APPLIED
PHYSICS EXPERIMENTS FOR
RELATED WOODWORKING TRADES

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By

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FOREWORD

The State Department of Education and Oklahoma Agricultural and Mechanical College authorities are interested in promoting the efficiency of Vocational Education in the secondary schools of the state. One method of improving this program is through the compilation of currently valuable instructional material.

The writer of this thesis has accepted an assignment and has paved the way in preparing typical experiments and has set the stage for further studies in the development of applied experiments in physics valuable to workers and prospective workers in related woodworking trades.

It is hoped that others will take advantage of this opportunity to be of greater service to the program and will carry on further studies related to other vocations.

H. A. Huntington
Head of the Department
of Trade and Industrial
Education

ACKNOWLEDGMENT

The writer wishes to acknowledge help given him from the responses and information received in the survey, and from the various books and bulletins studied in securing information.

An expression of appreciation is made to Mr. W. Fred Heisler, Head of the School of Technical Training, for carefully reading this manuscript and offering valuable scientific suggestions.

Special acknowledgment is due Professor H. A. Huntington, Head of the Department of Trade and Industrial Education, for his inspiring efforts and able assistance in the selection and development of this study.

The writer is grateful to his wife, Golda Prewett, for her inspiration and for her efficient, sympathetic assistance in the making of this study.

C. H. P.

PREFACE

With practical courses of instruction being demanded not only by vocational educators but also by academicians, as shown by recent lists of book publishing companies, it is apparent that the time has come for an intensive study of the various subjects to determine their relation to actual life applications.

The further expansion of vocational education through the recent George-Deen Act has brought coordinators and teachers of related subjects to the various colleges demanding that more related material be prepared to help them to care for the needs of the students in each type of vocational training taught in the public schools.

In the field of science there are at present few available textbooks and manuals which make the application of the principles taught to actual life situations, or which relate abstract principles directly in the manner they will be used. It is the plan of the writer to make a compilation of some few of the principles through experiments and applications which may be used to achieve the above purpose.

Such a study is a long task and one which is really inexhaustive. This study is intended for the related woodworking trades, and the physics experiments compiled are based upon the elementary principles of science as recommended by the State Vocational Department. Work is rapidly being carried on in the preparation of such experiments in science, manuals of experiments, and texts as here mentioned. The writer hopes this small contribution may aid in the development of this study in science related to the woodwork and related trades.

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CHAPTER I

PURPOSE AND EXTENT OF THE STUDY

The students in Trade and Industrial Education on the campus during the summer of 1937 were very much interested in having more related science material developed. For several years a deficiency in the knowledge of the common principles of science by students who have gone through the regular abstract courses in the science now given, has been noted. These students, even those who have had all the science offered in the high school, have trouble applying the principles on the job. Science to them has been an impractical, uninteresting, toy tinkering proposition, and the value or interest of these principles to the student has ended when he leaves the laboratory. The magnitude of this situation, as it faces industrialized America today, is serious. Many employers are forced to send their prospective employees to company schools, and they are holding evening classes in applied science, to teach men science related to their trade or work. In many occupations, it is necessary for middle aged men and women to take these courses, if advancement is expected in their chosen line.

The problem is left for vocational education as general education is not fitting the needs of its students in this respect. Prosser and Allen state:

> Nor do they recognize, apparently, the misuse of public funds on instruction he will not use and does not expect

to use.[1]

The organization of trade classes previously mentioned provides the necessary transition for the acquisition of the principles of science, and men and women who have had these practical courses are advancing because of the better understanding of their trade.

The definite need of this study is shown by analyzing the reason why the majority of high school graduates have failed to acquire the basic principles of science. Science, as taught in the regular high schools where the masses are educated, usually is stale and uninteresting. Few practical experiments and applications of the principles of science, as used in earning a living, are studied. Science as it is taught is a matter of memorizing long abstract rules and performing theoretical experiments which many students seldom understand, and in which few can make themselves become interested. If the teacher can realize the actualities of life that exist for the great masses; and can assist the student to learn in a practical way the basic principles of science with which he is directly concerned, he will have helped the student to acquire fundamental knowledge.

