A PROPOSED COURSE OF MATHEMATICS
AS RELATED TO WOODWORK

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By

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C. M. J.

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CHAPTER I

INTERPRETATION OF THE PROBLEM

Woodwork, like any other subject in the curriculum, has developed from the ever changing demands of society. Today courses in woodwork are recognized throughout our country as an important factor in our educational system. Woodwork is one of the courses included in industrial arts. The term 'manual training' which has been used in the past to include the courses in the shop has been disregarded and industrial arts substituted in its place.

> Industrial arts, while not free from criticism, seems to be the most satisfactory term yet proposed, and does not suggest the invidious implications so often attributed to "manual training."[1]

At present the greatest stress is placed on industrial arts in the junior high school, although there are subjects which receive much consideration in the senior high school, such as: woodwork, mechanical drawing, metal work, electricity and others.

Selection of Problem

Courses of woodwork as a school activity are subjects that offer many correlative possibilities. One of the subjects that may be very closely correlated is mathematics. There is a growing tendency on the part of educators to make a departure from current practice in teaching mathematics. The tendency is to teach problems and exercises that are

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[1] Frederick G. Bonser and Lois C. Mossman, Industrial Arts in the Elementary School, p. 10.

are grouped by situations taken from actual experiences to that the pupil meets problems vital to his home and school interest. Shop work gives the opportunity for such practice in mathematics and is referred to as shop mathematics.

Meriam, in referring to this tendency states: "Just such is the effort in many schools to 'vitalize' the subject of the curriculum."[2]

In some cases time and conditions may not permit a course in shop mathematics to be given, but related mathematics will suffice. Psychology teaches that if we learn a fact through experience, we will retain the knowledge longer than if we learn by rote memorization. Therefore, the mathematics that the pupil learns from actual experience in the shop, will be of greater value to him in life, provided the problems chosen are lifelike. Shop work offers great opportunities for practical mathematics. Calvin O. Davis states the case most emphatically:

> Without a basic knowledge of mathematics the principles and processes involved in drawing, manual arts, domestic arts-------are impossible of comprehension in any other than a rule-of-thumb manner unless correlated with mathematics and interpreted by it.[3]

Before we can properly teach shop mathematics it is necessary to know the mathematical skills involved. After the

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[2] J. L. Meriam, Child Life and the Curriculum, p. 133.

[3] C. Davis, High School Course of Study, p. 38.

teacher knows these skills, then, through proper application, the subject can be made of greater value to the pupil in life.

The first aim of the study was to determine the mathematics that could successfully be taught in a course of industrial arts. Industrial arts include a number of different subjects taught in the shop. Up to now there is no definite number of courses that could be included under the study of industrial arts. It was also found that each subject within itself would have to be analyzed separately, as a separate problem would have been presented in each of the courses. There is no particular arrangement of courses taught in industrial arts. It was found that after the data had been selected, one would be unable to arrange the material in a course.

This study was made from one course in industrial arts. Woodwork is one of the main courses taught in industrial arts. Woodwork and mechanical drawing are the two courses that are combined to any extent in the Oklahoma Course of Study[4] for industrial arts. This study was made on two classes of woodwork in determining what mathematics could be taught in relation to woodwork.

The study was made for the purpose of determining what mathematics could be taught in combination with the projects taught in a course of woodwork. The Department of

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[4] State of Oklahoma Department of Education, High School Course of Study in Industrial Arts, Bulletin No. 124, 1930.

Superintendence, is quoted as follows:

> Standing out most prominently then, two tendencies seem evident in courses in industrial arts: (1) an increasing emphasis upon content relating to health, economics, and art values in the use of the material supplies and equipment of life; and (2) a recognition and use of the parts of industrial arts and other subjects closely related, making for economy of time and effort in the teaching of all of these related subjects.[5]

The boy in the shop must know mathematics to some degree before he can work successfully in woodwork.

> The boys in the manual training class must necessarily measure lumber, compute sizes, and secure results that are accurate to a high degree. Without the necessary knowledge of arithmetic-------no boy can carry on his work in manual training successfully.[6]

The course of woodwork has been analyzed from the standpoint of operations taken up in the course. The projects that are worked on in the shop must be studied, because by them the operations are taught.

The Nature of Analysis

Realizing that the arithmetic course needed a practical basis, the author made a job analysis of a course in woodwork as taught in the ninth and tenth grades. In addition to analyzing the jobs in the course, six textbooks were selected for the study. The course in woodwork was organized

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[5] Department of Superintendence of the National Education Association of the United States, <u>Third Year Book</u>, p. 336.

[6] H. B. Wilson and G. M. Wilson, <u>The Motivation of School Work</u>, p. 159.

from the list of "things to do and things to know" as set up by the American Vocational Association.[7]

The job analysis was divided into seven woodworking units. These project units were set up as found in the texts. No definite time has been suggested for working out each unit as set up. Since one group will be able to work the unit faster than another, a number of projects has been listed under each. Under this condition one student may make more projects than another but their work will involve the same operations, in the same unit.

Although there will probably be a number of changes in the unit problems, there will be practically no change in the operations and operating points. This is due to the fact that fundamental operations in woodwork do not change. For example, squaring up stock will be done the same way, but the kind of projects may change as to style and shape.

The job analysis of the course functioned in two ways: first, to determine what woodwork jobs should be taught, as indicated by the list of the American Vocational Association, and by the content of the textbooks; and second, to determine what mathematical principles are required in the foregoing woodwork units.

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[7] American Vocational Association Committee in Industrial Arts, Standards of Attainment in Industrial Arts Teaching, pp. 35-39.

Studies of Similar Nature

There has been much time devoted by the writer in searching for literature that bears directly on this study. It is no exaggeration to state that the literature dealing with this problem is exceedingly meager. The following list of literature is believed to be representative, and is intended to aid the reader in interpreting the results. Because of the limited amount of literature dealing with this study, the study may be considered more interesting, as well as a contribution to the field of industrial arts.

Strickler made a study of the training and experience of 480 industrial arts teachers. The purpose of this study was to point out the various elements that make up the training and experience of industrial arts teachers. The results could be used in a helpful way to the persons working in the field as well as preparing teachers for industrial arts work. The findings of this study are supposed to be both reliable and valid.[8]

Strickler sent out six thousand questionnaires to obtain his data. He received 544 returns, and made his study from 480. These questionnaires were distributed to every state in the union. Strickler shows in this study that 136 of the 480 instructors have taken courses in shop mathematics, and twenty recommend the subject as being

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[8] F. Strickler, Training and Experience of 480 Industrial Arts Teachers. (review of book)

helpful to them. Table IV points out that the total number of courses in mathematics taken by the 480 instructors numbered 512, or an average of 1.07 courses per person. The average mathematical preparation of these 480 industrial arts teachers was 5 per cent. There is no mention made in Strickler's study of the mathematical skills involved in the shop work.

An article by T. Diamond, which appeared in the Industrial Education Magazine, states: "Perhaps too much mathematics is given in the schools today that does not apply directly to everyday life." He is in favor of giving the pupils problems that involve principles and processes that may be used in everyday life. This survey was made of the workers of eighty-six occupations ranging from sixteen to forty-five years of age. No worker was requested to take part but volunteered on his own accord. Diamond allowed the study to continue for a week and precautions were taken to avoid misleading tabulations.

This study was based on 911 replies received from the workers of eighty-six occupations. Diamond found that 515 reported that they had used arithmetic, and 396 reported that they had used none. In other words, 42.03 per cent of the workers had used no mathematics during the week of work. It is interesting to note that not once did these 911 workers have use for algebra or geometry. Two individuals out of these 911 workers had use for pi (3.1416) in determining the circumference of a circle from the diameter. The study points out that many of the details considered by an arithmetic teacher were a source of amusement in the shop. It is assumed that this is a fair sampling of the average worker in relation to the use of mathematics.

A summary of the study as given by Diamond is as follows:

> 1. About 45 per cent of our workers do not use arithmetic in their work.
> 2. Less than 24 per cent of all workers use addition in their work.
> 3. Less than 17 per cent of all workers use subtraction in their work.
> 4. Less than 17 per cent of all workers use multiplication in their work.
> 5. Less than 12 per cent of all workers use division in their work.
> 6. Less than 3 per cent of all workers use common fractions in their work.
> 7. All other problems reported were used by fewer than 2 per cent of the workers, and a number of them were used by as few as one-tenth of one per cent.
> 8. There seems to be little difference between skilled, semi-skilled, and unskilled workers in regard to the frequency with which arithmetic is used.
> 9. In spite of these conditions more emphasis is placed upon arithmetic in our vocational schools than upon any other academic subject.[9]

If W. W. Charter's idea of curriculum construction is to be followed, that:

> we should frankly accept usefulness as our aim rather than comprehensive knowledge, and that no fictitious emphasis should be placed on the value of formal discipline.[10]

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[9] T. Diamond, "How Extensive Should a Course in Shop Mathematics Be," Industrial Education Magazine, Vol. 16, p.250.

[10] W. W. Charters, Curriculum Construction, p. 4.

the advanced courses in mathematics might well be supplemented by more work in fundamental arithmetic. Diamond would place more stress on the development of the four fundamentals for speed and accuracy.

A study was made by the Maryland State Department of Education in regard to the mistakes made in arithmetic. The main purpose of this study was to improve instruction in arithmetic. After a series of tests was given, the errors were summarized as to their frequency in the following table:

Chief Arithmetic Errors and Their Frequency	Per Cent
1. Superficial reading--modifying conditions of problems not noted carefully	51
2. Incorrect reasoning of problem	14
3. Inaccuracies in processes, esepcially in addition and multiplication	12
4. Omission of problem--apparent lack of comprehension or ineffective attempts	8
5. Careless recording of answer (failure to reduce fractions, failure to include decimal point, etc)	4
6. Lack of knowledge of everyday facts (table of measure, etc.)	3
7. Omission of final zero in quotient	2
8. Other errors	6
Total	100 [11]

A proposed course of practical mathematics as related to trade dressmaking instruction was a thesis written by Esther Collier Price at the Oklahoma Agricultural and Mechanical College in 1934. In this study Mrs. Price analyzed the jobs taught in a trade dressmaking course, and

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11 Marland State Department of Education, "A Year's Supervision of Elementary Instruction in Carolina County, 1923-24," Elementary School Journal, Vol. 25, p. 484.

sent out two questionnaires to the different trade schools, in regard to the kind and types of mathematics that could be taught in relation to the course. The writer came to the conclusion that the course of study as proposed would be of practical value to the average trade dressmaking girl.[12]

Another thesis, "The Mathematics Involved in the Teaching of Industrial Arts," was written by Theodore Neill, at Iowa State College, in 1931. In this study, Neill sent out a questionnaire to schools in five different states, in regard to the kinds of mathematics courses that have proved beneficial to the instructors in industrial arts.

This study was based on replies from 202 instructors, who have almost enough college credit to qualify for a degree. The findings of this study were presented with the conviction that it conforms to standards of scientific inquiry to a degree which makes its findings fairly reliable and valid.

(1) The average amount of college preparation in mathematics was found to be eleven per cent of the instructor's entire college course. Of the 120 semester hours constituting a regular college course, thirteen hours of the instructor's preparation was in mathematics.

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[12] Esther Collier Price, "A Proposed Course of Practical Mathematics as Related to Trade Dressmaking Instruction."

(2) The following courses in mathematics were found to be valuable to the teacher of industrial arts: Arithmetic, Plane Geometry, Algebra, and Solid Geometry.[13]

Predicted Outcome and Use of Results

The course of woodwork as analyzed from the operations and projects taught in the shop will make a much broader course, than has been taught before. The material with which the student works will be more varied than the mechanical devices used in the modern home. The student will be able to explore and develop his industrial aptitudes more than was the case with the regular course as outlined in a single text. Thus the student who gains these experiences will become a more intelligent and cooperative citizen.

Along with the course, as outlined as to unit operations and projects, will be a proposed course of study to be taught in combination with the woodwork. This course was derived from the study of the operations performed in the shop and questions raised by the students. In order for the students to benefit the most from this study a little more time will be required for the regular class discussion. Proper teaching devices and testing methods must be advantageously employed, if each student in the class is given an opportunity to develop himself individually.

CHAPTER II

PHILOSOPHICAL BACKGROUND

Objectives of Secondary Education

In America general educational aims, which have found wide acceptance, are individual development and social efficiency. There are variations of opinion as to which should be emphasized the most, but most educators agree on the two general aims. For the last few years, we as high school teachers have been familiar with the Cardinal Principles of Secondary Education, formulated by a committee of the National Educational Association. Recently the eighth was added. Not all subjects lend themselves to all eight of these principles, but every subject can obviously further the realization of some of them.

The seven principles, to which number eight has been added, are:

1. Health
2. Command of the Fundamental Processes
3. Ethical Character
4. Citizenship
5. Vocation
6. Worthy Home Membership
7. Worthy Use of Leisure Time and
8. Worldmindedness[1]

Industrial Arts is only indirectly concerned with the first two, but with the development of consumers appreciation

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[1] United States Bureau of Education, Bulletin No. 35, p.11.

and "handy-man" abilities, it does contribute much to worthy home membership. To some who become acquainted with the world's work through the school, the fifth aim gives them an opportunity to select their vocation wisely. Civic education and ethical character are only indirect outcomes of woodwork in the schools. Shop training undoubtedly contributes much to the worthy use of leisure time by giving the student an insight and development of interest in hobbies of an industrial nature. Thus, it is seen that training in the shop contributes directly to three and indirectly to most of the other seven objectives of secondary education as set forth by this commission.

The shop departments of our schools are becoming more and more important as the place they fill in the lives of boys is recognized by the rank and file of teachers in general. There is nothing else in the school curriculum, that supplies so well to the 12 and 16 year old boy that manipulative experience, which his nature craves and really needs, and without which his normal growth is surely handicapped. The home no longer furnishes it, therefore the school must supply the need. This is perhaps the most important function of all the shop courses in industrial arts.

