10					10		20					10		
74	Tube, Transistor, Diode Checker							1									
75	Component Set							10									
76	Precision Mechanical Linkage Kit								10								
77	Electronic Kit									10							
78	Pulse Transformer									10							
79	Lamps & Bulbs									70					70		
80	Switches									130							
81	Thermister									10							
82	Semiconductor Device Kit									10							
83	Circuit Breadboard					10		20		10		10	10				
84	Computer Facilities									1							
85	Blank Card									200							
86	Tool Kit										10						
87	Pieces of Cardboard										2						
88	Linear Potentiometer										10						
89	Rotary Potentiometer										20						

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE															
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
90	Rheostat																10
91	Drafting Kit										20						
92	Fluid Component Kit											10					
93	Copper Wire											1					
94	Michrome Wire											1					
95	Beaker											10					10
96	Vacuum Gauge											10					
97	Air Regulator											20	10				
98	Thermometer											10					
99	Pendulum											10					
100	Electric Component Kit											10					
101	Mechanical Component Kit											10					
102	Ammeter																10
103	DC Generator				10	10							10				
104	Voltmeter																10
105	Wheatstone Bridge											10	10				
106	Thermostat												10				
107	Dual Pressure Control												10				
108	Air Supply	1										1	1				
109	Pressure Gauge												20				
110	Hand Valve												10				
111	Air Cylinder												10				
112	2-Way Cylinder												10				
113	4-Way Valve												10				

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE															
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
114	Hydraulic Pressure Gauge												30				
115	Hydraulic Supply												10				
116	AC Motor												10				
117	Variable Transformer												10		10		
118	Hydraulic Regulator												10				
119	Hydraulic Pressure Gauge												10				
120	Hydraulic Motor											10	10				
121	Mechanical Tachometer				10												
122	Synchro, 23TX6												10		10		
123	Synchro, 23CT6												10		10		
124	DC Amplifier												10				
125	VTVM		10					10				10	10				
126	AC Amplifier												10				
127	Thermocouple Bridge												10				
128	AC Ammeter												10				
129	Motor Generator Unit												10				
130	Minor Equipment Kit												10				
131	Electronic Equipment Kit												10				
132	Numerical Controlled Machine													1			
133	Program Punching Machine													1			
134	Drill Set													1			
135	Milling Tool													1			
136	File													20			
137	Engine Lathe													4			

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE														
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
138	Bench Vise													10			10
139	Soldering Iron													10			
140	Emery Cloth													10			10
141	Rod													20			
142	Tubing													20			
143	Coil Spring													20			
144	Micrometer													10			10
145	Ruler													10			
146	Rod													20			
147	Pin Jack													20			
148	Capacitors													60			
149	Resistors													80			
150	Transistors													120			
151	Battery													20			
152	FET													80			
153	Toy Organ or Piano													10			
154	Gear Train													10			
155	Synchro 23TR6														10		
156	Synchro 23TDR														10		
157	Synchro 23CDX														10		
158	Servoamplifier														10		
159	AC Servomotor														10		
160	DC Servomotor														10		
161	Motor-Generator														10		

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE															
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
162	Harmonic Drive														10		
163	Function Generator					10				10			10		10		
164	Magnetic Amplifier														10		
165	Meter														10		
166	Amplifier							10							10		
167	Mechanical Equipment Kit														10		
168	Electronic Equipment Kit														10		
169	Resistors														200		
170	Potentiometer														50		
171	Capacitors														100		
172	Student Component Kit															10	
173	Transmitter															10	
174	Receiver															10	
175	RF Generator															10	
176	Battery Pack															10	
177	Servo															20	
178	AM Receiver															10	
179	AM Wireless Transmitter															10	
180	Loading Frame																10
181	Hydraulic Piston																10
182	Ring Force Transducer																20
183	Dial Indicator																10
184	Rockwell Hardness Tester																10
185	Links																140

Table II (Continued)

ITEM NUMBER	ITEM NAME	QUANTITY REQUIRED BY COURSE															
		FLUIDS	ELECTRICITY	DRIVES	DEVICES	CONTROLS	OPTICS	AMPLIFIERS	LINKAGES	DIGITAL	MACHINES	TRANSDUCERS	AUTO. CONTROLS	FABRICATION	SERVOS	COMMUNICATIONS	MATERIALS
186	Beam Member																10
187	Weight Pan																10
188	Weight Set																10
189	Connectors																170
190	Pins																10
191	Extensometer Bracket																10
192	Specimen Kit																10
193	Divider																10
194	Machinist Scale																10
195	HR Steel Beam																20
196	Load Connector																10
197	Joints																20
198	Hack Saw Blade																10
199	Oxygen-Acetylene Torch																1
200	Fire Brick																20
201	Permanent Magnet																10
202	Ball Peen Hammer																10
203	Bolts																70
204	Hand Spring Balance											10					
205	Wire																10
206	Voltmeter																10
207	Anvil																10

Summary

Table II contains the list of equipment used in the EMT program. Much of the equipment is listed in the table as kits. Each item listed in this manner, or a similar type of grouping, is itemized completely in the Appendices.

The list is made up of many different types of equipment ranging from complicated and expensive numerically controlled machines, down to items as simple and inexpensive as pieces of cardboard. Many of the items are used in several courses while a few are used in almost all of the courses. Some of the equipment is used in just one course.

Each item number and corresponding item name are listed again in Appendix A; where each item name is followed by specifications and an estimated unit cost. Some items contain more complete specifications than do other items. In either case, the description of the equipment should be sufficient to use as a guide in ordering equipment to equip any particular program.

Due to the large variety of equipment available from numerous manufacturers, and with many different prices, the specifications and cost in this study should be used as a reference.

The prices of the items in the equipment list were obtained from current catalogs which dealt with electrical and mechanical equipment.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to develop a model for selecting the equipment needed to implement an electromechanical tecnician education program. This model contains an equipment list along with the quantity, specifications, and estimated unit cost of that equipment.

The entire equipment list came directly from the curriculum material written for the Electromechanical Development Program at Oklahoma State University. The curriculum material was written, implemented, evaluated, and revised to best accommodate the objectives of the EMT program. The equipment in this study is the actual equipment needed to implement a successful EMT curriculum which duplicates the OSU Program.

The review of literature suggested numerous factors which must be considered when selecting laboratory equipment for a technical education program. Some of the most important factors were: quality, quantity, cost, utilization, and selection. Sequencing and scheduling of courses within the EMT program are very much dependent upon the equipment selection. The more equipment available, the easier it is to schedule courses; as far as equipment dependency is concerned. Less equipment requires much tighter course scheduling and much better equipment utilization.

Findings

The questions answered by this study, as supported by the data gathered in this thesis, are summarized below:

Question 1. What specific types of equipment are needed for each laboratory course in the EMT program?

There is a large variety of equipment required for this EMT program. The equipment varies from numerically controlled machines down to inexpensive pieces of cardboard. Many of the machines are of the type that required regular maintenance such as the electronic and hydraulic machines; while other items are of the throw away nature, such as electronic components and less expensive items.

Table II lists the specific types of equipment needed for the EMT program under item name. The equipment is sufficient to operate the laboratories in the courses of the curriculum outline.

Question 2. How much of each specific type of equipment is needed to implement a 10 setup, 20 student laboratory?

Approximately 5,956 items make up the equipment list for a 10 setup, 20 student laboratory. Some of these items in the list are kits and student benches which contain extra items themselves.

Table II contains the amount of each piece of equipment needed for a 10 setup, 20 student laboratory. This is specified in the columns under the main heading of Quantity Required by Course. This shows the amount of each particular piece of equipment that is required for each course listed.

Question 3. What is the presently estimated cost of each item?

The cost of the items in the equipment list vary greatly. The range is from approximately $11,000.00 per item to 2¢ per item. Thirty-two of the items cost over $1,000.00 each, while about 260 items are in the $500.00 range. Approximately 475 items are valued at between $100.00 and $375.00, while the remaining items are below the $100.00 value. The majority of these cheaper items cost approximately $1.00 each.