It is the purpose of this study to help in the preparation of material by ascertaining the need for supplemental experiments in science; first, by obtaining experiments from the files of the teachers of related science in the state;

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1. Charles A. Prosser and Charles R. Allen, Vocational Education in a Democracy, p. 198.

and second, by securing and compiling additional available information.

Survey blanks[2] were mailed to seventeen teachers of related science in Oklahoma with the specific purpose of finding their needs, and also to obtain material about related science and reference book lists that they used in teaching. Seven returned the blanks while five filled in the survey blanks and returned experiments and references.

Survey blanks[3] in single page form, were mailed to twenty three teachers of related science in Oklahoma accompanied by a letter of instructions asking each to express his need and include in a return addressed envelope a practical experiment that he had found valuable in teaching related science. Two returned blanks and sent seven experiments in physics.

Then a need was felt for information concerning what other states had done along this line. Twenty one inquiries[4] were mailed to the training agencies in a selected group of trade centers over the United States asking for experiments, manuals, other materials concerning related science, or references to persons who could supply such materials. Return letters were received from each giving twenty nine references of persons who might be able to send

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2. See appendix, Form I, pp. 99-101.

3. Ibid., Form II, pp. 102-103.

4. Ibid., Form III, p. 104.

specified materials. Very little material pertaining to related science was received from these sources.

The twenty nine references were sent letters[5] similar to those mentioned above. Approximately three fourths replied but sent practically no related instructional material. The failure to receive applied experiments raises the question whether they are being used, and shows a further need for this type of study. The replies showed that this kind of material was wanted definitely, and that in most instances it is being prepared.

Due to the lack of practical material received in the four surveys, the writer made a careful survey of available literature, and the experiments that follow are based upon this related material, as it seemed this would provide more adaptable, instructional applications of science. They have been prepared to supplement Mr. Fred Heisler's study of "Elementary Science for the Student of Industry", which is commonly used as an introduction to applied science in Trade and Industrial Training Programs in Oklahoma.

The principles of science of the above named text can be taught as a unit, or by any other practical method. According to the accepted method of teaching science, the student must demonstrate these principles to his satisfaction by experimentation. To the student interested in woodworking, these experiments will show the relation of the prin-

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5. Ibid., Form IV, p. 105.

ciples of science definitely to the woodworking trades, while to the trade printing student, the principles should be related directly to printing, and so forth.

The experiments prepared in this study are to be used by students interested in related woodworking trades. They have been prepared and compiled according to the sequence followed in the previously stated reference. They may be used in loose leaf order if desired. The writer realizes that these supplemental experiments in physics prepared and compiled for the related woodworking trades are incomplete; however, it is believed that this study is a step in the direction that will help lead to better training for tradesmen.

CHAPTER II

APPLIED EXPERIMENTS

Experiment 1

PROPERTIES OF MATTER

Name ____________________

Date ____________________

OBJECT: To study the property of strength in different woods.

MATERIALS: Testing apparatus made of Harwood steel bar clamp as shown. Wood of three different cross sections: (1/8 X 1/8 X 24"), (1/4 X 1/4 X 24"), (5/16 X 5/16 X 24"). Use pine, oak, fir, or balsa wood.

DIRECTIONS:

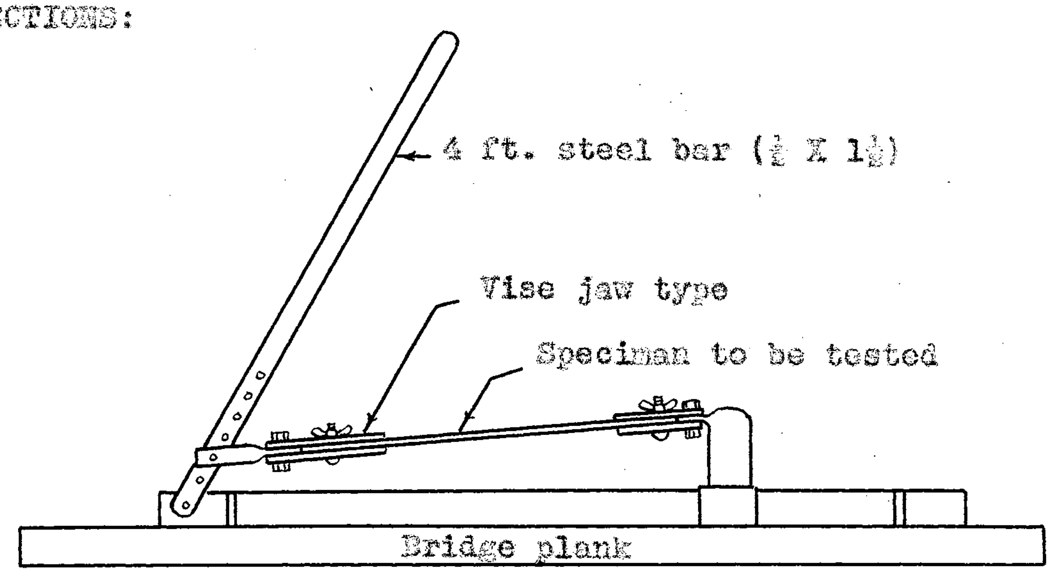


Fig. 1

In industry, by far the greatest use of materials is based upon tensile strength. The brake rods on an automobile are constantly being subjected to pulls or tensile stresses. Chain hoists in shops must withstand certain tensile stresses. In the building trades, the carpenter needs to know that wood varies in its ability to withstand the different stresses. Determining tensile stress also gives some idea of the ability of wood to withstand bending (flexure) and compression stresses.

In the experiment several woods will be tested in order that you may observe the comparative amounts of tension that they are able to withstand before breaking. The pieces of wood are fixed securely at both ends of the apparatus and are subjected to a tensile stress by pulling the lever. See Fig. 1. Test the three pieces of pine first, then oak, etc. In describing the tensile strength, use such terms as "the least", "the most", "less", "more", etc., to denote changes in the amount of pull.

RESULTS:

Material	Cross-section	Force needed to break	Ability to resist tension

Table continued:

Material	Cross-section	Force needed to break	Ability to resist tension

REFERENCES:

Dooley: Science Training for Metal and Wood Trades, pp. 227-242.

Deming and Nerden: Science in the World of Work, Vol. I, pp. 145-168.

CONCLUSION:

1. Would a variation in the amounts of pull required, mean a difference in the tensile strength of the material?
2. What effect does the size of a cross-section of the same kind of wood have on the pull needed to break it? Of different kinds of wood?
3. What effect on tensile strength is produced by varying the length of the material?
4. What holds the molecules of wood together?
5. The U. S. Department of Commerce has set up certain minimum live loads for use in buildings. What is meant by this?
6. In what position does wood show its greatest unit of strength?
7. The studs that support the roof of a building are under what stress?

Experiment 1 A

PROPERTIES OF MATTER

Name ____________________

Date ____________________

OBJECT: To study the property of strength in different woods.

MATERIALS: Testing apparatus (three ton auto hydraulic jack fitted with 50# guage and home made accessories); wood of three different cross sections: (1/8 X 1/8 X 24"), (3/16 X 3/16 X 24"), (1/4 X 1/4 X 24"). Use pine, oak, fir, or balsa wood.

DIRECTIONS:

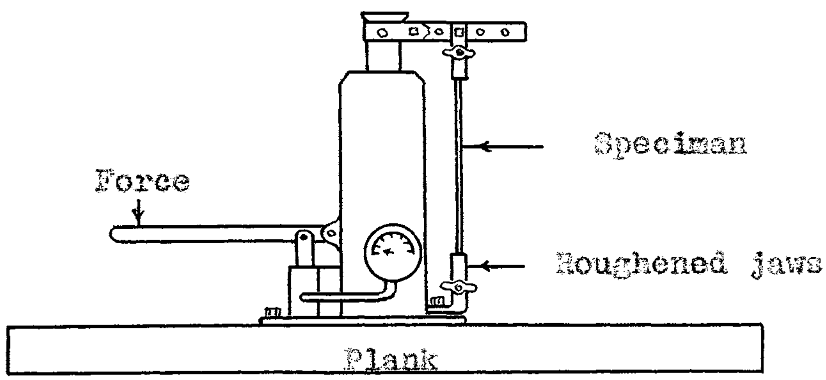


Fig. 1

In industry, by far the greatest number of materials are based upon tensile strength. The brake rods on an automobile are constantly being subjected to pulls or tensile stresses. Chain hoists in shops must withstand certain tensile stresses. In the building trades, the carpenter needs to know that wood varies in its ability to withstand the different stresses.

Determining tensile stress also gives a good idea of the ability of wood to withstand bending (flexure) and compression strains.

In the experiment several woods will be tested in order that you may observe the comparative amounts of tension that they are able to withstand before breaking. The pieces of wood are fixed securely at both ends of the apparatus and are subjected to tensile stress by pumping the lever. See Fig. 1. Test the three pieces of pine first, then oak, etc. Record reading of pressure guage. Obtain diameters of the pistons of the hydraulic jack from instructor and calculate force exerted on wood by using formula:

$$\frac{A}{a} = \frac{F \times A}{f \times a},$$

where A equals area of large piston; a equals area of small piston; F equals force on large piston times A; and f equals force on small piston or guage reading times a.

Calculate the tensile strength of each in pounds per square inch.

RESULTS:

Material	Cross section	Force needed to work	Tensile strength # per sq. in.

Table continued:

Material	Cross section	Force needed to work	Tensile strength # per sq. in.

REFERENCES:

Dooley: Science Training for Metal and Wood Trades, pp. 227-242.

Deming and Nerden: Science in the World of Work, Vol. I, pp. 145-168.

CONCLUSION:

1. Would a variation in the amounts of pull required mean a difference in the tensile strength of the material? Why?
2. What effect does the size of a cross section of the same kind of wood have on the pull needed to break it? Of different kinds of wood?
3. What effect is produced in varying the length on tensile strength? On compression? On bending?
4. What holds the molecules of wood together?
5. The U. S. Department of Commerce has set up certain minimum live loads for use in building con-

struction. What does the department mean by that?

6. In what position does wood show its greatest unit of strength?

7. The studs that support the roof of a building are under what stress?

Experiment 2

PROPERTIES OF MATERIALS

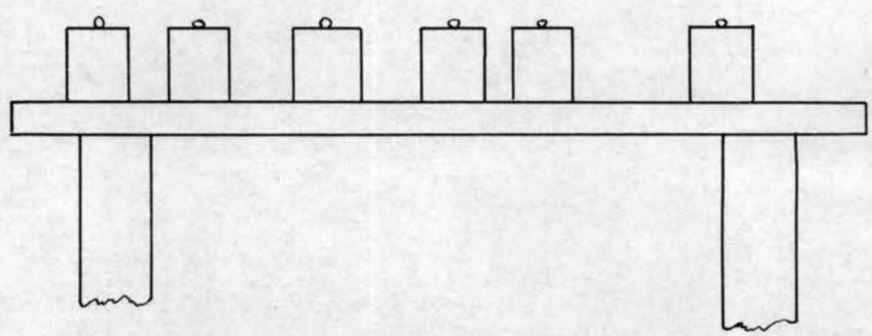
Name ____________________

Date ____________________

OBJECT: To study the weight per unit volume of different kinds of wood.

MATERIALS: Four, one inch cubes of white pine, basswood, ebony, oak, walnut, cottonwood; spring balance; eyes.

DIRECTIONS:



The value of a material depends upon the presence of very definite qualities. These qualities vary in different materials and in the same materials such as wood. Some substances are lighter than others, and this makes them valuable for different uses. Light wood, as balsa wood, used for toy airplanes, kites, and insulating refrigerators, is not usually as strong as a heavier wood. Oak, a heavy, strong wood, is used in the manufacture of furniture and refrigerators. Wood for this purpose must be capable of taking a high polish and of withstanding long usage.