Objectives of Industrial Arts

Very little research work has been done in this field; it seems as though the beginning has been made and it is hoped that more will be done in the near future. Warner selected fifteen concepts of industrial arts objectives which seemed to represent fairly all points of view and submitted them to a jury of one hundred specialists:

> A. Exploration
> B. Educational Guidance
> C. Vocational Guidance
> D. Consumers' Knowledge and Appreciations
> E. Household Mechanics
> F. Social Habits and Attitudes
> G. Pre-vocational Purposes
> H. Advocational purposes
> I. A degree of Skill
> J. The Seven Cardinal Principles
> K. Mechanical Intelligence
> L. Correlation with other Subjects
> M. Developing the "Faculties"
> N. Coordinating the "hand and eye"
> O. Vocational Training
>
> The fifteen objectives were then printed and submitted to the jury in the form of individual strips of paper, each piece containing an objective. Each juror was asked to lay the fifteen strips in front of him, in the order of their importance and rank them; first, in the order of their importance for the senior high school. Sixty-one replies, of which fifty-eight were complete, were received from individuals in twenty states.......[2]

Woodwork is one of the oldest subjects taught in the shop, and is recognized as one of the main courses in industrial arts. In this study industrial arts will be referred to at times, but with the understanding that woodwork is a division of industrial arts.

> Industrial arts deals with materials, their use by society, and the manipulation with tools. Because woods find such a wide variety of uses, and because of the ease with which it is worked, it has been the first material introduced into our school shops.-----

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[2] William E. Warner, <u>Policies in Industrial Arts Education</u>, pp. 33-36.

> Small schools cannot afford to equip several shops, each for a single line of work, as is common in large systems. It is possible, however to arrange one large shop in such a way as to give a varied experience in many different materials, and thus serve as a background for the study and appreciation of major divisions of industry.------[3]

Historical Development of Industrial Arts

Early History: The beginning of the industrial arts movement dates back as far as 1858. The industrial arts movement as a school activity did not find its origin in this country. The development of shop work started in the Finland schools, and by 1866 the Finnish school authorities made some form of shop work compulsory for boys living in rural communities. This requirement was made because the work was practical, and taught the boy to make use of his leisure time. The early courses were quite different in content and practice from what is found in the curriculum today, as the work consisted of pottery, carving, woodwork, and some metal work.[4]

Later this handicraft movement spread through Sweden, and the work was modified in the Swedish schools. By 1872 the government of Sweden urged rural homes to devote some time to such handicrafts as carpentry, carving, stonework, and basketry. In 1872 the Sloyd system was established for the purpose of giving handicraft work in the school. By

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[3] State of Oklahoma Department of Education, Loc. cit., p. 10.

[4] Jesse Samuel Vaughn and Arthur B. Mays, Content and Methods of Industrial Arts, p. 24.

1874 it was probably making the greatest progress. By 1877 it was made an optional study. At almost the same time, when this movement was gaining much headway in Finland and Sweden, Victor Della Vox, director of the St. Petersburg Imperial Technical School for government Engineers, introduced shop instruction into his school and started what has since been known as the Russian system of manual training. This work consisted of tool processes in a logical sequence. After a pupil had this knowlege, it could later be applied to real construction work. Today we would consider this method highly disciplinary, rather than practical. Thus these three European countries, Finland, Sweden, and Russia, preceded the United States in recognizing manual training as a school activity.[5]

Early History in the United States: In the United States the manual training movement began as a school activity when the exhibits of Swedish Sloyd and Russian manual training were shown at the Centennial exposition in Philadelphia in 1876. J. D. Runkle and C. M. Woodward were pioneers in starting this work in the United States.

The first school manual training in the United States was established by Woodward at St. Louis, and was opened September, 1880. By 1882, Woodward had fully established

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[5] Jesse Samuel Vaughn and Arthur B. Mays, op. cit., pp. 21-40.

a three-year curriculum. Soon thereafter many other schools of this type were established in the United States. The work given in these early schools was much different from what is included in the industrial arts courses today. This work continued to develop as it was known at the close of the nineteenth century as manual arts.[6]

Development of Industrial Arts in the United States: Soon after the Civil War, industry began to make some marked changes, especially in relation to industrial education. Previous to this time, America was essentially a commercial and agricultural nation. The steady progress of industrial growth was somewhat promoted during the World War. The shortage of labor presented a serious problem. Child labor thus seemed a very easy method of solving the problem. Public schools were given an extra burden of being partially responsible for preparing the child for industrial work; consequently industrial education was considered a necessity for our further economic development, and also for a greater usefulness of the individual in the industrial world.[7] Bonser and Mossman well express the growing trend of industrial arts in the United States. They define industrial arts for educative purposes, as:

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[6] David S. Snedden and William E. Warner, Reconstruction of the Industrial Arts Courses, pp. 1-10.

[7] A. B. Mays, Problems of Industrial Education, pp. 3-13.

> ---a study of the changes made by man in forms of material to increase their values, and of problems of life related to these changes...[8]

Many of the old types of manual training teachers do not realize this fact, and are continuing to use old methods and practices in the present industrial arts program. A comparison of definitions might assist in understanding the differences of terminology. Payne defines manual training as:

> Manual training has for its object general education. The education of the mind in part through the hand. Its motive is educational and not vocational. If properly carried on, it gives the pupil a general acquaintance with mechanical and constructive activity and it may make a pupil generally handy, but it does not go further.[9]

Probably, in the future, vocational work will be developed more and more in the industrial arts program. Industrial arts work has been developed in this country as a school activity during the past fifty years. It is difficult to state what development will take place in industrial arts work in the future.

In 1917 the United States government passed the Smith-Hughes Act which provides for the appropriation and expenditure of Federal money,

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[8] Frederick G. Bonser and Lois C. Mossman, Loc. Cit., p. 18.

[9] A. F. Payne, Methods of Teaching Industrial Subjects, p. 57.

> ....for the purpose of co-operating with the states in paying the salaries of teachers of trade, home economics, and industrial subjects. ....[10]

This act constituted a great encouragement for work along industrial lines. The present tendency is to establish schools offering practical courses for training in some phase of life activity. Many states have established part-time schools and evening schools to offer opportunity of study along industrial lines.

The Current Program of Industrial Arts

Industrial arts as a school activity is just entering the most fruitful and promising stage. Shop work is beginning to break away from the rigidity and inflexibility which have long impeded its progress. Early industrial arts work in this country consisted of woodwork and mechanical drawing; however, the old-fashioned tool exercises given in this work for the sole purpose of manipulative skills, along with the limited amount of geometric drawings, are things of the past, and undoubtedly will never return. These old practices of manual training have been supplemented by a richer variety of work taken from industry and involve thought-provoking material. The present courses given in industrial arts consist of a series of problems instead of a set of exercises and models.

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[10] Smith-Hughes Act, United States Laws, Statutes, etc., Statutes at Large, Vol. 39, Chapter 114, p. 1.

What Mathematics is Needed in Woodwork

In trying to determine what mathematics should be taught in woodwork, the study was made from a standpoint of job analysis. The course was arranged as suggested by the Standards of Attainments Committee,[11] Projects arranged into units and taught in a shop course in the ninth and tenth grades. From the operations that were performed in the shop, questions and problems arose, and from these questions and problems a course of mathematics was proposed to be taught in combination with woodwork.

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[11] American Vocational Association, loc. cit., pp. 35-39.

CHAPTER III

SELECTING CONTENT

Introduction

The study has been made along the line of woodwork which is only one phase of industrial arts. Mathematics in electricity, sheet metal, welding and the other phases of industrial arts would require a definite study in each of the subjects itself. In selecting the content to be included in the study something definite had to be established from which to work.

Some of the books that have been analyzed were so narrow as to only include one particular phase of woodwork, such as the use of tools. So as to make the course as broad as possible and as practical as it could be, the list of "Things to Do and Things to Know in Woodwork" as set up by a Committee on Standards of Attainment in Industrial Arts was used as the basis in attaining "what should be taught in woodwork."

Analysis of a Course of Woodwork

In analyzing the course of woodwork in this study, two different analyses have been used: first, the course has been studied from the standpoint of the texts in woodwork, written in the last few years; and second, from the standpoint of the projects taught in the shop.

As has been stated before, the list of attainments to be taught in woodwork as set up by the Committee of the American Vocational Association, at the Pittsburgh Convention, December 7, 1934, was used as the basis in analyzing the texts in woodwork.

All the projects taught in the shop could not very well be analyzed to determine what mathematics was used. Only a few of the projects from each unit of study have been selected. The projects which have been studied, are the ones that have been made by students in the Foraker High School shop. The questions which have come up in class, from the standpoint of the student, are the ones that have been taken into consideration in this study.

Analysis of Subject Matter Taught in Woodwork: In analyzing the course by textbook analysis, six texts were used. The texts covered a period from 1918 to 1932. The books that were used for this study were:

1. Hunt, DeWitt, A manual for Hand Woodworking, 1925;
2. Hunt, DeWitt, A Manual for Hand Woodworking, Book 2, 1925;
3. Tustison, F.E. and Brown, Arthur G., Instructional Units in Hand Woodwork, 1930;
4. Douglass, James H. and Roberts, Richard H., Instruction and Information Units for Hand Woodworking, 1932;
5. Griffith, Ira Samuel, Essentials of Woodworking, 1922;
6. Rusch, Herman F., and Conway, Claud Carlton, Shopwork, 1918.

The books used in the study seemed to be the ones of greatest importance to the writer. These books were selected for study because they are the ones that have been used by the author and have been suggested by a number of woodwork teachers for the study.

Two lists have been used in checking the texts listed above. The Information Units as listed in Table I were made up of the "Things to Do," as listed by the Committee of American Vocational Association and the Information Topics were listed by the Committee as "Things to Know." The books have thus been analyzed from the standpoint of the committee, which is excepted as authority in the industrial field.

Report of Committee on Standard of Attainment in Industrial Arts: A committee appointed by Cooley of the American Vocational Association, industrial Arts section, in 1928, started to solve some of the problems directed against industrial arts in the schools. It has been alleged that: (1) there is lack of agreement as to the acceptable objectives of the work; (2) there is lack of agreement as to the content of a program for the realization of these objectives; and (3) there is lack of generally accepted standards of achievement as applied to the work of pupils.[1] For more than six years a committee has been at work on these problems.

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[1] American Vocational Association, *op. cit.*, p. 2.

At the American Vocational Association held at Pittsburgh, Pennsylvania, December 7, 1934, a final report of the Committee was presented and accepted. This was the sixth and final report submitted by the committee.

This committee was not given a definite assignment, but was instructed to proceed in its own way. After considerable correspondence it was decided to limit the work of the committee to a study of those things which the boy should know and be able to do, in the field of industrial arts, by the close of the junior high school period.

With the cooperation of a large number of supervisors and teachers, lists of "Operations" and Units of Related Knowledge" were prepared in six shop subjects: Woodwork, Household Mechanics, Electricity, Sheet Metal Work, Printing, and Auto-mechanics.

The lists of operations and units of related knowledge in woodwork have been used as the standard of rating the woodwork texts. This committee has endeavored to broaden the course of woodwork, and states:

> Woodworking courses in the schools have in the past been too narrow, and the experiences provided have not given contact with a sufficient number of materials. There is no more reason for excluding other materials from a course in woodworking than there is for excluding all reference to history from a course of literature. As a matter of fact, we have lost much in value and practical usefulness of both academic and industrial-arts subjects by our 'logical' and exclusive divisions of subject matter---------[2]

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[2] American Vocational Association, op. cit., p. 35.

Unit Operations: The Unit Operations as listed in Table I were taken from "The Things You Should be Able to Do," found in the "Standards of Attainment in Industrial Arts Teaching." (Final Report of the Committee, as presented at the Pittsburgh Convention, Hotel William Penn, Friday, December 7, 1934.)

There were 107 units listed in the Standards of Attainment. This list has been reduced to 80, by combining some of the topics, such as: plane a surface true, plane an edge square with an adjoining surface, plane end-grain, and proceed properly in squaring up a board; these were separated topics listed by the committee, and have been combined into one topic 'how to square stock to dimensions.'

The unit operations are listed on Table I and give the pages as found in the references. Six texts were used in this study and will be referred to later by the notation given below.