This information is contained in Appendix A. This gives the equipment specifications, including the estimated unit cost. Due to rapidly changing prices and also the many different types and quality of equipment, the prices quoted here are to be considered as an estimated cost at the time of this study.

Question 4. What is the minimum amount of equipment required to implement this program?

The minimum amount of equipment required in an electromechanical technology program is directly dependent upon how well the courses can be scheduled to utilize the equipment to its fullest extent. This may vary from program to program.

To select the minimum amount of equipment means to use the equipment in every course where it is required. If this was arranged it would take approximately 3,804 items on the list to equip the EMT program.

These items can be selected from the equipment list in this study in the following manner. Across from each item name is the number of that item required for each course. The largest number in this row represents the minimum amount of equipment required for the courses in which it is used. This minimum amount is sufficient to run all the

laboratories in all the courses where it is required. This is considered a minimum amount if the courses can be scheduled around this quantity of equipment.

Question 5. What effect does the equipment have upon the scheduling of the courses?

The equipment list for each separate course very clearly implies the importance of proper scheduling of the courses to achieve maximum benefits from the available equipment. The smaller amounts of equipment a program has the more complex the scheduling of courses becomes. The more numerous the equipment becomes, the easier it is to schedule the courses.

The minimum equipment arrangement in this study, which requires 3,804 of the items listed, would require very tight course scheduling. Every piece of equipment would have to be used in every course where it was required. This would require maximum equipment utilization for this type of program.

The maximum equipment arrangements in this study, which requires 5,956 items, would allow for easy course scheduling. This method would lower the utilization of the equipment and find large amounts of the more expensive equipment sitting idle most of the time.

Conclusion

This study revealed many factors which must be considered when selecting equipment for implementing a new program. Careful consideration must be given to the planning of laboratories, equipment selection, quantity, quality, and utilization.

There is a large variation of equipment needed to implement an EMT program. Some of the equipment is very expensive. The utilization of this expensive equipment should be given serious consideration before being purchased by an educator. Possible use of this equipment in other programs should be considered.

Some of the equipment in this study, such as the electrical, hydraulic, and mechanical machinery, require regular maintenance. A program using this equipment should have available funds to keep the equipment functioning correctly.

Many of the smaller equipment items need to be replaced whenever they are broken or destroyed by experimental error. These items might include electrical components or small laboratory tools and supplies. There should be funds available to replace items of this nature on a regular basis.

An educator selecting equipment for an EMT program should be aware of equipment quality, cost, and maintenance cost before he purchases for his program. Laboratories equipped with large quantities of low quality equipment can cost as much as laboratories equipped with smaller amounts of high quality equipment. The difference can be taken up in replacement frequency and maintenance, not to mention the benefits a student receives in operating good quality equipment.

Recommendations

This equipment list came directly from the curriculum material written at Oklahoma State University. This material may need to be revised as the electromechanical technology continues to grow.

The following recommendations are made based upon this study.

A. This study should be used as a guide in implementing an EMT program.

B. Also, future studies could be made on equipment selection and its effect upon course scheduling.

C. Future studies should be made to determine to what extent the list of equipment in this study is used in implementing EMT programs.

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APPENDIX

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
1	Hydraulic Student Bench including: Bench--steel frame and top 60" long x 23" deep x 33" high Hydraulic circuit pack Switch-O/L Hydraulic Pressure take-off assembly with gauge, hydraulic Return take-off assembly, double manifold Top-work circuit assembly--6 ft. Compressor and vacuum unit, single stage two cylinder Switch - O/L pneumatic Air receiver unit, automatic shut-off Drain cap Mount--Compressor, vacuum disconnect Adaptor, vacuum disconnect Compressor, vacuum assembly oiless Pump--hydraulic Hose assembly--return - 1/2" Hose assembly--pressure - 3/8" Relief valve--master control Motor--1 HP min. Intake assembly Bubbler assembly Drain return plug Gauge--reservoir oil level Reservoir--5 gal. JIC Plug--reservoir drain Cover--reservoir cleanout assembly with gasket Pressure switch, automatic shut-off electrical Valve--main air shut-off Air receiver--7 gal/min	$1,435.00
2	Student Tool Kit including: Tool box - 6" x 6" x 12" Adjustable wrench 10" Pipe wrench 10" Screwdriver set Phillips screwdriver set Rubber hammer Open end wrench set	42.70

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	Hack saw Tubing cutter Flat file Stop watch	
3	Flow Meter	92.00
	0-5 gal. per min. with quick disconnect fitting Calibrated for use with hydraulic fluid	
4	Component Kit including:	550.00
	Plastic barrel, 2-way cylinder 2-way cylinder 1 1/4" 2-way cylinder 2 1/4" 1-way spring return cylinder Cylinder base and riser plate 4-way valve, three position, pilot control Pilot control valve cylinder Quick exhaust valve with muffler Hydraulic motor fixed displacement, bidirectional Cam valve, 2-position Accumulator Compound gauges "X" Connector, 1/4" Flow control--2-way valves Four-way valve, closed center "T" connectors, 1/4" Flow control valves integral check Relief valve 4-way valve, open center Gauges, pressure Check valves 3/8" to 1/4" adaptor Vacuum adaptor Hose-plastic rayon reinforced 1/4" Hose-plastic rayon reinforced 3/8" Nipples--quick disconnect single check and inserts 1/4" assembly (std) Bodies--quick disconnect double check and inserts 1/4" (optional purchase) QC-1 Nipples--quick disconnect single check and insert 3/8" Bodies--quick disconnect double check and insert 3/8" (optional purchase) QC-1 Hoses--rubber rayon reinforced 1/4" Hoses--nylon flow 1/4" Manual--hydraulic handbook student, optional accessories Fittings hose, reusable type 1/4" Clamps-- 1/4" hose	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	Disconnect bodies quick type single check 1/4" Disconnect nipples quick type double check 1/4" (mounted on components) (optional purchase) QC-1 Fitting compression type 1/4" Oil--air lubrication non-detergent Oil--hydraulic type A automatic transmission	
5	Container 5 gal.	8.75
6	10 qt. graduated containers	12.55
7	Electronic Stroboscope, flashing light source (portable) used to measure the speed of fast moving devices:	345.00
	Power required: 105 to 125 volts Flashing-rate range (a) 110 to 25,000 flashes per minute (b) three direct reading scales (1) 110 to 680 (2) 670 to 4170 (3) 4000 to 25,000 Accuracy ± 1% of dial reading on middle range Mounting Flip-tilt case Dimensions 10 5/8" wide x 6 5/8" high x 6 1/8" deep	
8	Meter stick	1.65
9	Dial caliper 0-4 in, x.001 in. divisions Edmound 60-452 type	20.00
10	16 gal. storage tank with outlet valve at bottom	17.65
11	Thermometer-÷32° - 212°F	2.80
12	Steam generator	282.00
13	1000 ml. beaker (Pyrex)	1.67
14	225 ml. flask (Pyrex)	.60

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
15	Beaker, 4000 ml. (Pyrex)	.55
16	Electric Component Kit including: 1 DPST switch 1 Resistor 1 kohm 2W 1 Resistor 6 kohms 2W	1.54
17	DC Power Supply variable (0.30v, 0.4A) Load regulations 1.25 Max. ripple .1% Size (HWD) - 7 x 12 x 8 1/2"	175.00
18	Dual Channel strip chart recorder Range 0-50 MA DC at 5400 ohms Accuracy 2% of full scale Scale Width 1" per channel	167.50
19	5 lb. weight	2.00
20	Bunsen Burner for natural gas	2.25
21	Ring Stand with support (4 x 4 3/4") 2 rings (3 & 4") - rod length 18"	3.60
22	Kundts Tube Apparatus including: 1 Glass tube 48" x 1" ID 1 Steel rod 36" x 1/8" OD 1 Brass rod 36" x 1/8" OD 1 Woolen cloth Cork dust Rosin 1 Stand for glass tube 1 One hole stopper 1 Glass tube for stopper (4" long) 3 Stand clamps 1 Tuning fork 384 Hz 1 Tuning fork 420 Hz 1 Tuning fork 512 Hz	23.30