Compare the weight of the different woods listed by actually weighing with a spring balance. Screw the eyes in the ends of the different kinds of wood. Weigh each with the spring balance and record results below:

RESULTS:

Kind of wood	Weight	Porousness	Common uses	Tensile strength

REFERENCES:

U. S. Department of Agriculture, Wood Handbook.

Heisler: Elementary Science for Students of Industry, pp. 3-5, 10.

Deming and Nerden: Science in the World of Work, Vol. II, pp. 1-9.

CONCLUSION:

1. Show the comparative weights of the different kinds of wood studied by listing in order from the lightest to the heaviest.
2. Of what relative value are the weights of wood in furniture, carpentry, airplane, and pattern making? Of what relative value is porousness? Of what relative value is tensile strength?

3. What relation is there between porousness and weight of wood? What relation is there between porousness and tensile strength?
4. What are the density limits for hard woods? For soft woods?
5. Calculate the density of one cubic foot of pine by using the data of the experiment. Remember that there are 1728 cubic inches in one cubic foot.

Experiment 3

MEASUREMENT

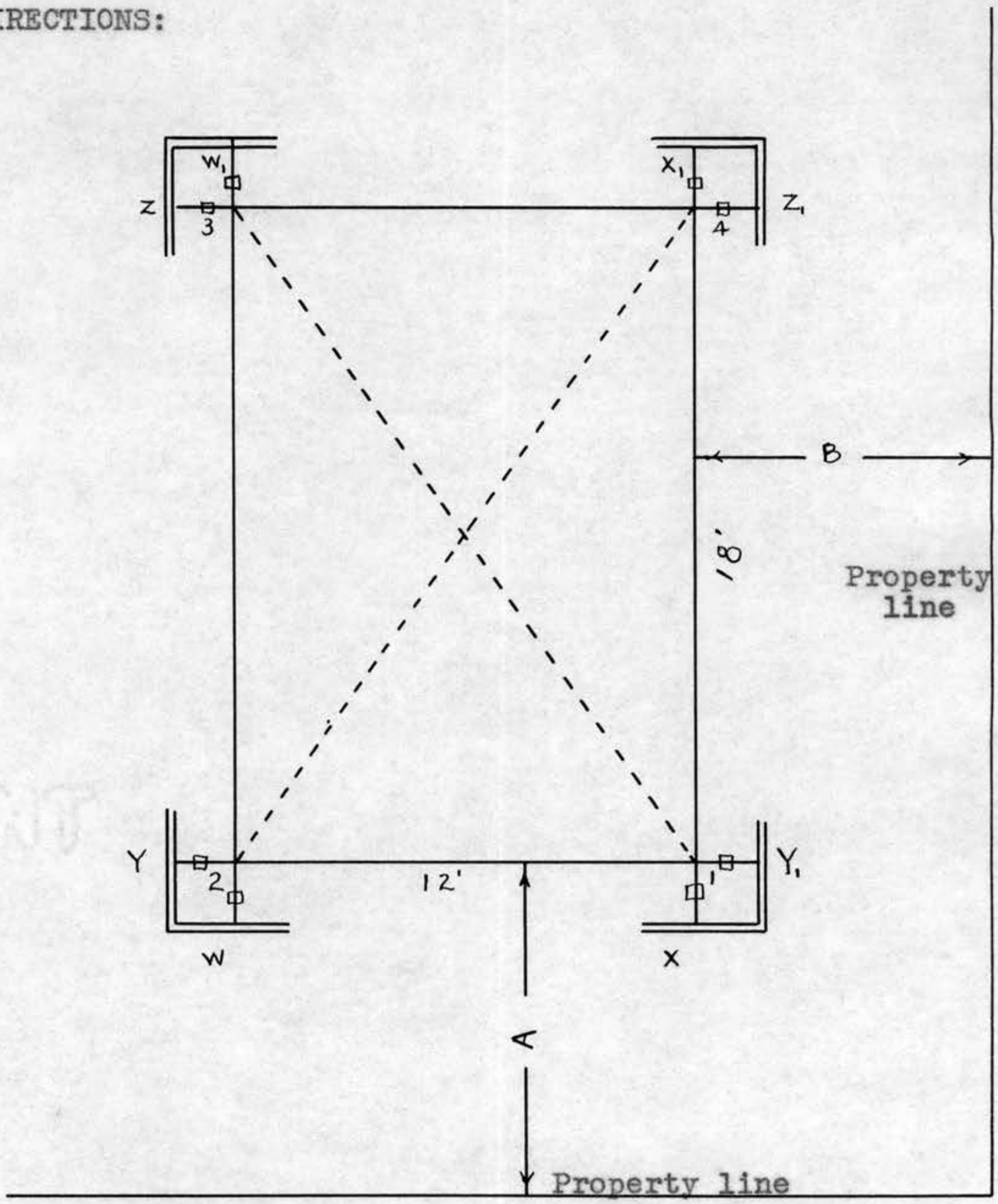
Name ____________________

Date ____________________

OBJECT: To lay out lines for a building by means of the 3-4-5 rule.

MATERIALS: Stakes, two tapes.

DIRECTIONS:



In order that a building may be located in the proper place, it is necessary to make measurements with the street or some established location in the community. Since buildings are constructed to definite sizes, the foundation must first be constructed to the required measurements. Regardless of the trade or industry, measurement must be made.

In this experiment foundation lines are to be measured for a small building. The distance the building will be from the front and side properties must first be known. Measure distances A and B from property lines. The small squares in Fig. 1 indicate where stakes are driven. Lay out line x-x_1 B distance from the side property line. Measure back distance A from the front property line, and lay out line y-y_1, using twice the 3-4-5 or the 6-8-10 rule to square the corner. This consists in measuring from the intersection at 1 along one line a distance of 6 feet and sticking a pin in the tape at that point. In a similar manner, measure off 8 feet along the