A-1. Hunt, DeWitt, A Manual for Hand Woodworking

A-2. Hunt, DeWitt, A Manual for Hand Woodworking, Book 2

B. Tustison, F. E. and Brown, Arthur G., Instructional Units in Hand Woodwork

C. Douglass, James H. and Roberts, Richard H., Instruction and Information Units for Hand Woodworking

D. Griffith, Ira Samule, Essentials of Woodworking

E. Rusch, Herman F. and Conway, Claud Carlton, Shopwork.

TABLE I

UNIT OPERATIONS

	A-1	A-2	B	C	D	E
1. How to make a working drawing-----------------	-	-	5	7	201	3
2. Plan the procedure in doing your job----------------	-	-	3	11	-	33
3. Check material when received --------------------	-	-	1	-	-	-
4. Lay out pattern on stock-	-	-	-	12	-	-
5. How to read and use the rule and square---------------	-	-	23	15	-	11
6. Divide spaces with dividers	-	-	-	13	18	12
7. Adjust a jack-plane or a smooth plane-------------	37	-	52	23	31	-
8. Lay out an octagon-------	21	-	99	-	206	-
9. How to square stock to dimensions---------------	1	-	50	27	38	18
10. Gage with a marking-gage and pencil	28	-	29	14	15	11
11. How to plane chamfers and bevels ------------------	15	-	80	29	49	21
12. Saw to a line with crow-cut or rip saw-----------	18	-	33	19	24	14
13. Use a back saw-----------	40	-	77	42	25	15
14. How to lay out, cut and finish curves------------	46	-	103	31	77	23
15. Cut curves with a turning saw---------------------	-	-	103	32	27	-
16. Lay out an ellipse-------	-	-	-	-	207	-
17. How to bore holes with wood bits--------------------	25	-	117	35	57	121
18. Lay out a hexagon--------	-	-	98	-	206	-
19. How to make a complete bill of material--------------	52	115	10	11	-	73
20. Clean and care for enamel brushes-----------------	-	108	-	-	-	-
21. Transfer a design--------	-	21	97	-	-	-
22. Sharpen edge tools, such as a knife, chisel, and plane-------------------	79	28	56	25	67	31
23. Use a guage for guage work---------------------	28	-	29	14	15	-
24. Clean and care for lacquer brushes-----------------	-	-	87	-	-	-
25. How to prepare wood surfaces for finish---------	91	-	84	69	83	128
26. How to apply varnish-----	93	84	-	84	185	169

TABLE I (Continued)

UNIT OPERATIONS

	A-1	A-2	B	C	D	E
27. How to apply lacquer, enamel and wax----------	-	90	-	85	199	171
28. Clean and care for varnish brushes-----------------	92	84	87	-	-	-
29. Shape ends, edges, and curves with woodrasp-----	138	-	114	32	-	131
30. Countersink holes--------	68	-	158	34	55	124
31. Use brad-awl for making holes for screws or nails	-	-	157	39	56	14
32. How to fasten stock with screws------------------	64	-	156	39	90	115
33. Lay out irregular design by means of squares--------------	-	-	-	-	-	-
34. Keep tools free from rust	-	-	-	-	-	-
35. Adjust a block plane-----	82	-	77	22	36	17
36. Give a fumed-oak finish--	-	104	-	-	-	-
37. Clean and care for stain brushes------------------	-	93	-	-	-	-
38. Dress a screwdriver------	-	-	158	40	90	25
39. How to drive and draw nails-	54	-	148	41	87	113
40. Lay out duplicate parts--	84	-	-	-	82	-
41. Apply paint with brush---	-	74	-	-	188	-
42. Clean and care for paint brushes-----------------	-	-	-	-	177	-
43. Fit hinges---------------	-	121	-	65	131	-
44. Apply inlay--------------	-	-	-	-	-	-
45. How stains are applied to wood--------------------	91	93	-	77	181	172
46. How to apply wood filler--	-	90	-	79	178	167
47. How to apply shellac-----	92	-	-	83	184	168
48. Trim or pare with a chisel	127	-	-	44	64	-
49. Round or form work with a spokeshave------------	48	-	112	-	78	-
50. How to mortise and Tenon joint is made------------	-	1	201	51	108	55
51. Apply stain for two-tone effect------------------	-	-	-	-	-	-
52. Clean and care for enamel brushes------------------	-	93	-	-	-	-
53. Lay out and cut tapers---	-	-	-	-	-	-
54. Do upholstering involving simple padding-----------	-	-	-	89	-	-
55. How to mix and apply the common glues------------	-	41	135	59	104	117
56. Cut an edge mold---------	-	-	-	-	-	89
57. Sharpen auger bits-------	-	-	-	-	54	-

TABLE I (Continued)
UNIT OPERATIONS

	A-1	A-2	B	C	D	E
58. How to cut braces--------	102	-	-	-	-	99
59. How the cross-lap joint is made------------------	88	-	176	49	129	55
60. Set and use an expansive bit---------------------	-	20	117	34	-	123
61. Sharpen a scraper--------	-	28	85	69	84	32
62. Fasten on a table top----	-	37	175	-	-	-
63. Use a Forstner bit-------	36	-	118	34	-	123
64. How the mortise and Tenon joint is made------------	-	133	162	53	107	55
65. Do simple upholstery involving webbing and rolled edges-------------------	-	-	-	-	-	-
66. Do simple upholstery involving use of springs-------	-	-	100	-	-	-
67. Use a doweling jig-------	-	42	-	-	56	-
68. Construct a panel--------	-	-	-	-	127	93
69. How to clamp stock for gluing------------------	-	110	127	57	92	27
70. Put on drawer pulls------	-	-	-	64	-	-
71. Lay out and cut miter joints	-	-	-	-	116	-
72. Clean and care for a spray gun---------------------	-	-	-	-	-	-
73. Lay out and cut a housed joint-------------------	-	48	-	-	-	57
74. Make a drawer-slide------	-	-	-	-	-	-
75. Make and fit a drawer----	-	45	-	-	126	-
76. How to make a doweled joint	-	133	162	53	107	55
77. How to cut rafters-------	105	-	-	-	-	101
78. How to file saws---------	130	-	-	91	28	109
79. How to attach a cabinet lock	-	125	215	-	133	-
80. Make a splined joint-----	-	-	-	-	195	58 [3]

It will be noticed that in order to teach these unit operations as set forth in Table I a number of texts must be used to obtain the desired results.

Information Topics: The Information Topics as listed in Table II, were taken from "The Things You Should Know"

[3] American Vocational Association, op, cit., p. 35.

TABLE II
INFORMATION TOPICS

	A-1	A-2	B	C	D	E
1. Be able to identify common kinds of lumber used in the community----------------	-	-	-	3	XII*	142
2. Know the principal characteristics, working qualities, the principal uses, and sources of supply of each-------------------	-	55	-	2	XII	142
3. Know methods of cutting and milling------------	-	-	-	-	148	135
4. Know how lumber is dried	-	67	-	-	142	139
5. Know the effect of moisture on wood----------------	-	67	-	-	142	139
6. Know the standard dimensions of lumber and how classified-------------	-	58	-	-	-	141
7. Know the nominal and the actual dimensions of lumber	-	52	-	-	-	141
8. Know how veneer and plywoods are made, and their uses------------------	-	-	-	-	-	91
9. The kinds of nails-----	54	-	148	38	-	113
10. The uses of the different kinds-----------------	62	-	149	38	-	114
11. The sizes of nails-----	56	-	149	38	-	114
12. How nails are sold-----	57	-	-	-	-	-
13. How nails are manufactured	-	-	-	-	88	-
14. Sizes of brads and how sold	58	-	149	-	-	114
15. Size, kinds, and uses of corrugated fasteners---	-	-	150	38	-	115
16. Sizes and uses of clamp nails-----------------	-	-	-	-	-	114
17. The object of finishes--	-	-	-	73	173	163
18. The kinds of finishes in common use------------	91	77**- 109		75 86	180 189	CXI
19. The durability of different finishes--------------	-	109***		86	-	CXI
20. The conditions or places in which various kinds of finishes may be used to advantage--------------	91	109	-	86	-	CXI
21. Materials from which finishes are made---------	-	109	-	86	199	CXI
22. The kinds of sandpaper-	43	-	-	71	86	128
23. Grades of sandpaper-----	43	-	91	71	-	129

TABLE II (Continued)
INFORMATION TOPICS

	A-1	A-2	B	C	D	E
24. Principal uses-----------	45	-	94	71	85	-
25. Grades and uses of steel wool---------------------	44	-	-	71	-	130
26. The kinds of glue--------	-	136	135	59	-	117
27. The preparation of glue--	-	137	137	59	93	117
28. The conditions and requirements in use-------------	-	137	-	59	-	-
29. The distinguishing characteristics of different types of period furniture	-	-	-	-	-	XII
30. Types of tools and their uses; saws, planes, knives, chisels, hammers, boring tools, files------------	40 37 33	-	29 67	17 34	23 31 53	II
31. Types of hinges and their uses--------------------	-	122	212	63	-	-
32. Types of latches and where used--------------------	-	-	-	64	-	-
33. Types of locks and where used--------------------	-	125	215	-	133	-
34. Types of nails and where used--------------------	XVI	-	148	38	-	113
35. Special types of fittings	-	-	-	-	-	-
In the design of furniture you should develop a fair judgment with respect to the following:						
36. Is it adapted to the use for which it is indicated?----	-	-	-	-	-	XII
37. Is it structurally good-----		-	-	-	-	XII
38. Is it well made-------------		-	-	-	-	XII
39. Are the structural members in good proportion-------	-	-	-	-	-	XII
40. Does it have an appearance of stability-------------	-	-	-	-	-	XII
41. Is the structural as a whole well proportioned--------	-	-	-	-	-	XII
42. Are the outlines pleasing	-	-	-	-	-	XII
43. Is it well finished with an appropriate finish-------	-	-	-	-	-	XII [4]

NOTE: *The Roman Numerals refer to chapters in place of pages.
**The topics will be discussed between these pages.
***If the topics are discussed on the same pages or in the same chapters it is indicated by this mark ("). The topics have been rearranged so they may be studied as the projects are taken up.

[4] American Vocational Association, *op. cit.*, p. 38.

as listed by the Committee in their final report to the A. V. A.* The information topics are related subjects or information relating to the units that are to be studied in the course. The topics are to be used and taught at any time a job is to be done, that requires any of this information. The same references were used in the study on information topics, with the same notation that was used in Table I.

Division as to Units: The course has been broken up into units, as to the order in which the projects are generally taught. Each unit takes up a few practices that in no way are related to the preceding unit. The division of the course of woodwork into units will be found in Table III. This method was carried out in the same order by authors of the texts that were examined in Tables I and II.

Before the student undertakes to perform the unit operations required for doing a job, it is necessary for him to have the related information needed to intelligently perform the operations. For this reason the unit operations have been separated from the information topics and arranged to precede them. This is in accordance with R. W. Selvidge's statement, which is quoted as follows:

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* NOTE: A. V. A. - American Vocational Association.

TABLE III

Unit I	One Piece Projects Game Board, Bread Board, Placques, Meat Board
Unit II	Small Piece Projects Door Stop, Tie Rack, Broom Support, Toothbrush Rack
Unit III	Butt Joints Handkerchief Box, Ladder, Nail Box, Flower Box
Unit IV	Dado and Rabbet Joint Wall Rack, Tabouret, Book Rack, Foot Stool, Baby Chair and Rocker
Unit V	Cross Lap Joint Hall Tree, End Table, Smoking Stand, Flower Stand, Quilting Frames
Unit VI	Mortise and Tenon Joint Foot Stool, Tables, Smoking Stand, Piano Bench, Chairs
Unit VII	Doweled Joint Cedar Chest, Desk, Larger Tables, Book Cases

'Unit Operations' and the 'Topics of Information' should be listed and treated separately. This is desirable because it only confuses a learner to impose upon him a theoretical discussion when he should be giving his undivided attention to the establishment of fixed habits of doing a thing economically and effectively. Skill is only a thoroughly established habit of doing a thing in the most economical way. To establish a habit, attention and repetition are necessary. Anything that distracts the attention from the manipulative process or interferes with its repetition, until the point is reached where fatigue affects muscular control, is delaying the development of skill. When a boy is doing something in which he is establishing good habits of work, he should not be interrupted in order to give him some uninteresting and often valueless fact. It may be a good way to teach the fact, but it is a poor way to form the habit.------There is a time for theory, but it is not when you are trying to establish a habit.

There is another reason for separating the unit operations from the topics of information.

> The principles, or information, belong with jobs and not with operations-------The topics of information are therefore listed separately to be used and taught at any time a job is to be done that requires any of this information.[5]

The Unit Operations and the Information Topics which relate to the units in Table III have been listed in Table IV. This devision was brought about to aid in the teaching of the objectives as set forth by the American Vocational Association Committee.

Table IV has been arranged so the teacher and the student may see the progress that has been made or the deficiency in a particular unit. The table also serves as a device in showing what is expected to be accomplished in the course as a whole. Table IV may be called a "Student-Teacher Guide."

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[5] J. H. Douglas and R. H. Roberts, Instruction and Information Units for Hand Woodwork, p. 3.

TABLE IV
UNIT OPERATIONS

																Names
																UNIT I
																1. How to make a working drawing
																2. Plan the procedure in doing your job
																3. Check material when received
																4. Lay out pattern on stock
																5. How to read and use the rule and square
																6. Divide spaces with dividers
																7. Adjust a jack-plane or a smooth plane
																8. Lay out a octagon
																9. How to square stock to dimensions
																10. Gage with a marking gage and pencil
																11. How to plane chamfers and bevels
																12. Saw to a line with cross-cut or rip saw
																13. Use a back saw
																14. How to lay out, cut and finish curves
																15. Cut curves with turning saw
																16. Lay out an ellipse

TABLE IV (Continued)
UNIT OPERATIONS

																17. How to bore holes with wood bits
																18. Lay out a hexagon
																19. How to make a complete bill of material
																20. Clean and care of enamel brushes
																21. Transfer a design
																22. Sharpen edge tools, such as a knife, chisel, and plane
																23. Use gage for gage work
																24. Clean and care for lacquer brushes
																25. How to prepare wood surfaces for finish
																26. How to apply varnish
																27. How to apply lacquer, enamel and wax
																28. Clean and care for varnish brushes
																UNIT II
																Unit Operations
																29. Shape ends, edges and curves with wood rasp
																30. Counter-sinc holes
																31. Use brad-awl for making holes for screws or nails
																32. How to fasten stock with screws
																33. Lay out irregular design by means of squares
																34. Keep tools free from rust

TABLE IV (Continued)
UNIT OPERATIONS

																35. Adjust a block plane
																36. Give a fumed-oak finish
																37. Clean and care for stain brushes
																Information Topics
																1. Be able to identify common kinds of lumber used in the community
																2. Know the principal characteristics, working qualities, the principal uses, and sources of supply of each
																3. Know methods of cutting and milling
																4. Know how lumber is dried
																5. Know the effect of moister on wood
																6. Know the standard dimensions of lumber and how classified
																7. Know the nominal and the actual dimensions of lumber
																8. Know how veneer and ply-woods are made, and their uses
																UNIT III Unit Operations
																38. Dress a screwdriver
																39. How to drive and draw nails
																40. Lay out duplicate parts

TABLE IV (Continued)
UNIT OPERATIONS

																41. Apply paint with brush
																42. Clean and care for paint brushes
																43. Fit hinges
																44. Apply inlay
																45. How stains are applied to wood
																46. How to apply wood filler
																47. How to apply shellac
																Information Topics
																9. The kinds of nails
																10. The uses of the different kinds
																11. The sizes of nails
																12. How nails are sold
																13. How nails are manufactured
																14. Sizes of brads and how sold
																15. Size, kinds, and uses of corrugated fasteners
																16. Sizes and uses of clamp-nails
																UNIT IV
																Unit Operations
																48. Trim or pare with a chisel
																49. Round or form work with a spokeshave
																50. How to make a dado and rabbet joint
																51. Apply stain for two-tone effect