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
23	Stool	25.00
	Construction Steel frame swivel type with back rest Adjustable seat 22" to 27" high	
24	Portable Chalkboard	78.85
	4' x 6' double surface with portable stand	
25	Demonstration Sliderule	60.00
	Approximately 12" x 72" suitable for wall mounting	
26	Storage Cabinet	92.00
	18 gauge steel construction Double doors with lock 3 adjustable shelves 36 x 18 x 78 in. outside dimensions	
27	Student Component Kit including:	110.64
	1 75 ohms resistor 20W 1 100 ohms resistor 2W 1 150 ohms resistor 10W 1 250 ohms resistor 20W 1 5 kohms resistor 2W 1 10 kohms resistor 2W 1 No. 26 nichrome wire, 100 ft. roll 1 No. 28 nichrome wire, 100 ft. roll 1 No. 30 nichrome wire, 100 ft. roll 1 No. 32 nichrome wire, 100 ft. roll 1 No. 34 nichrome wire, 100 ft. roll 1 Glo-bar resistor (GC 25-912 or equiv.) 1 28 volt pilot lamp 1 Pilot lamp base 2 10 uF capacitor 600V oil filled 2 1 uF capacitor 600V oil filled 2 14 H, High Q inductor 1 1 H, inductor 1 Transformer (1:1 turns ratio) 1 Audio transformer 1 Single pole, single throw switch	
28	Dual Regulated Power Supply	480.00
	Output: 0-40 volts 0-1A 0-400 volts 0-100mA Regulation: Better than 1%	

ITEM	EOUIPMENT SPECIFICATIONS	UNIT COST

Ripple: Less than 1%
Overload Protection: Current limiter & relay
Metered

29 Sine/Square Wave Generator 255.00

Frequency range

5 Hz - 600 kHz

Output Level

Sine wave: 10V into 600 ohms
Square wave: 10V p-p

Amplitude variation

± 1 db band-band

Distortion

Less than 1% 5 kHz-600 kHz

Rise time

Less than 0.2 usec.

Calibration accuracy

± 2%

30 Resistance Decade Box 39.95

1/2% accuracy
2 watt precision resistors
5 decades
Range from 0 to 99.000 ohms

Output level

Sine wave: 10V into 600 ohms
Square wave: 10V p-p

Amplitude variation

± 1 db band-band

Distortion

Less than 1% 5 kHz - 600 kHz

Rise time

Less than 0.2 sec.

Calibration accuracy

± 2%

ITEM	EQUIPMENT SPECIFICATIONS	UNIT COST
31	Thermocouple Meter Three ranges 0 - 50 mV 0 - 500 mV 0 - 1000 mV	126.00
32	Multipurpose Meter DC volts Ranges: 0 to 1, 3, 10, 30, 100, 300 and 1000 full scale Input resistance: 15 megohms shunted by 14 pF Accuracy: ± 3% full scale AC Volts Ranges: (Rms): 0 to 1, 3, 10, 30, 100, 300 and 1000 full scale Ranges: (peak to peak) 0-2.8, 8.4, 28. 84, 280 and 840, and 2800 full scale, frequency compensated Input resistance: 10 megohms shunted by 29 pF Frequency response: 10 Hz to 10 MHz Accuracy: ± 5% full scale Ohmmeter Ranges: 0-100 microamps, 1 mA, 10 mA, 100 mA, and 1 ampere Accuracy: ± 3% full scale General Meter: 4 1/2", 100 microamp ± 2%, diode protected and isolated from input Ohms battery: 1.5V "C" cell Power supply battery: 9 volt	45.00
33	Dynamometer with Power Supply Hysteresis type 0-100 in-oz 0-15,000 RPM Base plate 7 x 13 1/2 inches	350.00
34	Oscilloscope, Tektronix 533A Type Vertical amplifier Band width: DC to 10 MHz, 3 db down Rise time: 35 ns Deflection factor: 50-200,000mV/cm, in 14 steps Input impedance: 1 megohm in parallel with 30 pF	1,525.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	Horizontal deflection	
	External Band width: 10Hz to 0.5 MHz, 3db Deflection factor: continuously adjustable from 300 mV to 50V Internal Time base: 100ns to 0.5 sec. Time base adjustment: Cal. steps in 1,2,5 seq.	
	Triggering	
	External trigger input impedance: 0.1 megohm in parallel with 25 pF max. Maximum external trigger input: 400V DC to peak AC	
	CRT	
	Diameter 4"	
35	AC Relay	6.10
	115V AC 60 Hz DPST contacts 5 different frame constructions Core approx. 1/2" dia. x 1" long Coil approx. 2" dia. x 1" long	
36	Transformer	5.31
	1:1 ratio 115V AC 60 Hz 1/2 KVA	
37	Series Motor	25.00
	28V AC/DC 1/100 HP 7000 RPM Approx. 2 1/2" dia. x 3" long	
38	PM Motor	30.00
	27.5 VDC 1/100 HP 15,000 RPM Approx. 2 1/2" dia. x 3" long	
39	Solid State Regulated Low Voltage Power Supply	325.00
	Output	
	0.5-50 VDC 1.5 amps	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	Load regulation ± 15 millivolts Line regulation 0.05% Ripple and noise Less than 150 microvolts Overload protection Current limiter and relay Metered Dimensions 5-1/8" x 13-1/4" and 9"	
40	AC Motor 115V AC 60 Hz 1/25 HP 3000 RPM Approx. 2 1/2" dia. x 3" long	9.25
41	AC Milliameter 0-1/2A Mounted in meter case suitable for bench top use	15.35
42	Wattmeter 0-20 watts Mounted in meter case suitable for bench top use Dynamometer type	38.70
43	DC Current Meter Movement Mounted in meter case 0-1 mA DC 55 ohm internal resistance 2 1/2" face	18.00
44	Variac 0-130 volt output 115V 60 Hz input 2 amp fused	13.00
45	Student Tool Kit including: Tool box Soldering iron 35W	61.20

ITEM	EQUIPMENT SPECIFICATION	UNIT COST

Diagonal cutters 6"
Long nose pliers 6"
Combination pliers 6"
Screwdriver 1/8" blade 2" shaft
Screwdriver 1/4" blade 4" shaft
Phillips screwdriver 3/16" blade, 3" shaft
Tweezers
Nutdriver set
12" rule
1" micrometer caliper
1 stopwatch

46 Workbench 88.80

Top

28 1/2" x 64" laminated maple 2 1/4" thick

Legs

31" high steel leg frames with steel stringer

Wiring

60" plug strip with 6 115V outlets prewired

47 Magnetic Chalkboard 1,500.00

Brodhead-Garrett Model AM-1000
4 x 8 feet with roll around stand

48 Precision Mechanical Drives Kit including: 882.08

(All drive components are precision 1 quality and bored for 1/4" shafting unless otherwise noted. All spur gears are 48 pitch).