other line, and then measure the hypotenuse of the triangle so formed. It should measure 10 feet. Then hold the end of one tape on point 2 and the end of another tape on point 4, allowing them to intersect at point 3. The length of the building is the reading on the first tape, and the width of the building is the reading on the other. This will complete the rectangle. Check work by measuring the diagonals 2-4 and 1-3. These should be identical.

In laying out lines for construction which will extend over a considerable period of time, it is best to build batter boards, as shown. In most cases, however, stakes will serve quite satisfactorily.

RESULTS: Make a freehand sketch of your foundation plan and place on it the dimensions used.

REFERENCES:

Griffith: Carpentry, pp. 1-17.

Heisler: Elementary Science for the Student of Industry, pp. 11-12.

CONCLUSION:

1. What are the common units of measurement used by the carpenter?
2. To what part of an inch in measuring would a carpenter consider accurate? Would that be accurate to a machinest?
3. What is a batter board?
4. Where buildings are large and important, the foundation is usually marked off with what instruments? Who does the work?
5. How did the procedure you followed, show that the lay out lines were a perfect rectangle?

Experiment 4

SPECIFIC GRAVITY

Name ________________

Date ________________

OBJECT: To determine the specific gravity of wood.

MATERIALS: White pine, oak, maple, and walnut pieces exactly 3" X 3" X 3"; scales; oven; Forest Products Laboratory equation table.

DIRECTIONS: In the selection of wood, the carpenter is usually interested in its strength. The specific gravity of wood affords an approximate indication of its strength properties.

(a) Place the different wood blocks in an oven at 212 degrees F., and dry until constant weight is attained. Remove the blocks from the oven and weigh each. Measure the length, breadth, and thickness of each with a rule and calculate volume. Compute the specific gravity using the formula:

$$\text{Sp. Gr.} = \frac{W}{V},$$

where W equals weight of wood in grams, and V equals volume in cc.

RESULTS:

	Weight	Dimensions after drying	Volume	Specific gravity
Oak	_____	_____	_____	_____
White Pine	_____	_____	_____	_____
Maple	_____	_____	_____	_____
Walnut	_____	_____	_____	_____

REFERENCES:

Black and Davis: Elementary Practical Physics, p. 100.