TABLE IV (Continued)
UNIT OPERATIONS

																52. Clean and care for shellac brushes
																53. Lay out and cut tapers
																54. Do upholstering involving simple padding
																55. How to mix and apply the common glues
																56. Cut an edge mold
																57. Sharpen auger bits
																58. How to cut braces
																Information Topics
																17. The object of finishes
																18. The kinds of finishes in common use
																19. The durability of different finishes
																20. The conditions or places in which various kinds of finishes may be used to advantage
																21. Materials from which finishes are made
																22. The kinds of sandpaper
																23. Grades of sandpaper
																24. Principal uses
																25. Grades and uses of steel wool
																UNIT V
																Unit Operations
																59. How the cross-lap joint is made
																60. Set and use an expansive bit

TABLE IV (Continued)
UNIT OPERATIONS

																61. Sharpen a scraper
																62. Fasten on a table top
																63. Use a Forstner Bit
																Information Topics
																26. The kinds of blue
																27. The preparation of glue
																28. The conditions and requirements in use
																29. The distinguishing characteristics of different types of period furniture
																30. Types of tools and their uses; saws, planes, knives, chisels, hammers, boring tools, files
																UNIT VI
																Unit Operations
																64. How the mortise and tenon joint is made
																65. Do simple upholstery involving webbing and rolled edges
																66. Do simple upholstery involving use of springs
																67. Use a doweling jig
																68. Construct a panel
																69. How to clamp stock for glueing
																70. Put on drawer pulls

TABLE IV (Continued)

UNIT OPERATIONS

																71. Lay out and cut miter joints
																72. Clean and care for spray gun
																73. Lay out and cut a housed joint
																74. Make a drawer slide
																75. Make and fit a drawer
																Information Topics
																31. Types of hinges and their uses
																32. Types of latches and where used
																33. Types of locks and where used
																34. Types of nails and where used
																35. Special types of fittings
																UNIT VII Unit Operations
																76. How to make a doweled joint
																77. How to cut rafters
																78. How to file saws
																79. How to attach a cabinet lock
																80. Make a splined joint
																Information Topics In the design of furniture you should develop a fair judgment with respect to the following:

TABLE IV (Continued)
UNIT OPERATIONS

																36. Is it adapted to the use for which it is indicated
																37. Is it structurally good
																38. Is it well made
																39. Are the structural members in good proportion
																40. Does it have an appearance of stability
																41. Is the structural member in good proportion
																42. Are the outlines pleasing
																43. Is it well finished with an appropriate finish

Analysis of Projects Taught in Woodwork

The projects taught in woodwork are about standardized to a certain extent. The different books, in woodwork, list about the same projects in order to teach a certain joint or operation.

The projects listed in Table III are by no means all that may be taught under those different units. It will be found that the projects listed are the most common.

Analysis of projects taught in woodwork has been done from the time the student started his work until the project was completed. It will be impossible to show all work and how every problem arose.

In Table V stock bills of one or two projects in each unit are listed. These bills were copied from the job sheets in the shop as made out by the students.

TABLE V
STOCK BILLS OF PROJECTS

Projects in Unit I

Bread Board

Material Bill

Name	No. Pcs.	Cutting Size	Finish	No. Bd. Ft.
B. Board	1	1 x 12 x 14	6/8 x 10 x 12	1 1/6

Kind of Material	W. Pine	Cost bd. ft. .10 total	1 1/6
		Cost of material--------	.11
	Finish	Blue enamel-------------	.03
		total cost--------------	.14

Some of the boards were made in rectangular shape and some elliptical.

Meat Board

Material Bill

Name	No. Pcs.	Cutting Size	Finish Size	No.Bd.Ft.
M. Board	1	1 x 12 x 12	7/8 x 10 x 10	1

Kind of Material W. Pine Cost Bd. Ft. .10 total 1
cost of material .10

Finish W. Enamel on edge .03
Total cost---------- .13

These boards were made in different sizes and shapes.

Project in Unit II:

Broom Rack

Material Bill

Name	No. Pics.	Cutting Size	Finish Size	No.Bd.Ft.
Back	1	1 x 15 x 5½	7/8 x 14 x 5	.65
B. Support	1	1 x 13 x 3½	7/8 x 12 x 3	.32

Kind of Material W. Pine Cost Bd. Ft. .10 Total .97 bd. ft.
Cost of material .10
Hardware 3 screws .02
Finish D. Oak Varnish & Stain------------- .05
Total .17

Project in Unit III:

Flower Box

Material Bill

Name	No. Pics.	Cutting Size	Finish Size	no.Bd.Ft
Sides	2	1 x 10 x 38	1 x 9½ x 36	5 1/3
Ends	2	1 x 10 x 12	1 x 9½ x 12	1 2/3
Bottom	1	1 x 4 x 38	1 x 3 1/2 x 36	1

Kind of Material W. Pine Cost Bd. Ft. .10 Total 8 bd. ft.
10% for waste 1 Bd. ft.
Total & waste 9
Cost of Material .90
Finish Green Lacquer ¼ .05 a Ft. .45
Total Cost 1.35

Project in Unit IV:

Tabouret
Material Bill

Name	No. Pics.	Cutting Size	Finish Size	No.Bd.Ft.
Top	1	1 x 12 x 12	1 x 10 x 10	1
Legs	4	1 x 3 x 18	1 x 2½ x 16½	1 1/2
Braces	2	1 x 3 x 12	1 x 2½ x 10	1/2

Kind of Material Gum	Per Bd. Ft. .17	Total	3 Bd. Ft.
	Waste 10%		.3
	Total		3.3
	Cost .17		.23
	1/2 doz. screws R. H.		.12
Finish Varnish			.15
	Total Cost		.50

Project in Unit V:

End table
Material Bill

Name	No. Pcs.	Cutting Size	Finish Size	No.Bd.Ft.
Top	1	1 x 14 x 28	1 x 14 x 26	2.8
Legs	3	1 x 3 x 28	1 x 3 x 26	1.8
Braces	2	1 x 1¼ x 28	3/4 x 1 x 26	.5
Braces	2	1 x 1¼ x 12	3/4 x 1 x 10	.2

Kind of Material Gum	Cost Bd. Ft. .17	Total	5.3
	10% for waste		.5
	Total & waste		5.8
	Cost of Material	.99	
Hardware------15 screws--------		.12	
Finish Varnish		.25	
	Total Cost	$1.36	

Project in Unit VI:

Footstool
Material Bill

Name	No. Pics.	Cutting Size	Finish Size	No.Bd.Ft.
Legs	4	2 x 2 x 10	1½ x 1½ x 10	1 1/8
S. Rails	2	1 x 3 x 14	3/4 x 2 3/4 x 14	1/2
E. Rails	2	1 x 3 x 9	3/4 x 2 3/4 x 9	3/8
	Above Material Walnut Per Bd.Ft. .30			2 Bd.Ft.
		Waste 10%		.2
			Total Walnut	2.2

C. Braces	1	1 x 3 1/4 x 16	1 x 3 x 16	3/8
Slip Frame	2	1 x 3 x 14	3/4 x 2½ x 14	1/2
Slip Frame	2	1 x 3 x 9	3/4 x 2½ x 9	3/8

Material W. Pine Per Bd.Ft. .10 Total 1 1/4 Bd.Ft.

Cost	.13
Cost of walnut	.66
Hardware 1 1/2 doz. F. H. 13 screws	.12
Upholstering material	1.00
Finish Material	.30
Total Cost	2.21

Project in Unit VII:

Cedar Chest
Material Bill

Name	No. Pcs	Cutting Size	Finish Size	Bd.Ft.
Top	1	1 x 18 x 46	1 x 18 x 42	5.5
Bottom	1	1 x 18 x 46	1 x 18 x 42	5.5
Ends	2	1 x 22 x 22	1 x 20 x 20	6.8
Sides	2	1 x 19 x 42	1 x 17½ x 42	11.
Legs	4	2 x 4 x 4		2.6
Handles	2	2 x 4 x 2		1.3
Molding	1	1 x 3 x 6½		1.5
	Material	Cedar Per ft.	.17	34.2
		Waste 10%		3.4
				37.6

Cost of Cedar @ .17	6.39
3 hinges	.20
3 pieces of copper @ .40	1.20
1 lock	.70
1 stay	.10
1 brace	.09
Finish C. Varnish	1.50
	10.18

Mathematics Needed in Woodwork

Since it has been set forth what is to be accomplished in a course of woodwork, what is to be taught, and what projects are to be made, the problem of selecting the mathematics to be used becomes a much simpler problem than it was at first.

The method of selecting the mathematics required was done by job analysis. The projects that were completed in the shop, aroused questions that could be answered or worked out by the group, in place of each individual solving the questions that confronted him with the aid of his instructor. The questions that have come up in the shop have come from the individual. These questions or problems have been listed and taken up and solved in the class.

The problems that came up in the class have been grouped under five heads: stock bills, drawings, making and transferring of designs, laying out work as planned, and care of equipment.

The stock bills listed in Table V require a great number of mathematical problems that must be taken up in the shop and studied before the students are able to solve them with ease and accuracy. It is impossible to show how the problems in drawing, making and transferring of designs, and laying out work came up in class. However, this will be taken up in the proposed course of study that will follow in a later chapter.

Summary

A decided trend of the curriculum of our present day schools toward the practical arts, the present economic conditions, and the steadily increasing enrollment in the secondary schools, are factors that have made it necessary for the shop instructors to handle larger classes. Investigations will show that in many schools the size of shop classes has doubled in the last few years. Due to these conditions, shop instructors have found it necessary to supplement their oral instruction and information with written instruction and information. Teacher training institutions all over the country are recognizing this need and are training their students to make use of written materials.

This study has been made to bring together material that is needed in the shop and can be found and used without a great deal of work on the part of teachers or students. The materials listed in the tables are arranged so as to save as much time as possible in obtaining the material needed for class instruction. One is also able to tell or show what is covered or attempted to be covered in the course in woodwork. The student is able to see what is required of him, and what progress he has made as compared with the rest of the class.

Table I shows what should be taught in the course and where the operations may be found in the six references listed. Table I[1] shows the related topics that in some way are connected with the unit operations in Table I, and where they may be found for immediate use in the same references. Table III has broken the course up into seven units, as to projects made in the shop, and lists projects under each unit. Table IV shows what unit operations and information topics could best be taught in each of the units. This table is so arranged that the teacher may check the progress of each student and the student as well can see what progress he is making in class. Table V lists stock bills of projects under each unit as shown in Table III.

The tables listed have been of a great help to the writer and they will be of service to others that choose to use them. A proposed course of mathematics will follow in a later chapter, which was worked out in a class taught by the use of these tables.

CHAPTER IV

ARRANGEMENT OF COURSE OF STUDY

Introduction

Since the course in woodwork has been arranged as set forth by the Standard of Attainments Committee, and has been divided into units as listed in Table III, one can point definitely to what should be taught in a course of woodwork. The content of the course has been determined so that from the different jobs that are performed the related mathematics can be selected.

For boys of high school age, the practical work of the shop should be supplemented by work in fields connected with their courses such as, drawing and design, mathematics, and science. These related subjects will help to give meaning and content to courses in woodwork. The late Bonser states:

> Either all of this (additional courses) may be integrated into one course in which each part is given its proper place and attention at the time it best fits, or paralleled courses may be provided. The first plan is perhaps more sound pedagogically, but it is more difficult because of broader preparation and greater teaching ability required to do it well.[1]

In this study an attempt has been made to see what mathematics is needed in a class of woodwork and how it can best be taught. As it has been stated by Bonser there is

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[1] Frederick G. Bonser, Industrial Arts for Public School Administrators, p. 81.

a relation between the two subjects, and should be realized as such. A statement taken from Vaughn and Mays:

> So long as there are teachers of science, mathematics, drawing, etc., in the school, it would seem unfortunate if the shop teachers should have to take their time to teach the boys and the principles of physics, chemistry, arithmetic, geometry, etc., that relate to the activities of the shop. And yet this is exactly what has been happening all along the line.[2]

If by this study a closer connection is made between the mathematics departments of the schools and the shop departments, the author feels as though more will be accomplished by the student in both mathematics and woodwork.

Subject and Content in Courst of Study

The study and material collected has only been on the one course in the shop which is woodwork, as taught in the ninth and tenth grades. The course of study of Oklahoma only combines the two shop courses, woodwork and mechanical drawing.[3] It seems as though it would be impractical to extend the study to the different phases in industrial arts.

Introduction: The study has been made from two classes of woodwork students in the ninth and tenth grades. The projects that were studied were made in the shop and all possible questions were listed as came from the group as

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[2] Jesse Samuel Vaughn and Arthur B. Mays, *loc. cit.*, p. 149.

[3] State of Oklahoma Department of Education, *loc. cit.*

well as those that came from the individual. These questions or problems were divided into four groups, not as to their mathematical relation, but as they are related to shop activities.

Subjects Included in Study: The study has been on woodwork as taught in the shops in the ninth and tenth grades. The other phases of industrial arts have been excluded, for two reasons: (1) additional branches of industrial arts are not included in the Oklahoma State Course of Study; (2) study would be too extensive to cover all branches included under industrial arts. It seems as though we are facing a reorganization in our shops, but at the time of this writing nothing definite has been done. It was first thought that other branches of industrial arts would be included in the study, but as has been stated before the study would have been too extensive.

The work in the shop should be as practical as possible. Problems dealing with outside activities should be included. By bringing the two courses, woodwork and mathematics, closer together more practical good may be realized from both subjects.

> To be effective the non-vocational types of industrial work must be correlated with the vital activities of the school and the community. The teacher of the shop courses should make a place in his course plan for the meeting of some of the calls which always come from other departments of the school and from the community. [5]

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[5] Jesse Samuel Vaughn & Arthur B. Mays, loc. cit., p. 159.

Subject Matter Organized: The problems and questions that came up in a class of woodwork have made up the course of related mathematics that is to follow in the next chapter. These problems were grouped under five heads: stock bills, drawing, making and transferring of designs, laying out work as planned, and care of equipment.