1 Breadboard plate
4 Breadboard legs
4 Rubber feet (for brbd. legs)
2 Shaft hangers
2 Oiless bronze bearings
6 Bearing adapters
6 Flanged ball bearings
3 Shaft 1/4 x 4"
2 Hollow shaft 1/4 x 2", 1/8" ID
1 Shaft
1 Lead screw assembly
6 Set screw collars
3 Spur gear 36T steel
1 Spur gear 50T steel
1 Spur gear 72T alum.
2 Spur gears 95T alum.
1 Bevel gear set 3:1

ITEM	EQUIPMENT SPECIFICATION	UNIT COST

1 Bevel pinion
1 Internal gear 144T
3 Dial index
4 Bearing plate spacer 3"
2 Spring balance post 5"
2 Spring balances 0-2 lb.
1 Dial caliper
1 Component hanger
1 DC Motor 7000 RPM, 1/100 HP, 28 VDC
1 Differential junction block
2 Lever arms 2"
2 Spring balance clamp assemblies
1 Bearing plate, plastic
1 Bearing plate alum.
1 Internal gear spacer
1 Planet carrier
1 Sprocket 40T
1 Roller chain
1 No-slip pulley 56T
1 No-slip pulley 48T
1 No-slip pulley 30T
1 No-slip belt
1 Cam assembly
1 Cam follower assembly
1 Rack 48p
1 Single universal joint
1 Double universal joint
1 Sleeve coupling
1 Dial 360° 2" CW
1 Dial 360° 2" CCW
1 Dial 360° 1/2" CW
1 RH helical gear 50T
1 LH helical pinion 25T
1 LH helical gear 50T
1 RH helical pinion 25T
1 Spur gear 72 T 1/8 bore
1 Worm
1 Work wheel 6[illegible]OD
2 Pulleys 1" steel
1 Pulley 1-1/2" steel
2 Pulleys 2" steel
1 Belt 1/8" OD
1 "O"-ring 1/8" OD
1 Sprocket 26T
3 Dial index mounts
30 Screws 1/2" #8-32
14 Screws 1 1/2" #8-32
4 Screws 1/2" #6-32
18 Screws 1/2" #4-40
4 Screws 1/2" #6-32
30 Washers for #8-32

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	18 Washers for #4-40 4 Nuts #8-32 1 Dial 360° 1/2" CW 1/8 bore 1 Universal hub 4 Bearing plate clamps 1 4" blank dial	
49	Precision Mechanical Breadboard Kit including:	1,227.50
	(All drive components are precision 1 quality and bored for 1/4" shafting unless otherwise noted. All spur gear are 48 pitch). 15 Shafts from 2" to 10" 42 Shims 60 Spacers 12 Collars 4 Couplings 16 Bearings 16 Gears with set screw hubs 60T to 100T 20 Gears with clamp hubs 21T to 44T 3 Flat gears 60, 72, 90T 18 Clamps 21 Cleats 6 Dial assemblies 3 Bevel gear sets 1, 2, 3:1 6 Couplings 2 Dial hangers 1 Adjustable Cam 2 Antibacklash gears 4 Indices 2 Worm gears 1 Worm 16 Shaft hangers 1 Slip clutch 10 Component hangers 1 Differential 6 End gears 6 Hand cranks 1 Lead screw 1 Limit stop 1 Shaft extension 75 Screws 75 Lock washers 36 Retainer rings 2 Breadboard complete 64 Wingscrews 50 Washers	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
50	DC Motor Control Input 115V AC 60 Hz Speed range 200-1 Output 0-35V DC Speed stability ± 2% 10 turn speed adjustment	72.60
51	Tool Kit including: 1 Protractor 1 Felt lined case 1 Plastic hammer 1 Instrument screwdriver set 1 Adjustable end wrench 1 Pair of tweezers 1 Pair of pliers 1 Steep scale 1 Allen wrench set 1 Inspection mirror 1 Pair of retainer pliers	24.68
52	Student Component Kit (Electrical) including: 1 10 watt output transformer 100 ohms: 4/8/16 ohms 1 Resistor 15 ohms 2W 1 Resistor 1 kohms 25W 1 Resistor 5 kohms 2W 1 Resistor 10 kohms 2W 1 Resistor 100 kohms 2W 1 Resistor 500 kohms 25W 1 Capacitor 1 uF 600 VDC 1 Capacitor 2 uF 600 VDC 1 Inductor 1 H Q = 10 at 60 Hz 1 Switch SPDT 2 Bar magnets 1" x 6" x 1/4" 1 Magnetic compass 1 Shaker with iron fillings	44.22
53	Student Component Kit (Mechanical) including: 1 Breadboard 8" x 16" x 1/4" with legs 1 Motor shaft coupling 1 Ring stand with clamps 1 Pulley 2" OD 1/4" bore hub 1 Pulley 1 1/2" OD 1/4" bore hub 5 "C" clamps 2" adjustment 2 Piano wire 0.062" dia. 24" long 1 Spring stock 6" x 1/8" OD 2 Flywheel, 6" x 10"	78.25

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
54	Spring Balance 0 - 21 lb.	20.95
55	DC Relay 115V Open frame construction with coil spring on armature	6.25
56	Student Tool Kit including: Tool box Soldering iron 35W Diagonal cutters 6" Long nose pliers 6" Combination pliers 6" Screwdriver 1/8" blade, 2" shaft Screwdriver 1/4" blade, 4" shaft Phillips screwdriver 3/16" blade, 3" shaft Tweezers Nutdriver set 12" rule 1" micrometer caliper Hand drill and twist bit (3/8")	54.25
57	Student Component Kit (Electrical) including: 1 Resistor 3 ohms 10W 2 Resistor 25 ohms 2W 1 Resistor 47 ohms 2W 1 Resistor 100 ohms 1/2W 1 Resistor 470 ohms 2W 1 Resistor 1 kohms 5W 1 Resistor 5 kohms 1/2W 1 Resistor 47 kohms 1/2W 1 Resistor 68 kohms 1/2W 1 Resistor 1 megohms 1/2W 1 Potentiometer 10 kohms 1W 1 Potentiometer 25 kohms 1W 1 Potentiometer 250 kohms 1W 3 Potentiometer 1 megohm 1W 1 Rheostat 150 ohms 15W 2 Capacitor 0.1 uF 600W VDC 1 Capacitor 1.0 uF 600W VDC 1 Capacitor 10 uF 600W VDC 1 Transformer 4:1 ratio secondary CT 1 Transformer, transistor input type 1 Transformer 1:1 0.5 kVA 1 Citcuit board 3" x 5" 1 Switch SPST 1 Diode 1N 2982B	62.86

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	4 Diode 1N 270 2 Diode HEP 153 1 Diac ST2 (GE) 1 Triac SC40B (GE) 2 Transistor 2N 3766 1 Transistor 2N 268 1 Transistor 2N 3819 2 SCR CE 106 (GE) 1 UJT 2N 2160	
58	Student Component Kit (Mechanical) including: 1 Breadboard 8" x 16" with legs and clamps 1 Coupling 1/4" bore flexible 1 Motor mount 1 Lead screw assembly 1 Disk dial 360° 2" OD	61.38
59	Synchronous Motor 110 VAC 60Hz Approx. 2 1/2" dia. x 2" long	21.32
60	Induction Motor 110 VAC 60 Hz 1/100 HP 3600 RPM Approx. 2 1/2" dia. x 3" long	38.40
61	Tool Kit including: 1 Felt lined case 1 Plastic hammer 1 Instrument screwdriver set 1 Adjustable end wrench 1 Pair of tweezers 1 Pair of pliers 1 Steel scale 1 Allen wrench set 1 Inspection mirror 1 Pair of retainer pliers	24.08
62	Incremental Motor 28V DC 12 step Approx. 2 1/2" dia. x 3" long	20.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
63	Pulse Generator (1KHz - pulse width 250 to 900μs) Variable pulse rate and pulse width 10 VP-P output into 600 ohms	300.00
64	Chart Recorder 0 - 15 volt range Variable chart speed	110.00
65	He-Ne Gas Laser (Coleman Model 75) For 150-125V, 60 cycles, 50 watts Output - 1 milliwatt CW Beam diameter - 2mm at exit Wave length ≈ 6328 Angstroms, visible red Solid state power supply Housing - metal	295.00
66	Optical Bench and Support Platform Steel rail, 75 cm long, 2.5 cm wide V shaped grove on underside Millimeter graduation Detachable rod, 25 cm long, dia. 12 mm. Angle of inclincation adjustable sides of 28 cm on stand	47.00
67	Optical Kit including: 1 Screen holder 4 Carriages 1 Object box 2 Lens holders 1 Image screen 1 Plane mirror 1 Concave mirror 2 Front surfaces mirrors 10 Lenses with assorted diameters and focal lengths 3 Double convex 1 Plane convex 1 Meniscus positive 3 Double concave 1 Plane concave 1 Meniscus negative 1 Achromatic telescope 2 45-90-45 degree prisms 2 60-60-60 degree prisms 2 Mirror beam splitters 1 Prism beam splitter	192.27