Forest Products Laboratory, Madison, Wis., Technical Notes, B-14.

Heisler: Elementary Science for the Student of Industry, p. 13.

CONCLUSION:

1. What is specific gravity?
2. Of what value is a knowledge of a wood's specific gravity to a woodworker?
3. How does the specific gravity of the different woods tested compare with values in reference three?
4. List the four woods in the order of their indicated strength.
5. Compare the specific gravity of green wood and wet wood.
6. Use equation table and calculate for each: (a) strength of speciman as a beam, (b) shock resisting ability, (c) ability to withstand wear, (d) its toughness, (e) and its shearing strength.

Experiment 5

FORCES

Name ____________________

Date ____________________

OBJECT: To study beam deflection in wood.

MATERIALS: Saw horses; weights; white pine pieces:

1" X 3" X 10', 1" X 5" X 10', 2" X 3" X 10'.

DIRECTIONS:

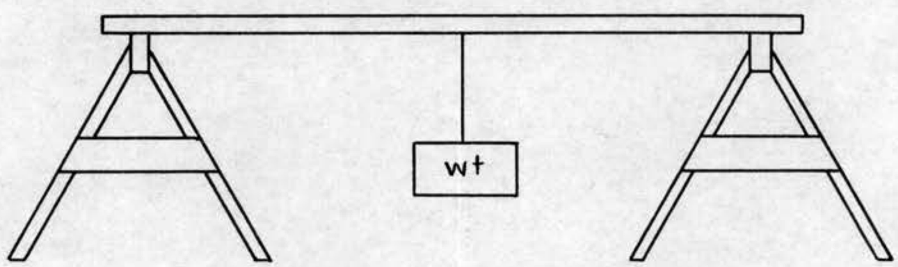


Fig. 1.

The builder is interested in building a house that will not sag, as the owner wishes to have a strong beautiful home. A bridge contractor must build a bridge that will not give way under heavy loads.

In the experiment with parallel forces, the principle used is that the sum of the pressures acting downward on a beam is equal to the supporting forces, if the beam is in equilibrium. There is another principle called beam deflection that is important, it states the amount of deflection that takes place when a beam is subjected to a given stress. You will note this property of a beam as follows:

(a) Support a piece of white pine 1" X 3" X 10' on two sawhorses as shown in Fig. 1. From a point midway between the supports, suspend a weight of 15 pounds. Lay a straight edged board across the sawhorses and measure distance from weight to straight edge. Place the sawhorses closer together, and measure results.

(b) Repeat as before for a piece of pine which is 1" X 5" X 10'.

(c) Repeat preceding directions for a piece of pine which is 2" X 3" X 10'.

RESULTS:

	Trial	Beam (T X W X L)	Amount of deflection
(a)	1	____________	______________
	2	____________	______________
(b)	1	____________	______________
	2	____________	______________
(c)	1	____________	______________
	2	____________	______________

REFERENCES:

Deming and Nerden: Science in the World of Work, pp. 117-120.

Dooley: Science Training for Metal and Wood Trades, p. 237.

CONCLUSION:

1. What effect does a load have upon a beam?

2. Would your general conclusion apply to a cantilever beam? Why?
3. What would be the effect on deflection, if the beam is placed on its edge? If in doubt, experiment.
4. Did increasing the width of the beam influence deflection? Increasing the thickness?
5. In some old factories and store buildings, it is a general rule that the center aisle of the building must never be stocked with heavy cases, boxes, trucks, etc. Explain why this rule is a safety measure.
6. If a pine floor were sagging at its midpoint, and the job became yours to remedy, explain in detail the methods that might be used as remedies for the situation.
7. What effect would different kinds of wood have upon beam deflection? See references. Why would a bridge builder need to know this?
8. Explain why a heavy beam might not be as strong as a lighter beam.

Experiment 6

PARALLEL FORCES

Name ____________________

Date ____________________

OBJECT: To study the effect of parallel forces on wood that is supported at each end.

MATERIALS: Pair of 25 pound spring balances; wood bar, 2 X 2 X 36"; weights.