Problems dealing with stock bills were selected from the stock bills of projects that were made in the shop. Table V lists projects from each unit. These problems were questions that students were unable to solve and came to the instructor for help, or perhaps a question that arose from class discussion.

Drawings were required of all projects made in the shop where this study was made. The problems which came up were from the standpoint of woodwork and not mechanical drawing. Although there is an overlaping, it will be almost impossible to get around all the questions that would come up in mechanical drawing. In the study of the jobs themselves questions arose that it will be impossible to illustrate as in the study of the stock bills.

In the making and transferring of designs, the study of scales must be included. The student is unable to picture an object as half size drawn to scale. Problems arise in the mind of every student and must be settled as an individual, if not as a group, by making pattern designs with the use of squares.

Laying out work on stock that has previously been planed, perhaps on a drawing or taken from some picture or model, will bring problems of a mathematical nature that must be worked out on that project at that particular time.

One may be unable to see how problems could come up in regard to the care of equipment. The shop teacher has these problems to deal with all through the year. It may be illustrated as follows: To burnish a scraper blade: the burnisher must be held at an agle of 40° for the first strokes, then raised to 30° for the next strokes, then for the last strokes 15° with the horizontal. The student is unable to understand the operation if he has not been instructed in the application of the terms necessary to describe the job.

It is impossible to show how all classes or types of problems arose. From the study of the different projects and unit operations which were taught in the shop, all questions and problems could not be listed in the study. The ones which are listed in the proposed study will help in answering the other problems that were omitted.

The problems are listed as they arose around the different projects that were taught under the same unit. The order follows the unit operations as listed in Table IV. In place of learning all about fractions at once, they were studied as they came up in class. All students worked on the same unit at the same time. Some were faster than others and the faster students made more projects than the slower ones.

Methods of Teaching Mathematics in Industrial Arts

There seems to be two possible ways in which mathematics may be taught in relation to woodwork. There are in a number of our larger high schools, where teachers are available, courses offered in vocational and shop mathematics. Sometimes this course is taught by a teacher in the mathematics department and in some cases by a shop teacher who is qualified to teach mathematics. This method seems to be fairly satisfactory for these schools.

The smaller schools are unable to organize courses of this type, so as to be able to give the students in the smaller school the same advantages, other arrangements must be made. According to Bonser there are two possible methods by which mathematics may be taught in relation to woodwork: (1) teaching the courses by combination and (2) teaching the courses in parallel.[6]

Teaching the Courses by Combination: Woodwork and mathematics may be taught by the same teacher during the same class period. This method may be difficult because of the broader preparation and greater teaching ability required to do it well. It would require more time than

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[6] Frederick G. Bonser, loc. cit., pp. 81-86.

the regular class of woodwork, but by this method the practical application of the problem would be motivated. An ideal situation for learning would be set up in the classroom.

> So long as the child comprehends more or less clearly the relationship between the work he is doing and the end sought, his work is motivated. The more definitely he appreciates this relationship, and the more keenly he desires to reach the given goal, the more impelling are his motives for work.[7]

Teaching the Courses in Parallel: If the courses were to be taught in parallel each course would be taught by a different teacher in perhaps a different room and under different conditions. The coordination of the two fields should be so worked out by the teachers that they will supplement each other as much as possible. Most separate courses in related work go far too much afield from the industrial needs and usage of the occupation in which the high school boy will work.

> By cooperation of teachers whose courses are related and course-of-study revision, the unification of the work as a whole may be made much more satisfactory than is now common, whether the parts be unified in one course or taught in parallel courses.[8]

By teaching the two courses in parallel, if there is not a strong cooperation between the teachers the courses will be as far apart as ever before.

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[7] H. B. Wilson and G. M. Wilson, loc. cit., p. 14.

[8] Frederick G. Bonser, loc. cit., p. 82.

Method Followed in This Study: It seems as though there is a lack of motivation in the courses as taught in parallel. For this reason the course of related mathematics has been set up to be taught in combination with woodwork. The student's questions will be solved at the time they are needed most by him.

The problems that have come out of the study have been ones that were derived by students in the shop. These questions were the ones the student wanted answered as quickly as possible, in order to continue on the desired project that is to be completed as soon as possible.

Summary

From the tables that have been set forth in Chapter III, which were taken from a class in woodwork, five different classes of mathematical problems were established. These classes of problems were set up from their relation to the shop activities and not from their mathematical nature.

A course in related mathematics may, according to Bonser, be taught in relation to woodwork two different ways: (1) by combination, and (2) in parallel. Teaching the courses by combination seemed to be the most practical and is the one that proposed to be followed in the course of related mathematics which is to follow in the next chapter.

CHAPTER V

A PROPOSED COURSE OF MATHEMATICS AS RELATED TO WOODWORK

Introduction

The course of mathematics which is to be correlated with woodwork is made out in lesson sheets and may be presented to the student at times when it is thought desirable by the instructor. The problems which have been selected follow the unit operations as listed in Table V.

It has been found valuable to have certain discussion periods. During the discussion periods the different questions that have come up in class, new material, and problems or exercises that have been previously assigned were discussed or presented. The lesson sheets will serve as an aid to the instructor as well as to the student in helping to answer questions on projects which are made in the different units.

Method of Procedure for New Mathematics Course

The course should be taught in combination with woodwork. At the same time the boy is working on a project in the shop he sees a need for the problems on his lesson sheet which has been previously handed to him by the instructor. There is a need for this problem to be solved, and the boy can realize its need.

Each boy will work each lesson individually, or with the help of the instructor in charge of the class. No one should be permitted to proceed to the advanced lesson until the previous lesson is corrected. The mistakes that are made should be recorded and taken up in class discussion.

Progress charts may be made showing the record of each individual's work. Charts may be made similar to the one shown in Table IV.

Material Covered in Outline Form, as Determined from Analysis: In determining what mathematics was to be taught in connection with woodwork, something definite had to be set up, that was taught in the course. It can be seen by the analysis performed on the textbooks in Tables I and II that very few operations or topics, as set up by the Standards Committee of the A. V. A., were listed in the six texts analyzed. The material as set forth by the committee was used as a basis for the study.

The different projects were divided into seven units and listed as found in the books analyzed. In Table III a series of projects were listed under each unit. The operations and information topics were listed under the respective project unit they would first have to be learned before further progress could be made. The operations and topics were divided and listed under the respective units in Table IV.

The course of woodwork was taught as listed in the first four tables in the Foraker School by the writer. Projects were selected from each unit and stock bills were listed forming Table V, which was used in helping to determine some of the problems necessary for the course.

Questions arose from the course as taught and these questions made up the major part of the problems as listed in the proposed course.

Use of Lesson Sheets: The course of study was written for the purpose of using the material as a students' handbook.

The writer realizes that part of the teacher's task in writing a handbook is to make the work as easy as possible; yet, providing ample practice work for the pupil. Therefore, if the pupil thoroughly understands the methods of solving the problems, he is capable of solving the practice problems. The pupil will then be capable of applying the mathematical principles to his woodwork problems.

Realizing that the learning process is more or less difficult, the writer decided to use this particular type of lesson sheet.

The "Object" introduces to the pupil the subject to be learned in each lesson.

The "Information" gives the pupil a broad insight of the various purposes of the "Object" of the lesson.

The "Rule" gives the pupil a definite working basis for applying the "Information" to the problem.

The writer believes that the three parts of the lesson sheets serve to make the pupil's work as easy as possible and eliminate the waste of his shop time by giving him the thorough explanation of the work.

The "Problems" test the pupil's ability in the application of the above principles to similar problems. Thus, if the pupil solves some or all of the problems, the young mind has learned to think in logical progressive steps. He has also mastered the "Object" of his lesson.

Having accomplished these facts, the boy will be familiar with his woodwork problems in the job analysis; he will solve his woodwork problems with less difficulty, less discouragement, and less waste of time.

Time to Spend: At first glance, the "Proposed Course of Study" may give the reader the impression that there will not be enough time in the course to teach the related mathematics. A study made by Ralph W. Rogers showed that eight and one-half minutes were now being consumed during class hour for lecture and demonstration in woodwork classes.[1] The lessons have been so arranged by the different steps to save time. Less time will be required to do the work in mathematics by all students working on the lesson sheets, in place of the instructor helping each student with his own individual problems. The lesson sheets have been so arranged for the student with information, rules and references, that most of the work may be done by the student himself. More than eight and one-half minutes

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[1] Ralph W. Rodgers, Visual Aids as a Means of Making the Subject of Woodwork in the Secondary School More Intellectual, p. 44.

of time can be used per hour for teaching information without conflicting with previous ideas of time spent in tool manipulation.

The time to discuss the mistakes made on the lesson sheets may be taken up at the general discussion periods. Sheets may be passed out to students whenever the instructor desires.

A PROPOSED COURSE OF MATHEMATICS

AS RELATED TO WOODWORK

By

CHARLES M. JOHNSON

LESSONS ARRANGED AS TO UNITS

Unit I

Lesson 1 To learn how to use the scale and angles.
Lesson 2 To learn how to measure with marking guage and square.
Lesson 3 Practical Geometry.
Lesson 4 Figuring Board Feet.
Lesson 5 Review over lessons 1, 2, 3, & 4.

Unit II

Lesson 6 Fractions.
Lesson 7 Figuring Stock Bills.
Lesson 8 Enlarging Irregular Designs with the Use of Squares.
Lesson 9 Practical Geometry in Unit II.
Lesson 10 Dividing Lengths into Equal Parts.

Unit III

Lesson 11 Reading and Writing of Decimals.
Lesson 12 Determining the Length and Kind of Nails to Use.
Lesson 13 Determining the Length and Kind of Screws to Use.
Lesson 14 Locating Dowels and Screws for Butt Joints.
Lesson 15 Use of the Right Triangle in Squaring up Stock.

Unit IV

Lesson 16 Cutting Braces.
Lesson 17 Wood Bits.
Lesson 18 Figuring Cost of Upholstering.
Lesson 19 Mathematics Used in the Dado Joint.
Lesson 20 Sand paper and Steel-Wool.

Unit V

Lesson 21 Mathematics Used in the Cross Lap Joint.
Lesson 22 Clamping and Glueing Stock.
Lesson 23 Scraper Tools.

Unit VI

Lesson 24 Mathematics Used in the Mortise and Tenon Joint.
Lesson 25 Figuring Square Feet in Panels.

Unit VII

A STUDY OF THE SCALE AND ANGLES

Lesson 1

Object: To learn how to use the scale and angles.

Information: Since it is impossible to draw most objects to their natural sizes, it is necessary to draw them to reduced scale. When a reduced scale has been used, however, the actual size dimensions are given. The architect's scale is used for measuring in mechanical drawing. The 3-32, 1/8, 3-16, ¼, 3/8, ½, 3/4, 1 in., and 1½ in. scales are usually formed on this scale. The architect generally uses a scale of ¼ in. equals one foot, while most cabinet drawings are reduced to a scale of 1/8, 3/16, or ¼ equals one inch.

The angles used in drawing are the 45° and the 30°-60°. With these angles it is possible to make a large number of different sized angles. Let it be kept in mind that angles are measured by degrees (one degree equals 1/360 of a complete circle or revolution).

Rules: Use scale to measure length and never as a guide to draw a line. On the ends of the Architect's Scale will be found nine different scales. In drawing lines on the angles draw from bottom up, and left to right. Degrees may be added, such as: 30° and 45° makes an angle of 75°.

Problem 1: With the scale measure off on writing paper and accurately indicate the following distances across the sheet:- 3/4", 5/8", ½", 3/8", ¼", 1/8", 3/32", 1/16".

How to do it:

1" divisions. . . .

Problem 2: Draw the following lengths to scale as indicated.

(a) Scale ¼" equals one inch: (¼" = 1")

3"; 6", 8", 10", 12½", 16".

(b) Scale 3-16" equals one inch;

2", 4", 8", 12", 16", 24".

(c) Scale 1/8" equals one inch;

1½", 4 3/4", 5¼", 6", 17", 26".

Problem 3: Draw the following angles with the 45° and the 30°-60° angles: 90°, 60°, 30°, 45°, 75°, 105°, 120°, and 15°.

Problem 4: Draw the following lines:

(a) Three parallel vertical lines 3" long and ¼" from each other.

(b) Four parallel horizontal lines 4" long and 1/8" apart on an angle of 45°.

(c) Three parallel lines 3" long and 1/16" apart on an angle of 60°.

(d) Four parallel lines 2" long and 3-32" apart on an angle of 30°.

MARKING GUAGE AND SQUARE

Lesson 2

Object: To learn how to measure with marking guage and square.

Information: The marking guage is usually made of wood and has a beam and head that may be adjusted to various lengths. The beam is usually 8" long and has a scale on it which is divided into sixteenths of an inch.

The framing square is a flat, right-angled piece of steel. The tongue is 16 in. long, and the blade is 24 in. in length. The carpenter finds this tool of great value in laying out rafters, foundations, and other frame work. The inch division of this square is divided into halves, quarters, eighths, tenths, twelfths, sixteenths and thirty-seconds.

Rule: In measuring with marking guage keep head square against edge of board, keep thumb screw tight.

In measuring with the square, measure on a line perpendicular to the surface. This is done by keeping the tongue or blade square against one side of the surface being measured. Measurements may begin from the inside or outside corner of the square on the tongue or the blade.

Problem 1: If the following measurements were measured off on each side of an edge of 90°, what would be the length of the chamfer or corner to be worked down or cut off?

$\frac{1}{4}$", 3/16", 1/8", 1", 2", $1\frac{1}{2}$".

Note: Get answer correct to two decimals.

Problem 2: Where should the marking guage be set to mark off the following chamfers?

.35", $\frac{1}{2}$", 3/4".

Problem 3: With the use of a square divide a sheet of paper into equal parts and give the length of each part. (This is used when it is necessary to divide an 8" board into three equal parts.)

Problem 4: With a square measure the width and thickness of the following boards.

2x4--1x12--1x6--4x4--2x6--2x8

How can you account for these measurements?

PRACTICAL GEOMETRY

Lesson 3

Object: To learn how to construct some of the geometric figures as used in woodwork.