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	3 Glass plates; Approximately 10 x 10 x 1 cm	
	2 Meter sticks	
	4 Lucite rods	
	10 45° rods	
	10 90° rods	
	10 135° rods	
	10 180° rods	
	1 White light source	
	1 LS 400 photo diode	
	10 100 kohms Resistor	
	1 Adjustable slit	
	1 Diffraction grating	
	1 Plexiglass plate	
	1 Plexiglass "U"	
	1 Plexiglass rectangular	
	1 Lucite plate	
	1 Polarimeter	
	1 Calcite crystal	
	1 Wooden wedge	
	2 Sheets cellophane: 10 x 10 cm	
	1 Protractor	
	1 Straight edge	
	4 Straight pin	
	1 Pointer (Wood or cardboard)	
	1 Double slit	
	1 Sheet graph paper	
	4 3" x 5" index cards	
68	Mechanical Breadboard, PIC BB-2 Type	42.00
	8" x 16" x 3/8"	
69	Clip Leads	5.40
	90	
70	Electronics Kit including:	193.15
	49 Resistors, 1/2W, mounted	
	4 Resistors, 1W, mounted	
	7 Resistors, 2W, mounted	
	3 Resistors, 10W, mounted	
	5 Potentiometers, 2W, mounted	
	1 Potentiometer, 25W, mounted	
	21 Capacitors, mounted	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST

Semiconductors including:

1 1N279
2 1N457A
2 1N540
1 1N3716
1 C22b
1 2N730
1 4423
1 ZA12)B
2 2W718A
1 2N2923

Tubes including:

1 3BP1A
1 2D21
1 0B2
1 816
1 6U4
1 6J6
1 6CB6A
1 12AX7

Miscellaneous including:

1 14H choke
1 power transformer
1 filament transformer
1 relay
2 electrodes
4 lamp sockets
4 coils
4 NE-2
3 tube sockets
2 mounting boards

Fast Clip Connectors: 50 assorted colors and lengths.
Metal storage cabinet with three plastic trays with printed storage [redacted]

71 Field Effect Meter 80.00

DC Volts

Ranges: 0-1, 3, 10, 30, 100, 300, and 1000 full scale. ± .5, 1.5, 5, 15, 50, 150, and 500 zero center scales
Input resistance: 15 megohms shunted by 14 pF
Accuracy: ± 3% full scale

ITEM	EQUIPMENT SPECIFICATION	UNIT COST

AC volts

Ranges: (RMS): 0-1, 3, 10, 30, 100, 300, and 1000 full scale
Ranges: (peak to peak) 0-2.8, 8.4, 28. 84, 280, 840, and 2800 full scale, frequency compensated
Input resistance: 10 megohms shunted by 29pF
Frequency response: 10 Hz to 10 MHz
Accuracy: ± 5% full scale

Ohmmeter

Ranges: 0-1000, 10 & 100 kohms, 10 & 1000 megohms
Accuracy: ± 3% linear arc

DC current measurements

Ranges: 0-100 microamps, 1mA, 10mA, 100mA & 1 ampere
Accuracy: ± 3% full scale

General

Meter: 4 1/2", 100 microamp ± 2%, diode protected & isolated from input
Ohms battery: 1.5V "C" cell
Power supply battery: 9 volt, Eveready type #222
Weight: 4 lbs.
Dimensions: 5" W x 7-3/16" H x 3-1/16" D

72 Resistance Substitution Box 16.95

Standard 1W values
15 ohms to 10 megohms

73 Capacitor Substitution Box 19.95

Standard values
100 pF to 0.22 uF

74 Tube, Transistor, Diode Checker 150.00

Must test

Vacuum tubes
Bipolar transistors
Field effect transistors
Unijunction transistors
Diacs
Triacs
Diodes
Silicon control rectifiers

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
75	Component Set including: 1 0.47 ohms 2W resistor 1 4 ohms 10W resistor 1 15 ohms 2W resistor 1 47 ohms 2W resistor 1 220 ohms 2W resistor 1 1k 20W resistor 1 2.2 kohms 1/2W resistor 1 6.2 kohns 1/2W resistor 2 6.8 kohms 1/2W resistor 1 8.2 kohns 1/2W resistor 2 10 kohms 1/2W resistor 1 18 kohms 1/2W resistor 1 47 kohns 1/2W resistor 1 0.1 uF 600 VDC capacitor 3 10 uF 50 VDC capacitor 1 10 uF 600 VDC capacitor 1 Transistor type 40468 1 IC type TI SN72709L 1 IC socket 2 Transistor sockets 1 Transistor input transformer 1 Transistor output transformer 1 Power transformer 1:1	35.01
76	Precision Mechanical Linkage Kit including: 2 Lever arms 1" with 1/4" bore hubs 2 Lever arms 2" with 1/4" bore hubs 1 Rigid coupling 1/4" bore hubs 3 Steel wires 0.055" x 12" 2 Slotted levers 2" with 1/4" bore hubs 1 Harmonic drive mechanism 2 Adjustable cams 3 Microswitches 3 Microswitches hangers 1 Geneva mechanism 3 Pilot lamp assemblies 1 Flexible coupling	212.50
77	Electronic Kit including: 3 Resistance Substitution Boxes (15 ohms-10 meg) 2W 1 220 ohms resistor 1/2W 4 1 kohms resistors 1/2W 4 2.2 kohms resistors 1/2W 2 2.5 kohms resistors 1/2W 2 2.7 kohms resistors 1/2W 1 6.8 kohms resistor 1/2W	113.84

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	2 8.2 kohms resistors 1/2W 2 33 kohms resistors 1/2W 2 47 kohms resistors 1/2W 1 2 kohms potentiometer 1W 2 10 kohms potentiometer 2W 2 100 kohms potentiometer 2W 2 0.01 uF capacitors, 50V 1 0.1 uF capacitors, 50V 1 0.5 uF capacitor, 6V 2 10.0 uF capacitors, 6V 2 Capacitor Substitution boxes (0.00022uF - 0.22uF, 400V) 1 1H Inductor	
78	3-Winding Pulse Transformer	8.70
	Blocking OSC type (United Transformer H-60)	
79	Lamps and Bulbs	83.80
	40 Lamps #48 with sockets 10 Lamps 75W, 115V with sockets 20 NE51 Neon bulbs with sockets	
80	Switches including:	101.30
	90 SPDT Switches 30 SPST Switches 10 DPDT Switches	
81	Thermister RB41L1	.96
82	Semiconductor Device Kit	66.89
	11 1N34 Diodes 3 1N305 Diodes 1 1N645 Diode 4 2N3709 Transistors 1 2N4891 Transistor 1 2N1204 Transistor 3 2N1204 Transistors 1 C22B Silicon controlled rectifier 1 MC 790P Integrated circuit 1 MC 724P Integrated circuit 5 SN1 5845 Integrated circuits 3 SN 7476 Integrated circuits 10 SN 15830 Integrated circuits 1 SN 15833 Integrated circuit 1 TI 7350 Integrated circuit	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	1 TI 1590 Integrated circuit 4 Transistor sockets 10 Integrated circuit sockets (To fit ICs used)	
83	Circuit Breadboard Vector type 837-3" x 5" (To 50 assorted colors and lengths of fast clip connectors)	2.35
84	Computer Facilities Capable of running Digital Electronic computer problems	no cost listed
85	Blank Computer Cards	1.00
86	Tool Kit including: 1 Plastic hammer 1 Instrument screwdriver set 1 Adjustable end wrench 1 Pair of tweezers 1 Steel rule, 6" long 1 Allen wrench set 1 Flat file 1 Pair of scissors	19.98
87	2 Pieces of Cardboard, 4" x 4"	
88	Linear Potentiometer 5kΩ, 1/2W	1.50
89	Rotary Potentiometer 1kΩ, 1/2W	1.25
90	Rheostat, 22 ohms, 50 watt (ohmite type J)	4.02
91	Drafting Kit including: 1 Drafting table or board 1 T-Square 1 Triangle (30°, 60°, 90°) 1 Triangle (45°, 45°, 90°) 1 Bow compass 1 Divider 1 Engineering scale 1 Protractor 1 Irregular curve 2 Sheets linear graph paper 9 Sheets drafting paper	18.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
92	**Fluid Component Kit including:**	583.00