Information: It is impossible to make some of the figures that are used in the shop unless some of the simple applications of geometry are used. In this work we will use the string method in constructing the ellipse, and the radius of the circumscribed circle for constructing the hexagon, (which is approximate.) Refer to Tustison & Brown, page 98 and page 100 for these methods.

The central angles of a regular hexagon contain 60°, the interior angles contain 120°. If lines are drawn from the center of a regular hexagon to the vertices six equilateral triangles are formed.

Rule: A hexagon is a six sided polygon. A regular hexagon may be made by inscribing it in a circle using the radius as the length of the sides.

An ellipse is an elongated circle, with a major and minor axis. The foci are two points on the major axis, such that the sum of the distances from any point on the ellipse to the foci are always constant.

Problem 1: Construct the following hexagons with sides 3", 4", 2", 1½", 1".

Problem 2: Construct the following ellipses:

(a) Distance between focii 4", constant distance 8".

(b) Distance between focii 6", constant distance 8".

FIGURING BOARD FEET

Lesson 4

Object: To learn how to figure board feet in one-inch stock.

Information: In giving the dimensions of lumber the thickness is given first, width next and then length, such as 1x12--10'. The unit measurement, the board foot, is one inch thick 12 in. by 12 in. Stock that is less than one inch thick is figured as one inch thick.

Rule: The following formula may be used to find the number of board feet in a piece of stock:

$$\frac{\text{No. of pieces} \times \text{thickness} \times \text{width} \times \text{length}}{12 \text{ or } 144}$$

If the length of stock is given in inches, use 144 as the denominator. If the length is given in feet, however, the denominator should be 12.

Problem 1. How many board feet in the following:

(a) 4--1x12--15"

(b) 2--1x8--24"

(c) 3--1x6--36"

Problem 2. The following stock is one inch thick and the surfaces contain the following square inches:

(a) 684

(b) 1728

(c) 1152

(d) 1224

How many board feet are in each board?

Problem 3: How many board feet in the following stock?

(a) 1--3/4x10--12'

(b) 2--1/2x8--16'

(c) 3--7/8x12--14'

(d) 6--5/8x6--10'

Problem 4: What would be the total cost of the following lumber at the cost of .10 cents per foot?

2-1x12-14"

3-1x4-3'

2-1x8-4'

REVIEW

Lesson 5

Problem 1: Draw the following lengths to scale as indicated, and determine the actual lengths:

(a) Scale ¼" equals one inch:

3"; 6"; 8"; 10"; 12½"; 16".

(b) Scale 3-16" equals one inch:

2", 4", 8", 12", 16", 24".

Problem 2: Draw the following angles with the 45° and the 30°-60° angles: 90°, 60°, 30°, 45°, 75°, 105°, 120°, and 15°.

Problem 3: Divide a sheet of paper into equal parts and give the length of each part

(State size of sheet)

3, 4, 5 parts.

Problem 4: Construct the following:

(a) Regular hexagon--side 4".

(b) Elipse: Distance between facii 4", construct distance 8".

Problem 5: How many board feet in the following?

(a) 4--1x12--15"

(b) 3--1x6--36"

(c) 3--7/8x12--14'

(d) 2--1x8--4'

FRACTIONS

Lesson 6

Object: To learn how to use fractions as related to screws, brace and bits, and how to locate centers for screws.

Information: Auger bits are usually obtained in sizes ranging, by sixteenths from $\frac{1}{4}$ to 1 inch. Number 9 on the tang indicates that it is a 9-16 inch bit. A 12 on the tang indicates that it is a 12-16 inch bit or the bit to use for a 3/4-inch hole.

The number of the screw indicates its diameter just below the head, according to a standard screw guage, (Brown and Sharp). Thus a No. 3 screw will be found to have a diameter of about 3-32 inch, while a No. 18 screw will be about 5-16 inch in diameter.

4 3/4 is a mixed number containing a whole number and a fraction. 16/11 is an improper fraction. 5/6 is a common fraction.

Rules: Mixed numbers may be changed to improper fractions by multiplying the whole number by the denominator of the fraction and adding on the numerator and writing the entire amount over the denominator.

To divide a number or improper fraction into a number of equal parts, divide the number by the number of parts desired.

Problem 1. Change to sixteenths:

a. 1/8 =	c. 1/2 =	e. 3/4 =	g. 7/8 =
b. 2/8 =	d. 1/4 =	f. 5/8 =	h. 8/32 =

Problem 2: Change to improper fractions:

a. 5 3/4 =	e. 8 3/4 =
b. 11 1/2 =	f. 12 6/8 =
c. 3 3/4 =	g. 15 1/2 =
d. 6 1/2 =	h. 12 3/4 =

Problem 3: Change to mixed numbers:

a. 21/4	e. 13/4	i. 11/2
b. 8/6	f. 15/2	
c. 12/8	g. 17/8	
d. 25/2	h. 36/8	

Problem 4: Divide the following numbers into equal parts:

a. 5 into 2 parts	e. 14 into 3 parts
b. 7 into 3 parts	f. 6 into 4 parts
c. 12 into 4 parts	g. 7/8 into 2 parts
d. 15 into 4 parts	h. 13/16 into 2 parts

These problems will be found necessary for locating centers for screws, for projects in Unit II.

Figuring Stock Bills

Lesson 7

Object: To learn how to figure a Bill of Material:

Information:

In figuring stock bills always figure the cutting size and not the finish size. Material less than one inch thick is figured as one inch. Figure material at 10 cents a foot.

Finish is figured as .05 cents a square foot, this includes the following finishes: varnish, shellac, lacquer and enamel.

Figure 10% of total amount of material for waste. Screws figured 10 cents a dozen.

Rules:

$$\frac{\text{No. of Pieces x Thickness x Width x Length}}{\text{12 or 144}}$$

In taking 10% of a number, mark off or move the decimal one place to the left.

Such as: 10% of 12.4 = 1.24

Problem 1: Give the total cost of the following bill:

Door Stop

1 - 1x6 - 6" =	10% for waste
1 - 1x8 - 6" =	3 - screws
1 - 1x4 - 6" =	Finish; Enamel
1 - 2x2 - 8" =	

Problem 2: Figure total cost of the following bill:

Tie Rack

1 - 1 x 4 - 12"	10% for waste
1 - 1 x 1 - 8"	4 screws
2 - 1 x 3 - 2"	Finish: varnish

Problem 3: Figure total cost of the following bill:

Broom Rack

1 - 1-15 x $5\frac{1}{2}$	10% for waste
1 - 1-13 x $3\frac{1}{2}$	3 screws
	Finish: enamel

Problem 4: Figure total cost of the following material:

Toothbrush Rack

1 - 1x4 - 8"	10% waste
1 - 1x3 - 7"	3 screws
	Finish: varnish

ENLARGING IRREGULAR DESIGNS WITH THE USE OF SQUARES

Lesson 8

Object: To learn to transfer irregular designs with the use of squares.

Information: In drawing symmetrical designs only half of the design should be drawn, it may then be traced on one side and then turned over.

If patterns are to be taken from a drawing, lay off the cardboard in squares the desired size. (This may be done with the drawing board and T-square).

Draw the curved design through the squares that correspond to the same squares on the drawing.

Rules: All squares are similar. Designs transferred from small squares to large squares will have the same shape.

Problem 1: If a 2" x 3" design was divided into 1/4" squares, what size squares must be used to make the design the following sizes? 4" x 6"; 6" x 9"; 8" x 12".

Problem 2: Divide a small design into 1/4" squares, reproduce this design on a sheet of paper using 1/2" squares.

Problem 3: An irregular design 8" x 10" was drawn by the use of 1/2" squares, what size would the design be if the following size squares were used?
1/4"; 3/4"; 1".

PRACTICAL GEOMETRY

Lesson 9

Object: To learn to apply the geometry used in Unit II.

Information: To draw a circle tangent to two perpendicular lines, construct a square with sides equal to the radius of the curve, with the inside corner as center and radius equal to the side of the square draw the desired curve.

If two circles are tangent to each other the line of centers is equal to the sum of the two radii.

Rules: Two circles are tangent if the line of centers pass through the point of tangency. A line is tangent to a circle or curve if the line intersects the circle or curve in one point.

Line of centers is the distance between the centers of two circles.

Problem 1: Construct arcs tangent to two perpendicular lines with radii as follows: 1", 1 1/2", 2", 2 1/4".

Problem 2: Construct arcs tangent to two parallel lines with radii as follows: 1", 1 1/2", 2", 2 1/4".

Problem 3: Construct the following curves with radii as follows, tangent to a 4" circle: 2", 2 1/2", 3".

Problem 4: Construct the following curves, with radii as follows, tangent to two circles with radii 4" & 2" and line of centers 4" long: 2", 2 1/2", 3".

DIVIDING LENGTHS INTO EQUAL PARTS

Lesson 10

Object: To learn how to divide a given length into an equal number of parts.

Information: This method may be used to locate centers for screws or any other uneven equal divisions that may occur. Use a sharp pencil in locating points.

Rules: If parallel lines cut off equal segments on one transversal it cuts off equal segments on every other transversal.

How to do it: To divide an 8" board into three equal parts. Use the square to draw a nine-inch oblique line on the board, mark off every third inch, use the square to draw lines parallel to ends through the three inch markings. The board is divided into three equal parts. (Use drawing board or square to locate points or divide lines.)

Problem 1: Divide a 5" line into 3 parts.

Problem 2: Locate 3 screw holes in a broom holder 10" long.

Problem 3: What must be the equal distances between 4 screws in a 10" board?

Problem 4: What would be the distances between 3 screws in a 12" board if the end screws are three inches from the ends of the board?

Problem 5: What would be the distances between 4 screws in a 14" board if the end screws are one inch from the ends of the board?

Problem 6: Divide the following lines into 3, 5 and 7 parts (use drawing board, T-square and angles).

a. 4" line

c. 8" line

b. 6" line

d. 13" line

READING AND WRITING DECIMALS

Lesson 11

Object: To learn how to read and write decimals correct to thousandths.

Information: The diameter of nails and wire brads are given in thousandths. The diameter of the head and shank of screws are given in thousandths. It becomes necessary for one to be able to read and write decimals easily and accurately to thousandths to be able to read and use the charts used for nails, brads, and screws.

Rules: The places to the right of the decimal are: tens, hundredths and thousandths.

In reading a whole number and a decimal insert 'and' where the decimal occurs, such as: 2.43 is read as, two and forty-three hundredths.

Problem 1: Associate the following decimals with the common fractions:

a. .25	e. .125
b. .10	f. .500
c. .200	g. .750
d. .800	h. .300

Problem 2: Read the following decimals:

a. .072	f. .148
b. .080	g. .162
c. .099	h. .192
e. .131	j. .121

Problem 3: Write the following decimals:

a. One hundred twenty-one thousandths

b. Five thousandths

c. Ninety-nine thousandths

d. One hundred thirteen thousandths

e. Eighty thousandths

f. Fifty-eight thousandths

g. Seventy-two thousandths

h. One hundred six thousandths

i. One hundred thirty-five thousandths

j. One hundred fifty thousandths.

Problem 4: Change to decimals of three places:

a. $1\frac{1}{2}$	f. 2/5
b. $1\frac{1}{4}$	g. 1/12
c. 1 3/4	h. 3/20
d. 3/10	i. 3/8
e. 1/8	j. 1 6/10

DETERMINING THE LENGTH AND KINDS OF NAILS TO USE

Lesson 12

Object: To learn how to tell the lengths and sizes of nails.

Information: The four kinds of nails are common, box, casing, and finish. These nails differ in diameter, with the exception of box and casing which have the same diameter. Nails are measured by the weight of 1000 nails. A 1000 eighty-penny (8-D) nails weigh eight pounds. Nails vary in length from 1" to 4". All number 2-D nails are the same length.

Rules: Nails increase ¼" in length from 2d to 10d. 2d nails are 1" long while 10d nails are 3" in length. 2d nails weigh 2# per 1000 nails.

Problem 1: Give length of the following nails:
2d, 3d, 4d, 5d, 6d, 7d, 8d, 9d, 10d.

Problem 2: Use table to find length and diameters of the following nails: (common, box, casing, finishing)
12d, 16d, 20d.

Problem 3: How much would a 1000 nails of the following kinds weigh? 4d, 6d, 8d, 12d, 16d.

Problem 4: Give the cost of the nails listed in Problem 3 at 4# for twenty-five cents.

Problem 5: Determine the number of 4d, 6d, 8d, and 12d nails that would be in the following weights: 4#, 6#, 8#, and 10#.

DETERMINING THE LENGTH AND KIND OF SCREWS TO USE

Lesson 13

Object: To learn how to tell the lengths and sizes of screws.

Information: The three kinds of screws are flathead, roundhead and ovalhead. Screws are made in lengths ranging from $\frac{1}{4}$ to 6 inches and in numbers from 0 to 24. The diameter of a screw is indicated by a number. Numbers 6, 8, 10, and 12 are the screws used extensively in the average joints. If the working drawing does not specify the size, one must make his own selection.

In fastening, the screw should be twice as long as the stock is thick. Should the screw drive into end grain, at least three times the length of the stock thickness should be used.

Rule: The diameter of a screw increases .013" with each number. No. 2 is .086", No. 3 is .900", No. 4 is .112".

Problem 1: Give the diameter of the following screws: 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20.

Problem 2: Use table and give pilot and anchor hole for each of the above screws. (Douglas and Roberts)

Problem 3: Give length of screws to use in fastening stock the following thickness: 3/4", 7/8", 1/2", 1", $1\frac{1}{2}$", $1\frac{1}{4}$".

Problem 4: Give length of screws to use in fastening stock to end grain. Use thickness of stock given above.

LOCATING DOWELS AND SCREWS FOR BUTT JOINTS

Lesson 14

Object: To learn how to locate centers for dowels and screws. Division by 1/2, 1/3, and 1/4.

Information: To locate center of end grain or edge of stock divide thickness by 2 or multiply by $\frac{1}{2}$. Dowels and screws should be located in the center. Perpendicular lines should be drawn to locate center for brace and bit to drill holes for dowels or screws. One of the lines shows the center of the stock while the other is drawn with the try-square showing the distance between each one.

Rules: In dividing mixed numbers, change to improper fractions and divide as with a common fraction.

To divide by 2, 3, and 4 multiply by the following fractions: 1/2, 1/3, and 1/4.

Problem 1: Divide by 2: 3/4, 5/8, 6/8, 7/8, 1/2, 1 1/4, 1 1/8.

Problem 2: Change to improper fractions: 2 3/4, 3 1/2, 4 1/4, 4 1/2, 5 2/3, 6 3/8.

Problem 3: Divide the above improper fractions by 2, 3, and 4.

Problem 4: How many screws would be required in the flower box listed on page 97, in Douglass-Roberts "Instruction and Information Units for Hand Woodworking," if three screws are used in each end and four on each side of the bottom of the box and the other screws are used as listed?

USE OF THE RIGHT TRIANGLE IN SQUARING UP PROJECTS

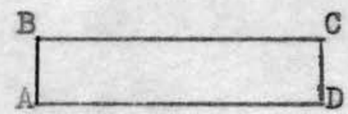
Lesson 15

Object: To learn proper use of right angle in squaring up projects.

Information: A right angle is equal to 90°.

A figure is a parallelogram if its opposite sides are equal. All rectangular figures are parallelograms. The opposite angles are equal and the adjacent angles are supplementary. (equal 180°.) In the rectangle ABCD: A and C are opposite angles.

A and D are adjacent angles.



Therefore, it can be shown that in a rectangular figure, if one angle is equal to 90°, all other angles are right angles.

Rules: If one angle of a square or rectangle is a right angle all other angles are right angles.

If two angles are equal to 180° the angles are supplementary.

Legs of a right triangle are the two shorter sides. The hypotenuse is the longest side or side opposite the right angle. The square on the hypotenuse is equal to the sum of the squares of the other two legs.

Problem 1: State if the following would form right angles:

a. 3, 4 and 5-----

b. 6, 8 and 10-----

c. 12, 16 and 20 -----

d. 8, 6 and 10-----

e. 8, 9 and 12-----

f. 18, 24 and 30-----

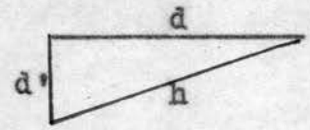
g. 4, 5 and 8-----

h. 9, 12 and 15-----

i. 17, 21 and 29-----

j. 5, 10 and 15-----

Problem 2: If the following distances (d and d') were measured off at a corner, on each side, how far must it be across to the end points to know the angle is a right angle?



	d	d'	h		d	d'	h
a.	3	4	-----	d.	9	12	-----
b.	6	8	-----	e.	18	24	-----
c.	9	12	------	f.	15	20	-----

Problem 3: Fill in with correct word:

a. All right angles contain ----------.

b. A rectangle is a -----------------.

c. The opposite sides of a rectangle are ----------.

d. The opposite angles of a rectangle are ---------.

e. The adjacent angles of a rectangle are ---------.
(two answers)

f. All sides of a ____________ are equal.

g. All angles of a square are----------.

h. If one angle of a rectangle is a right angle the other angles are ____________ angles.

i. A rectangle is a parallelogram with ____________ angles.

j. If the sides of a rectangle are 6 and 8 the diagonal would be ___________ inches long.

CUTTING BRACES

Lesson 16

Object: To learn mathematics connected with the cutting of common braces.

Information: The brace cutting that will be taken up in this discussion will be braces used in right angles only.

The angles of a triangle contain 180°. There are 90 degrees in the right angle, therefore, there would be 90° in the sum of the two acute angles.

The steel square may be used in cutting end cuts for braces. This method will not be discussed here but may be looked up in most woodwork texts.

Braces may be measured on inside or outside for cutting. The inside is the shorter length and outside longer length.

Rules: A right isosceles triangle is a right triangle with two equal angles and legs, each angle contains 45°.

An acute angle is an angle less than 90°.

To cut a 45° angle use miter box and have pointer set at "4". The square may be used to mark off the 45° cut.

Problem 1: Give the length of the following braces in a 90° corner, to be cut on a 45° angle, inside measurement:

a. 4" by 4" -----

b. 6" by 6" -----

c. 8" by 8" -----

d. 10" by 10" -----

e. 12" by 12" -----

f. 2' by 2' -----

Problem 2: State how to makr out a 45° cut with the use of the square.

Problem 3: State how to makr out the end cuts of a brace for a shelf, the brace extending out 8" on the shelf and 12" down on the wall (inside measurement). Give length.

Problem 4: Can the following angles be cut on the miter saw?

a. 45° -----

b. 60° -----

c. $72\frac{1}{2}^{\circ}$ -----

d. 75° -----

If so, how?

WOOD BITS

Lesson 17

Object: To learn the mathematics involved in the use of a brace and bit.

Information: On the tang of the bit is usually stamped a number which indicates the size. Auger bits are usually obtained in sizes ranging by sixteenths from ¼ to 1 inch. The number on the tang indicates the size of the bit in sixteenths as to diameter.

The twist drill bit ranges in size from 1/8 to ½ inch by thirty-seconds.

The expansive bit is used to bore holes from 1 to 4 inches in diameter and will be taken up later.

Rules: Auger bits are measured in sixteenths of an inch for diameter.

Twist drill bits are measured in thirty-seconds.

Problem 1: Give sizes of bits required to bore the following holes; (Sizes are diameters of holes).

a. ½" -----	f. 5/8" -----
b. ¼" -----	g. 7/8" -----
c. 3/8" ----	h. 11/16" -----
d. 5/16"----	i. 1" -----
e. 3/4" ----	j. 10/16" -----

Problem 2: Which is the larger bit?

	Twist Drill Bits		Auger Bits
a.	11/64"	or	1/4" -----

b. 5/32"	or	3/16"	-----
c. 9/32"	or	1/4"	-----
d. 11/32"	or	3/8"	-----
e. 15/32"	or	7/16"	-----

Problem 3: What would be the number of the twist drill bit to use that would be the same size as the auger bit? (Twist drill bit is measured in thirty-seconds)

Auger Bit	Twist Drill Bit	Auger Bit	Twist Drill Bit
a. 1/4"	---------	c. 3/8"	--------
b. 5/16"	---------	d. 7/16"	--------

Problem 4: Experience has shown that twist drills, ground with the cutting edge making an angle of 59° with the axis, work more satisfactory than the old type. The lip clearance should be from 12 to 15 degrees.

Draw the following angles, and tell how constructed. (Approximate)

a. 12° c. 59°

b. 15° d. 60°

FIGURING COST OF UPHOLSTERING

Lesson 18

Object: To learn how to figure upholstering costs.

Information: In determining the amount of upholstering to use always allow a few inches on the sides and ends for padding. In most cases the material should come down over the sides and ends, if not, it is generally tucked under the frame and tacked. Upholstering is bought by the yard and the widths are listed in inches, such as: 36", 42", 48", and 54". On these projects, the cost of the material will be figured by the square foot.

Rules: To change yards to inches multiply by 36. To change square inches to square feet divide by 144. To change yards to feet multiply by 3. To change inches to feet divide by 12.

Feet x feet = square feet

Yards x 36 x length in inches = square feet

Cost of Material:

Cotton Jacquard Velour---------1.44 yard

Rayon Frieze Effect----------- .94 yard

Colored Tapestry-------------- .89 yard

Cotton Friezette-------------- .67 yard

Flowered Denim---------------- .59 yard

Artificial Leather------------ .44 yard

Material 42" wide

Problem 1: Find the areas of the following pieces of materials: 3 yards long, 42 inches wide; $2\frac{1}{2}$ yards long, 48 inches wide; $1\frac{1}{2}$ yards long, 52 inches wide; 18 inches long and 42 inches wide.

Problem 2: What is the cost of the upholstering given above per square foot?

Problem 3: A boy wishes to upholster his footstool which is 10" x 14" with artificial leather, allowing 2" to come down on each side and end. Allow fifteen cents for the cost of webbing, gimp and tacks. What will be the cost?

Problem 4: Webbing cost four cents a yard, what would be the cost for the webbing to use on a footstool 18" x 12", running three strips long ways and four side ways?

Problem 5: What would be the cost to upholster the stool in Problem 4, allowing 3" on each side and end? Use Cotton Jacquard Velour and allow ten cents for gimp and tacks.

MATHEMATICS USED IN THE DADO JOINT

Lesson 19

Object: To learn mathematics connected with the construction of the dado joints.

Information: A dado joint is formed when the end of one member joins the surface of another some distance from the end. In the making of a dado one must be careful with measurements and use knife edge for marking.

In determining the width it is a good practice to use end of stock to be placed in dado.

Rules: Depth of dado should be one-half thickness of stock. A dado is cut across the grain. A groove is cut with the grain.

Problem 1: Give depth of dadoes in the following stocks:

a. 5/8" -----	c. 1" -----	e. 11/16" -----
b. 7/8" -----	d. $1\frac{1}{4}$" -----	f. 3/4" -----

Problem 2: Give distance to set marking guage to make inside line for the dado joint.

Width from end	Width of Dado	Distance for inside line from end
a. 1" -----	3/4" -----	____________
b. $1\frac{1}{4}$" -----	7/8" -----	____________
c. 1 3/8"-----	11/16"-----	____________
d. $1\frac{1}{2}$" -----	15/16"-----	____________
e. 1 3/16"----	7/8" -----	____________

Problem 3: Give length of braces on tabouret, if dado was cut one-half thickness of the legs, on page 93, Douglas-Roberts, "Instruction for Hand Woodworking."

Problem 4: Give length of shelves in wall shelf on page 93, Douglas-Roberts.

Problem 5: Give length of book case over-all, page 95, Douglas-Roberts.

SANDPAPER AND STEEL WOOL

Lesson 20

Object: To learn mathematics as related to the use of sandpaper and steel wool in the shop.

Information: Sandpaper is graded in various degrees of coarseness, ranging from No. 8-0 to No. 3 (very fine to coarse). The paper coarser than No. 3-0 is used for smoothing the surfaces of woods before applying finishes. The following are the most common No. 1, No. ½, No. 0 and No. 00. Sheets of sandpaper are generally 9 by 11 inches in size, and are packed in bundles of one quire (24 sheets).

Steel wool as to coarseness or fineness ranging by numbers from No. 000 to No. 3; the No. 000 being the finest. Steel wool is commonly packed in cylindrical-shaped cartons containing one pound each.

Rules: One quire contains 24.

One pound contains 16 ounces (avoirdupois weight).

Cost: 12 sheets of sandpaper .25 cents

1 quire of sandpaper .40 cents

1pound of steel wool .40 cents.

Problem 1: Is it cheaper to buy sandpaper by the quire or by the dozen? How much is saved on each dozen sheets?

Problem 2: If sandpaper is bought by the dozen sheets, what is the cost per sheet? cost for ¼ of a sheet?

Problem 3: 25/48 of a cent is a little more than what part of a cent?

Problem 4: Sandpaper bought by the quire cost how much per sheet? cost for ¼ of a sheet? (leave answer in two decilams.)

Problem 5: .41 of a cent is a little less than what part of a cent?

Problem 6: If the boy in the shop buys his own sandpaper he will be able to get it at the lumber yard for about two sheets for five cents. How much will be saved on six sheets if the shop sandpaper is used and is based on the cost per dozen sheets?

Problem 7: What is the cost of one ounce of steel wool?

Problem 8: A boy makes a tabouret and uses two sheets of sandpaper and one ounce of steel wool. What is the cost of material used?

Generally the shop does not charge for the use of these abrasives, but it is figured in the 10% of the lumber bill. Is the shop justified in charging an extra 10% over the amount of lumber used to take care of this material not charged for?

MATHEMATICS USED IN THE CROSS LAP JOINT

Lesson 21

Object: To learn mathematics as related to the cross lap joint.

Information: Square two pieces to dimensions being careful to get them the same length, width and thickness. Measure one-half the length of the stock from one end and square line across at this point. Measure and mark off one-half of the stock on each side of this line and square through these points. Set marking guage to one-half thickness to the stock.

In dividing the length, width, and thickness into two equal parts, care should be taken to see work is accurate. Make measurements exact. The two pieces of stock should form right angles when placed together.

Rules: To divide by 2, multiply the common or improper fraction by $\frac{1}{2}$. If mixed number change to improper fraction.

If two straight lines intersect forming one right angle, the other angles formed are right angles.

How to Do It: Divide 7 5/6 into two equal parts.
5 is not divisible by 2, so change 7 5/6 to 7 10/12, then to improper fraction 94/12. Multiply by 1/2.
$\frac{1}{2}$ x 94/12 = 47/12 or 3 11/12

Problem 1: Divide the following lengths into two equal parts:

a. 15"	d. 9 7/8"
b. 7"	e. 2'-3"
c. 6 3/4"	f. 3'-9½".

Problem 2: Divide the following widths into two equal parts:

a. 1 3/4"	d. 2 3/4"
b. 1 7/8"	e. 3 3/8"
c. 2 1/4"	f. 4 1/8"

Problem 3: Divide the following thicknesses into two equal parts:

a. 3/4"	d. 5/8"
b. 3/8"	e. 1 1/8"
c. 7/8"	f. 1 5/8"

Problem 4: In checking the cross lap joint is it necessary to check all four angles formed? If so, why?

CLAMPING AND GLUING STOCK

Lesson 22

Object: To learn mathematics that is connected with the clamping and gluing of stock.

Information: Better results in gluing can be obtained if more consideration is taken in regard to the weights of materials used.

The proportions used in the two different kinds of glues listed in the problems are not standard, for every glue has its proportion stated in the directions. If these directions are followed better results will be obtained.

Rules: Glue should be weighed to determine the exact quantity to be used with a certain weight of water.

In a proportion the product of the extremes is equal to the product of the means.

Problem 1: How much water by weight must be mixed with the following amounts of glue? (1 part of glue to 2½ parts of water by weight).

a. 5 oz.	d. 10 oz.
b. 6 oz.	e. 1 #
c. 8 oz.	

(If weight is equal to 16 ozs. or more, state answer in pounds.)