5 gal. container
2-way cylinder, 1 1/4"
2-way cylinder, 2 1/4"
1-way spring return cylinder
Cylinder base and riser plate
4-way valve, three position, pilot control
Pilot control valve cylinder
Quick exhaust valve with muffler
Hydraulic motor fixed displacement, bidirectional
Cam valve, 2-position
Accumulator
Compound gauges
"X" Connector, 1/4"
Flow control--2-way valves
Four-way valve, closed center
"T" Connector, 1/4"
Flow control valves integral check
Relief valve
4-way valve, open center
Gauges, pressure
Check valves
3/8 to 1/4 adaptor
Vacuum adaptor
Hose--plastic rayon reinforced 1/4"
Hose--plastic rayon reinforced 3/8"
Nipples--quick disconnect single check and inserts 1/4" assembly (std)
Bodies--quick disconnect double check and inserts 1/4" (optional purchase) QC-1
Nipples--Quick disconnect single check and insert 3/8"
Bodies--Quick disconnect double check and insert 3/8" (optional purcuase) QC-1
Hoses--rubber rayon reinforced 1/4"
Hoses--nylon flow 1/4"
U Tube manometer 16" long
Fittings hose, reusable type 1/4"
Clamps--1/4" hose
Disconnect bodies quick type single check 1/4"
Disconnect nipples quick type double check 1/4" (mounted on components) (optional purchase) QC-1
Fitting compression type 1/4"
Oil--air lubrication non-detergent
Oil--hydraulic type A automatic transmission
Pressure relay
Pressure transmitter
Cup container and ball
Flat Hydrometer and jar

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
93	100 ft. roll of No. 40 copper wire	1.50
94	100 ft. roll of No. 32 nichrome wire	1.00
95	Beaker, 250 ml. (Pyrex)	.91
96	Vacuum gauge 0-30 in. Hg.	6.00
97	Air regulator, 0-200 psi	18.50
98	Remote Bulb Thermometer, 0°F - 600°F	7.15
99	Steel Ball Pendulum, 1" dia.	3.50
100	Electric Component Kit including: 2 100W lamps 2 Lamp sockets 2 20 ohms resistor 2W 1 100 ohms resistor 2W 2 1 kohms resistor 2W 1 4.7 kohms resistor 2W 1 10 kohms resistor 2W 1 5 kohms resistor 2W 1 10 uF 50VDC capacitor 1 Transistor 2N 398A 1 Transistor Hep 232 1 Speaker 8 ohms 4" round with mount 1 Speaker 8 ohms 5" x 8" oval with mount 1 Output transformer 100 ohms: 16,8,4 ohms 5W 1 Relay 1 Relay counter 1 Copper rod 1 Zink rod 2 Photovoltic cells, B20PL 1 Photoconductive cell CS120M6 1 Movable core inductor 1 Piezoelectric cell 1 Thermocouple 2 Thermocouple wires chromel-alumel 1 Tach generator = 4 VDC/1000 RPM 1 Strain gauge, R = 120 ohms F = 2 1 Epoxy adhesive 1 Strain gauge bridge	232.00
101	Mechanical Component Kit including: 1 Shaft hanger 1 Breadboard 1 Post 1 Clamp	108.21

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	1 Weight set 0-15 lbs. 1 Shaft 4" x 1/4" 1 Lever arm 12" 1 Pointer 1 Extension spring stock 12" 1 Slider block 1 Pivot block 1 Pulley 1 Shaft coupling 1 Alum, bar 1/8 x 4 x 21 in. 1 Steel bar 1/8 x 2 1/2 x 20 in. 1 C-clamp 1 Pressure plate	
102	Ammeter, 0-15 amps, Panel Mount Including plugs for external use	3.70
103	DC Generator, 3.8 volts with mount 100 RPM min. - 6000 RPM max.	25.00
104	Voltmeter, 0-22 volts, panel mount	3.70
105	Wheatstone Bridge	205.00
106	Thermostat, 923A (Honeywell type)	24.86
107	Dual Pressure Control, 012-1505 (Ranco type)	52.46
108	Air Supply, 0-100 PSI (110 v Compressor with tank)	176.54
109	Pressure Gauge, 0-100 PSI	3.46
110	Hand Valve (Screw type for 3/8" air line)	12.30
111	Air Cylinder, 1" dia. piston x 4" stroke	20.00
112	2-Way Cylinder-1 1/2" dia. piston, 6" stroke	30.00
113	4-way Valve, electrically controlled	90.00
114	Hydraulic Pressure Gauge, 0-30 PSI	22.59
115	Hydraulic Supply, 0-500 PSI at 4 gal/min	250.00
116	AC Motor 115/115 volts, 60 Hz, 2 Phase, .30/.30 amps, 110 watts output, 2 poles	43.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
117	Variable transformer, 0-130 volts, 2a	13.00
118	Hydraulic regulator, 0-500 PSI	35.42
119	Hydraulic Pressure gauge, 0-500 PSI	28.59
120	Hydraulic Motor Mechanical tool and Eng. Co. or equivalent	95.00
121	Mechanical tachometer, portable hand type 0-10,000 RPM	24.95
122	Synchro, 23TX6 with mount	55.00
123	Synchro, 23CT6 with mount	47.50
124	DC Amplifier--with variable gain and damping RCA Model 121-127 type	43.00
125	Vacuum Tube Voltmeter, VTVM 11 meg DC input type Sencore FE-14 or equivalent	69.85
126	AC Amplifier Gain of 5000 with gain control and velocity feedback provision, input impedance 100 kohms, output impedance 400 ohms, output power 20 watts into rated load.	65.00
127	Thermocouple Bridge, 0-200° F	21.30
128	AC Ammeter, 0-2 amps, panel amount type	3.70
129	Motor-Generator Unit Motor--2 phase, 60 Hz, 115/115 volts, 2 pole, 3350 RPM, 7 oz. in. stall torque. Generator--32 volts, 60 Hz, separately excited, output approximately 3 volts/1000 RPM	84.50
130	Minor Equipment Kit including: 1 Shaft, 4" x 1/4" 3 Adapter Couplings 1 Lever arm, 3" 1 Heat sink, HEP 232	171.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	1 Heat sink, HEP 254	
	1 Scale and indicator assembly	
	3 Switch, SPST	
	1 Relay, SPDT contacts	
	1 Fan, 115 volt, 60 Hz	
	1 Scale, 0-10 cm	
	1 Spring, 3/4" diameter	
	1 Bellows assembly, 1"	
	1 Spring, 1/8" diameter	
	1 Scale, 0-3000 gram	
	1 Nut, .25" inside diameter	
	1 Fitting, adapter	
	3 Fittings, T-type	
	1 Arm, 9" flapper	
	1 Scale, 0-6"	
	2 Spring, K = 6 lb/in.	
	1 1 oz. weight	
	1 .5 lb. weight	
	1 1 lb. weight	
	2 2 lb. weights	
	3 3 lb. weights	
	2 Pulley, 2" diameter	
	2 Pointer assembly	
	2 Dials, 0°-360°	
131	Electronic Equipment Kit including:	34.90
	1 Transistor, HEP 232	
	1 Transistor, HEP 254	
	1 Transistor, HEP 53	
	2 Transistors, 2N398	
	1 UJT, 2N2664	
	1 SCR, GE type 106 B	
	1 Diode, 1N4148	
	1 Zener diode, 12 volts	
	1 Thermistor, 5 kohms at 25° C	
	2 Diodes, 1N457	
	5 Resistors, 1 kohms	
	2 Resistors, 10 kohms	
	2 Resistors, 2 kohms	
	1 Resistor, 18 kohms	
	1 Resistor, 22 kohms	
	1 Resistor, 2 ohms-8 watts	
	1 Resistor, 1 ohm-8 watts	
	1 Resistor, 100 ohms	
	1 Resistor, 68 kohms	
	1 Resistor, 12 kohms	
	1 Resistor, 6.8 kohms	
	1 Resistor, 47 ohms	
	2 Potentiometer, 10 kohms	
	1 Potentiometer, 20 kohms	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	1 Potentiometer, 100 kohms 3 Capacitors, 100 uF 1 Capacitor, 1 uF 1 Capacitor, 5 uF 1 Capacitor, 10 uF 1 Capacitor, .02 uF	
132	Numerical Controlled Machine and Comptroller The machine must be capable of point-to-point positioning and straight line milling. The controller must be capable of accepting paper tape coded instructions.	11,365.00
133	Program Punching Machine (with a supply of suitable paper tape)	30.00
134	Twist Drill set, assorted (standard sizes)	12.50
135	Milling Tool, 1/16 inch.	3.65
136	Fine cut file, 12 inch.	2.25
137	Engine Lathe, Unimat (lathe must include a three jaw-chuck and tool bits)	150.00
138	Bench Vise - 6 inch. jaw opening	26.26
139	Soldering Iron - 110V, 35 Watt	4.40
140	Fine Emery Cloth - 6" x 8" sheet, 300 grit	.20
141	Aluminum Rod 1/2" long 7/8" diameter	.05
142	Aluminum Tubing 3.5" long 5/8" outsider diameter 9/16" inside diameter	.08
143	Steel Coil Spring 1/4" long 1/4" outside diameter 3/16" inside diameter	.04

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
144	Micrometer (0-1 inch.)	14.95
145	Steel Rule (0-6 inch.)	1.50
146	Plastic Rod 1" long 3/4" diameter	.03
147	Pin Jack	.93
148	Capacitors 40 Capacitors--.04 uF miniature ceramic disk capacitor 20 Capacitors--100 pF miniature ceramic tubular capacitor	16.00
149	Resistors 40 Resistors--22 kohms 1/2 watt carbon resistor 40 Resistors--47 ohms 1/2 watt carbon resistor	26.00
150	Transistors 40 Transistors (audio frequency, low power, supply voltage is 1.5 VDC) 80 Unijunction transistor (one octave)	18.00
151	Penlight Battery--leakproof, 1.5 VDC	.20
152	FET (one octave)	.56
153	Toy Organ or Piano	20.00
154	Gear train--with capston drive motor	136.00
155	Synchro Receiver Type 23TR6 or equivalent with mount	55.00
156	Synchro Differential Receiver Type 23TDR or equivalent with mount	50.00
157	Synchro Differential Transmitter Type 23CDX or equivalent with mount	55.00
158	Servoamplifier (compatable with the servomotor)	129.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
159	AC Servomotor 115/115 volts, 60 Hz, 2 phase, .30/.30 amps, 110 watts output, 2 poles	139.00
160	DC Servomotor (PM or separately excited)	75.00
161	Motor Generator (or separate units that can be connected together). Generator field windings must be accessible.	59.50
162	Harmonic Drive--with mount	15.00
163	Function Generator (low frequency) Leader Lag 54 type	85.00
164	Magnetic Amplifier	78.00
165	AC Current Meter (0-5A), panel mount type	3.70
166	Operational Amplifier TI Type SN 724 or equivalent	12.50
167	Mechanical Equipment Kit including: 4 360° disk dial 3 Dial index 3 Dial index mounts 1 Spring balance 1 Spring balance post 1 Lever arm (1 in.) 1 Lever arm (2 in.) 1 Worm screw 1 Worm sheel 3 Spur gear 36N 2 Spur gear 95N 2 Shaft hangers (2 1/2 in.) 2 Shaft hangers (adjustable) 4 Collars 3 Shafts (1/4 x 4 in.) 1 Shaft (1/4 x 2 in.) 1 Potentiometer mounting bracket 2 Bearing plates with spacer 1 Rack and pinion (3/4 in.) 4 Bearing mounts with bearings 1 Geneva mechanism 1 Rigid coupling 1 Flex coupling	316.52

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
168	Electronic Equipment Kit including: 4 2N3709 Transistor 1 GE C22B Silicon controlled rectifier 1 2N4891 Unijunction transistor 1 ML 724) Integrated circuit 2 MC790P Integrated circuit 1 Rb41L1 Thermister 2 CL904 Photocell 1 NE2 Lamps 4 Lamps 3V # 48 with socket 1 Lamp 115V, 20 to 75 watt 1 Oven (cardboard box) 1 Switch, SPST 1 Switch, push button, normally open	23.55
169	Resistors including: 30 Resistance decade box (15 ohms-10 megohms) 2W 20 10 ohms resistors 10W 10 47 ohms resistors 1/2W 10 1 kohms resistors 1/2W 50 22 kohms resistors 1/2W 30 5 kohms resistors 2W 10 27 kohms resistors 1W 30 100 kohms resistors 2W 10 120 kohms resistors 1/2w	584.50
170	Potentiometers 20 10 kohms servo potentiometer with mount 10 10 kohms-20 kohms sine-cosine potentiometer 10 10 kohms-20 kohms triangular potentiometer 10 50 kohms potentiometer 2W	107.50
171	Capacitors including: 20 Capacitance decade box (.0022uF-.22uF) 400V 10 .01 uF capacitor 150V 30 .5 uF capacitor 16V 20 5 uF capacitor 6V 20 10 uF capacitor 6V	444.54
172	Student Component Kit including: 1 Resistor 1.2 kohms 1/2W 1 Resistor 2.2 kohms 1/2W 2 Resistors 3.3 kohms 1/2W 1 Resistor 10 kohms 1/2W 1 Potentiometer 5 kohms 1W 1 Capacitor 0.01 uF 50V	24.26

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	1 Transistor 2N2926 1 Ceramic filter 455kHz, 0-50 1 360 disk dial 1.5 in. dia. 1 Alignment tool kit, set of 4 tools	
173	Transmitter, GDA-19-1 (Heath Co.) or equivalent	86.50
	RF carrier frequency 1 Channel, crystal controlled on 27, 53, or 72 mHz Frequency stability ± .005% on 27 mHz, ± .002% on 53 and 72 mHz Temperature 0° to +160°F RF output circuit Pi-network Modulation On-off carrier keying Approximate current drain 100 mA Power supply Internal 9.6 volt nickel-cadmium battery. Rechargeable simultaneously with receiver battery at 35 to 40 mA from 120V.	
174	Receiver, GDA-19-2 (Heath Co.) or equivalent	49.95
	Received frequency 1 Channel, crystal controlled on 27, 53, or 72 mHz Frequency stability .003% on 27 mHz, .002% on 53 and 72 mHz Temperature range 0° to +160°F Sensitivity 5 uV or better Selectivity 6 dB at ± 4.0 kHz, 30 dB at ± 9.0 kHz Approximate current drain 6 mA	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST

Intermediate frequency

453 kHz

Power supply

Heath GDA-19-3 battery pack

Controls

On-off switch

Dimensions

25/32" H x 2" W x 2 7/32"d

Net receiver weight

2.3 oz.

175 RF Generator 65.00

RF output

Impedance, 50 ohms-voltage, 1,000,000 micro-volts max.

Attenuator

Coarse, 10:1 per step, 5 steps-fine, 10:1 continuous, indicated on meter

Amplitude modulation

CW, internal 400 Hz or external audio frequencies

Modulation depth

0 to 50% variable, indicated on meter

Power requirements

115/230 VAC, 50-60 Hz

Dimensions

13" W x 8 1/2" H x 7" D

176 Battery Pack and wiring harness, GDA-19-3 (Heath Co.) or equivalent 9.95

Type

Nickel-cadmium. Rechargeable simultaneous with transmitter battery at 40 to 50 mA from 120 volt.