Problem 2: If 5 oz. of glue mixed with 2½ parts of water makes one pint of liquid glue, how many pints will be made with the above amounts?

Problem 3: What would be the costs of the above amounts of glue figured at .48 cents a pound?

Problem 4: In mixing some Casein Glues a proportion of 9 parts of water to 5 of glue is used. How much water must be used with the following amounts of glue?

a. 3 oz.

b. 4 oz.

c. 2 oz.

d. 5 oz.

e. 7 oz.

Problem 5: Surfaces glue better at a temperature of 75 to 90 degrees F. How much do these temperatures differ from the room temperature?

Problem 6: More pressure can be applied to the stock to be glued if the clamps are applied at right angles to the stock. Explain.

SCRAPER TOOLS

Lesson 23

Object: To learn mathematics as related to the scraping tools.

Information: The following tools, hand scraper, cabinet scraper, scraper plane, wood files, and rasps, are classed as scraping tools. These scrapers are used to dress cross-grained or knotty stock which is difficult to dress smoothly with a plane.

The mathematics that will be taken up in this discussion will deal with the different angles that will be used in sharpening the different blades used. One is able to get better results from his blades if the instructions are followed as directed by the teacher.

Rules: An acute angle is less than a right angle. If two lines are perpendicular they form right angles.

Problem 1: Draw a series of parallel vertical lines. Parallel horizontal lines.

Problem 2: Draw a horizontal line. On the horizontal line draw the following angles below it:

a. 40°

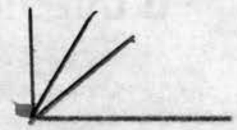
b. 30°

c. 15°

Problem 3: Draw four 45° angles.

Problem 4: Draw angles by approximate method.

Construct a free-hand right angle, divide it into three equal parts by guess. How many degrees should be in each angle? Check with protractor and see how far off you are. Continue until work is fairly accurate.



By this method draw the following angles: (Start with a right angle.)

a. 30° d. 75°

b. 15° e. 40°

c. 45°

Check work as to accuracy.

Problem 5: In burnishing the edge of a scraper blade, why start out with the first strokes about 40°, then 30° and last 15°? Explain.

Problem 6: What blades should be sharpened at an angle of 45°? Which ones, 90°?

THE MORTISE AND TENON JOINT

Lesson 24

Object: To learn the mathematics involved in the construction of the mortise and tenon joint.

Information: In marking a tenon be very careful on the measurements as to length, width and thickness. In laying out the mortise be very accurate with the length, width and thickness. After the lines are all layed out check to see if correct. Notice that all lines must be parallel or perpendicular.

To bore out the waste stock in the mortise hold brace and bit at right angles to stock. In removing waste stock with chisel hold perpendicularly when working near ends or sides.

A table as to the common proportions of parts of tenons may be found in "A Manual for Hand Woodworking," by Hunt, Book 2, page 13.

Rules: All mortise and tenon joints should fit snug. All lines should be parallel and perpendicular.

To add or subtract fractions get fractions to same common denominator, then add or subtract numerators as the case indicates. Denominators remain the same. If objects are perpendicular they must form right angles.

Problem 1: Specify the thickness and length that the tenon should be on rails the following thicknesses:

½ inch, 3/4 in., 1 in., 1½ in., and 2 inches.

Problem 2: What must be the depth of the mortises for the above tenons?

Problem 3: (a). If a 5/16 inch tenon is to be centered on a rail 5/8 inch thick, where should the marking guage be set to mark out the tenon?

(b). If a 3/8 inch tenon on a 7/8 inch rail is to be centered, how should the guage be set to mark out the tenon?

(c). If a 3/4 inch tenon on a 2 inch rail is to be centered, where should the marking guage be set to mark out the tenon?

Problem 4: What should be the length of the tenons on two rails entering a 2" x 2" leg if the tenons are mitered and centered on the leg? (thickness 3/4")

Problem 5: What should be the length of the tenons on two rails entering a 1½" x 1½" leg if the tenons are mitered and centered on the leg? (thickness 5/8")

Problem 6: How can you guage your brace and bit to tell if it is held perpendicular to the surface? (give two methods)

Problem 7: In locating mortises on the four legs of a table, how can this be done more accurate and faster, than by marking out one leg at a time? Explain.

FIGURING PANELS FOR DOORS AND DESKS

Lesson 25

Object: How to determine the amount and size of panels for doors and desks.

Information: Three-ply veneer, surfaced on two sides, (S 2S) white pine, is generally used for panel construction. If other kinds of veneers are desired, walnut, maple, cedar and others may be obtained, finished on one or both sides as desired.

Before panels are to be cut from the stock, have size checked for accuracy. Veneers cost as much, if not more, than the best of woods. Try to save as much waste as possible. Keep stock square at all times.

To measure the size of an opening for a panel always allow for the groove or slot which in most cases is ¼" or 3/8" deep.

Rules: In figuring square feet multiply length by width. To multiply mixed numbers change to improper fractions, then multiply. In multiplying fractions, multiply numerators together and the denominators together. Reduce to mixed numbers.

Price of Stock for Panels:

White pine 3-ply veneer 3/8" and 1/4"

S2S---------------------.10 cents a foot

S1S---------------------.06 cents a foot

Walnut 3-ply veneer 3/8"

S2S------------------.35 cents a foot

S1S------------------.20 cents a foot

Problem 1: Figure the size of the following panels. Give answer in square feet:

a. 14" x 18½"

b. 12 3/4" x 18 3/4"

c. 6" x 9½"

d. 1½' x 2'

e. 13 3/4" x 18 3/4"

Carry out to two decimal places.

Problem 2: Figure cost of panels listed above using W. P. S2S.

Problem 3: Figure cost of above panels using Walnut S2S.

Problem 4: What must be the sizes of the panels for the following openings: (grove along sides of opening ¼")

a. 12" x 14"

b. 18" x 24½"

c. 20¼" x 26 3/8"

d. 8¼" x 9"

e. 1½' x 2'.

Problem 5: Figure cost of panels listed above using W. P. S1S.

Problem 6: Give cost of above panels listed above using walnut veneer S1S.

THE DOWELED JOINTS

Lesson 26

Object: To learn mathematics involved in the making of doweled joints.

Information: Dowels may be used on butt, edge and end joints. The dowels used in joints are usually made of birch wood and may be obtained in diameters ranging from 1/8" (usually by eighths) to 1 inch. However, the 3/8 or 1/2 inch is the one most commonly used for dowel joints. Doweled edge and end joints are used in the construction of cedar chests in the shop.

Rules: Dowels should be cut slightly shorter than the total depth of the two holes bored for them.

Problem 1: Determine ½ thickness of the following boards: 7/8", 3/4", 1", 1½", and 1 3/8".

Problem 2: If 2½" dowels are used in an edge joint, how deep must the holes be bored for this joint?

Problem 3: In boring holes for dowels how should the brace and bit be held to the edge of the stock? What tool may be used to help do this more successfully?

Problem 4: In making an edge joint of two pieces of stock, with the use of dowels, how may the holes for the dowels be located?

Problem 5: Find two ways dowels are purchased and the cost for one hundred dowels 2" long.

Problem 6: A plane is determined by a straight line connecting any two points on its surface, and lying on its surface. How is this geometric principal used in surfacing lumber? Illustrate.

LOCATING AND ATTACHING LOCKS

Lesson 27

Object: To learn what mathematics is involved in locating and attaching locks on projects in the woodwork shop.

Information: There are three kinds of locks that may be used: wardrobe, mortise, and chest. The wardrobe is made of two kinds.

The project is finished, before the locks are to be installed. Much care must be taken in locating the lock. This work must be done carefully and as accurately as possible.

Rules: Locks on drawers and chests are usually placed in the center. Door locks are placed in most convenient positions for operation.

Problem 1: Locate the center of the following chests and drawers:

a. 42"	e. 49½"
b. 15"	f. 52 3/4"
c. 37"	g. 14 5/8"
d. 19½"	h. 18 7/8"

Problem 2: Take three cylinder locks, (chest or wardrobe) determine how far must be measured on the center lines in Problem 1 to locate the hole for the cylinders.

How did you determine this distance?

How are circles located?

Problem 3: In boring for cylinder lock why should the hole be bored perpendicularly?

Problem 4: Define the following terms: escutcheon, lock strike, bolt, selvedge cylinder, box, and barel key, as referred to locks.

SAW FILING

Lesson 28

Object: To learn the mathematics required in the filing of saws.

Information: If the directions are not followed very closely in filing a saw, the boy in the shop will be unable to do very much to his saw, except have it in a worse shape when the job is completed than before it was started.

The rip saw should be filed with the left face vertical or leaning 5° to 10° to left of vertical, and level or 5° below the horizontal. The file should be almost perpendicular to the face of the saw.

To file a cross cut saw hold file 45° to 55° to line of teeth, slope file 20° to 30° to horizontal, and left face so the teeth will be filed 75° to 78° to line of teeth.

Rules: Watch angles of the file at all times. Make all teeth the same size if possible.

Problem 1: Draw a series of parallel vertical lines the same length.

Problem 2: Draw a series of parallel horizontal lines.

Problem 3: Draw six lines perpendicular to a horizontal line.

Problem 4: (a) Draw a right angle.

(b) Divide it into three equal parts.

(c) Divide one of these parts into two equal parts. (guess)

(d) Divide one of the parts into three equal parts.

(e) How many degrees in each of the angles a, b, c, d, if accurate.

Problem 5: With protractor draw the following angles: 5°, 15°, 20°, 75°, 45°, 55°, and 10°.

Problem 6: Construct a saw filing guide with angles as indicated. Use Hunt's "Manual of Woodwork," Book 1, page 134.

FIGURING THE LENGTH AND CUTS OF COMMON RAFTERS

Lesson 29

Object: To learn how to determine the length of common rafters. How to make the seat and plumb cuts.

Information: In place of using square root in determining the length of rafters the framing square will be used.

The pitch is the ratio of the height of the roof above the plate to the width of the building.

The run is the length of projection of a rafter on a horizontal plate.

The rise of a roof is the total height of rafter above plate line.

The seat cut is the bottom horizontal cut on the rafter.

The plumb cut is the top vertical cut on the rafter.

Rules: The pitch of a roof is determined by dividing the width of the building into the rise of the roof.

The seat cut is made on the blade of the square, while the plumb cut is made on the tongue.

How to determine length of rafters: Use square, measure up on tongue height of rise, out on the blade the length of the run. From the point on the tongue to the point on the blade, which determined the rise and run, measure with a rule that is divided into twelfths.

Example: Determine length of rafter with $\frac{1}{4}$ pitch, whose width is 24'. The run equals $\frac{1}{2}$ of 24 which is 12. The rise is $\frac{1}{4}$ of 24 which is 6. Measure up six inches on the tongue of the square and eight inches on blade. With ruler measure across and determine the distance between these points which will be found to be 13 5/12", change to feet, because the building is in feet, therefore, 13'-5".

To determine cuts refer to page 106 in Hunt's "Manual for Woodworking," Book 2.

Problem 1: Give lengths of the following braces:

Rise	Run	Length
7'-10"	6'-0"	--------
7'-6"	6'-0"	--------
6'-0"	6'-0"	--------
5'-5"	4'-0"	--------
4'-10"	4'-6"	--------
4'-0"	4'-0"	--------
3'-8"	1'-8"	--------
2'-0"	1'-6"	--------

Problem 2: What numbers on the tongue and blade of the square would be placed against one side of the 2 x 4 in laying out the top and bottom cuts of the above braces?

Problem 3: Complete the following blanks:

	Width of building	Run	Rise	Pitch
a.	24'	-----	6'	-----
b.	24'	-----	4'	-----
c.	-----	8'	4'	-----
d.	-----	16'	8'	-----
e.	-----	12'	8'	-----
f.	-----	16'	-----	3/4
g.	-----	-----	6'	1/2
h.	30'	-----	5'	-----

Problem 4: Give length of above rafters

Problem 5: How may the cuts be layed out?

Explain how you would do each one.

SUMMARY AND CONCLUSIONS

The title of this thesis indicates that an attempt has been made to show that mathematics in the shop will increase the intellectual content of the subject of woodwork. The most scientific way to prove this contention would be to take comparable groups and subject them to the two types of teaching, one with the related mathematics and the other without, giving them tests at definite intervals. If this method is to show a definite result it must be taken in many sections of the country and with several groups in the same school.

The investigations recorded in this thesis cannot be defended as being the last word. The facts disclosed will serve as an initial study. It remains for someone else to begin here and work in a scientific way the problems discussed. Earlier studies that have been made in this field and related fields, and the quotations listed herein, show a place for mathematics to be taught, by combination or by parallel methods, in woodwork. The study of the course of woodwork taught by the unit operations, as listed in Table I, verified the need of the mathematics in the course itself. In analyzing the different jobs performed in the woodwork shop, mathematical terms and implications were found in every phase of analysis. These different types of mathematical operations were classed under five heads listed in Chapter IV on page 46, not as to their relation to mathematics but as related to the shop.

It was the experience of the writer that more could be accomplished in listing the mathematical operations as related to the operations in woodwork. The lesson sheets, in the proposed course of study, have been prepared as related to the operations as taught in woodwork. The lesson sheets in related mathematics are so arranged as to be worked on at the same time as the unit operations in the course are taught. The lessons, as the first of the proposed course, are listed on page 63 in the order in which they should be taught as related to the units listed in Table IV.

Throughout the course the boys realized the constant relationship between the problems in the mathematics course and the problems in the woodwork analysis. Although the job analysis was only a minor portion of the thesis, it was of major importance. It was the foundation upon which the experimental course was built. Table IV in Chapter III was also an outgrowth of the job analysis.

The proposed course of mathematics is to be taught in combination with a course in woodwork. If the suggestions contained in this thesis are to be given consideration more than eight and one-half minutes of time can be used per hour for teaching information without conflicting with previous ideas of time spent in tool manipulation.

Further study, better distribution of materials and better trained teachers are needed if the program is to accomplish the purpose set forth. With these conditions existing, the writer concludes from the remarks and suggestions taken from the study that the pupil will benefit from the "Proposed Course of Practical Mathematics as Related to Woodwork."

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