Voltage

± 2.4V and ± 4.8V outputs

Current rating

500 mA hours

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	Dimensions 5/8" H x 2 1/8" W x 2 3/8" Net weight 3.9 oz.	
177	Servo-GDA-19-4 (Heath co.) or equivalent Pulse 1 to 2 milliseconds wide 4 volts peak-to-peak Thrust 3 lbs., minimum Transit time for 5/8" travel 0.7 seconds Linear output travel 5/8" end-to-end 1/2" nominal Rotary output travel 0 to +100 degrees Power (battery) requirements: idling current 2 mA	19.95
178	AM Receiver, Superheterodyne Broadcast type May be either breadboard or packaged. Packard Bell 5 RI Panel type	129.00
179	AM Wireless Microphone Transmitter	10.00
180	Loading Frame (built in class) Materials required: 8 pieces channel iron 5" x 1 3/4" x 28" long 4 pieces channel iron 5" x 1 3/4" x 20.5" long 2 pieces steel bar 1/2" x 1" x 24" long	43.00
181	Hydraulic Piston 2.5 in. diameter 1 in. stroke	100.00
182	Ring Force Transducer Proving rings, with strain gauge attached (.0001 in. per division)	65.00

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
183	Dial Indicator	40.00
	Extensometer, may be removed from proving rings (.0001 in. per division)	
184	Rockwell Hardness Tester	346.00
	capable of both the R-B and R-C scales	
185	Links including:	83.00
	10 links, 1 1/2" 10 links, 4" 110 links, 4 1/2" 10 links, 5 1/2"	
186	Beam Member, 4"	1.00
187	Weight Pan (Metal)	6.46
188	Weight Sets	20.00
	1 lb. and 5 lb. weights	
189	Connectors including:	94.60
	140 joint connectors 20 connectors, 1" 10 connectors, 6"	
190	Box 1f 1/4 in. pins	.25
191	Extensometer Bracket	2.50
192	Specimen Kit including:	30.61
	1 Soft steel specimen 1 Aluminum specimen 2024 st. 1 Plastic specimen 2 Specimen connectors 1 Aluminum specimen, 2024-T6 1/2 inch diameter x 1 inch long 1 Yellow brass specimen 1/2 inch diameter x 1 inch long 1 Steel specimen, 1018 1/2" diameter x 1" long 1 Stainless steel specimen, 304 1/2" diameter x 1" long 1 Drill rod specimen 1/2" diameter x 1" long 1 Tool steel specimen 1/2" diameter x 1" long 1 File specimen with cutting teeth ground off	

ITEM	EQUIPMENT SPECIFICATION	UNIT COST

1 Yellow brass welding rod 1/8" diameter x 10" long
1 Aluminum welding rod 1/8" diameter x 10" long
1 Steel welding rod 1/8" diameter x 10" long
1 Drill rod welding rod 1/8" diameter x 10" long
6 Steel specimen, 1010, 1020, 1030, 1040, 1060, and 1090 (1/2" x 1/2")
4 Steel staples, 1/4" x 1/4" x 2"
3 Aluminum specimen, 2024 1" diameter x 1/2" thick

The following items are approximately 1/32 inch. thick unless otherwise specified.

2 Aluminum sheets, 1" x 3"
3 Magnesium sheets, 1" x 3"
3 Steel sheets, 1" x 3"
2 Copper sheets, 1" x 3"
1 Steel sheet, 1"x 3"
1 Copper sheet, 1" x 3"
1 Steel sheet, 1" x 6"
1 Aluminum sheet, 1" x 6"
1 Magnesium sheet, 1" x 6"
1 Zinc sheet, 1" x 6"
1 Stainless steel sheet, 1" x 6"
1 Tin sheet, 1" x 6"
1 Copper sheet, 1" x 6"
1 Copper sheet, 2" x 6"
1 Steel sheet, 2" x 6"
1 Copper sheet, 1/4" x 6"
1 Steel Sheet, 1/4" x 6"
1 Acetal specimen, 1/8" x 1" x 6"
1 Acrylic specimen, 1/8" x 1" x 6"
1 Cellulose acetate specimen, 1/8" x 1" x 6"
1 Polyethylene specimen, 1/8" x 1" x 6"
1 Polystyrene specimen, 1/8" x 1" x 6"
1 Polyvinyl chloride specimen, 1/8" x 1" x 6"
1 Nylon specimen, 1/8" x 1" x 6"
1 Teflon specimen, 1/8" x 1" x 6"
2 Acrylic specimen, 1/8" x 1" x 4"
2 Cellulose acetate specimen, 1/8" x 1" x 4"
2 Polystyrene specimen, 1/8" x 1" x 4"
2 Polyvinyl chloride specimen, 1/8" x 1" x 4"
2 Polyethylene, 1/8" x 1" x 4"
1 Bottle of methylene chloride with dropper
1 Bottle of ethylene dichloride with dropper
1 Bottle of acetone with dropper
1 Bottle of trichloroethylene with dropper
1 Bottle of chclohexanone with dropper
1 Acrylic specimen, 1/8" x 1" x 3"
1 Cellulose acetate specimen, 1/8" x 1" x 3"
1 Nylon specimen, 1/8" x 1" x 3"

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
	1 Polystyrene specimen, 1/8" x 1" x 3" 1 Polyvinyl chloride specimen, 1/8" x 1" x 3" 1 Polyethylene specimen, 1/8" x 1" x 3" 2 Polystyrene specimen, 1/8" x 1" x 2" 2 Polyethylene specimen, 1/8" x 1" x 2" 1 Yellow brass specimen, 1/16" x 2" x 6" 1 Copper specimen, 1/16" x 2" x 6" 1 Nickle specimen, 1/16" x 2" x 6" 1 Steel specimen, 1/16" x 2" x 6" 1 Emery cloth 3 Quarts nickle sulfate solution 12 oz. nickle sulfate 1 1/2 oz. ammonium chloride 1 1/2 oz. boric acid 3 qt. distilled water 3 Quarts copper sulfate solution 21 oz. copper sulfate 3 oz. sulfuric acid 3 qt. distilled water 3 Quarts sulfuric acid solution 10 oz. concentrated sulfuric acid 3 qt. distilled water	
193	Divider or Compass	2.10
194	Machinist Scale	16.00
195	HR Steel Beam 1/2" x 1" x 18"	1.00
196	Load Connector	2.00
197	Joints including: Type A joint Type B joint	2.55
198	Hack Saw Blade	.75
199	Oxygen-acetylene torch kit, single stage regulators, not including bottles	125.00
200	Fire Brick	.15
201	Permanent Magnet, 2" bar type	1.00
202	Ball Peen Hammer, 1/2 lb.	3.40

ITEM	EQUIPMENT SPECIFICATION	UNIT COST
203	Bolts including: 50 1/4-20 steel bolts 1/4" long with nuts 20 1/4-20 copper bolts 1/4" long with nuts	2.60
204	Hand Spring Balance (0-41 lb. with scoop)	18.00
205	Platinum Wire	1.00
206	Voltmeter, 0-1.5V Panel mount type	3.70
207	Vulcan Anvil, 30 lb.	45.00

VITA

Conrad Kent Solf

Candidate for the Degree of

Master of Science

Thesis: A MODEL FOR DETERMINING THE EQUIPMENT NEEDED FOR IMPLEMENTING AN ELECTROMECHANICAL TECHNICIAN EDUCATION PROGRAM

Major Field: Technical Education

Biographical:

Personal Data: Born in Cherokee, Oklahoma, July 25, 1943, the son of Mr. and Mrs. Conrad J. Solf.

Education: Attended and graduated from Lambert High School in Lambert, Oklahoma, in 1961; attended Northwestern State College at Alva, Oklahoma, from 1961-64; graduated from Oklahoma State University with a Bachelor of Science degree in Electrical Engineering in 1970; completed requirements for the Master of Science degree in Technical Education at Oklahoma State University in May, 1972.

Professional Organizations: American Vocational Association; Oklahoma Vocational Association.

Professional Experience: Two semesters of classroom experience at the post-secondary level; my duties included: working with students, practice teaching, testing, grading, and evaluating. This was one semester of Digital Electronics and one semester of Introductory Electronics, the latter being taught at the Technical Institute at Oklahoma State University in 1970-71.