DIRECTIONS:

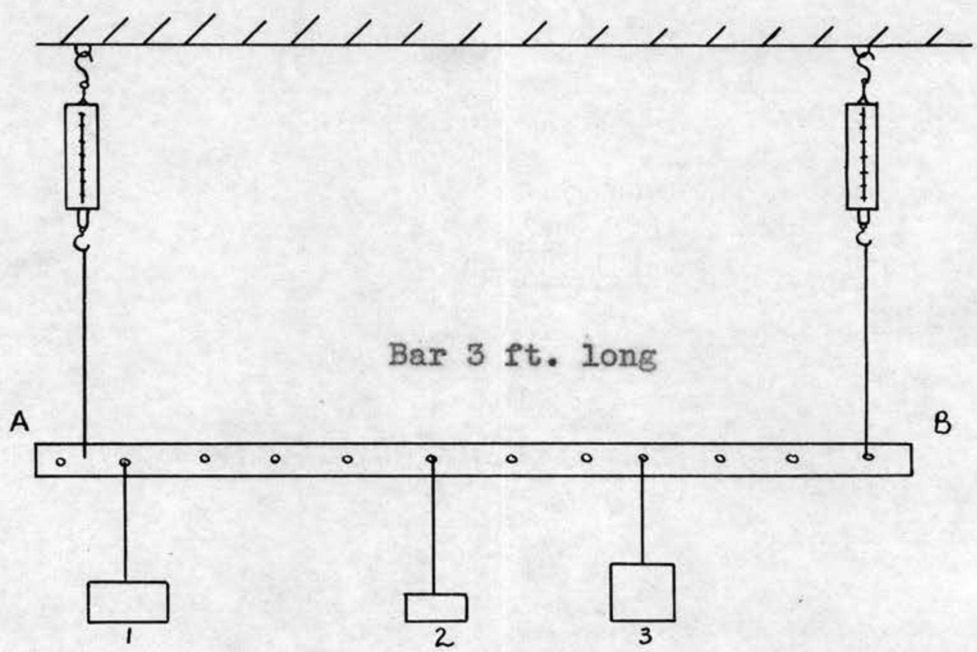


Fig. 1.

Nearly every day an automobile, a chair, or some other object is called upon to support our weight. If the thing that supports our weight does not break, nothing is thought about what effect our weight has upon the object. The carpenter must have a scaffold on which to work. The painter uses a similar device. The furniture builder considers the forces acting downward.

in the legs. These are all examples of parallel forces.

(a) Weigh a bar and hang it from a beam as shown in Fig. 1, with the 25 pound spring scales to support the bar on the ends. Place three weights (wt. one 8", wt. two 18", wt. three 24") along the bar, and read the results shown on the two scales. Add together the individual weights, and find the sum of all the forces acting down.

(b) Place all the load ten inches from end B of the bar, and notice the readings of both scales. Notice the scale readings when all the weight is in the middle.

RESULTS:

(a) Load at different places   Weight of bar ________

Balance 1 ____________   Weight 1 ____________

Balance 2 ____________   Weight 2 ____________

Sum ____________   Weight 3 ____________

Sum ____________

(b) Load near balance 1

Balance 1 ____________   Weight ____________

Balance 2 ____________

Load in center

Balance 1 ____________   Weight ____________

Balance 2 ____________

REFERENCES:

Black and Davis: Elementary Practical Physics, p. 27.

Griffith: Carpentry, pp. 28 and 96.

Nerden and Deming: Science in the World of Work, pp. 110-112

Voc. Board: Carpentry, p. 30.

CONCLUSION:

1. What else besides the weight of the bar represents the total force acting downward on the bar?
2. Does the sum of the scale readings give the total force acting upward on the bar?
3. Since the bar does not move, what could be assumed about the strength of the opposing forces? Suppose a building sagged, what would be the comparison?
4. When the weight was placed entirely at one end of the bar, how did the reading of the scale on that end compare with the reading of the scale for the opposite end of the bar?
5. When the weight was placed in the middle of the bar, how did the readings of both scales compare with each other?
6. When pressure is put on a rigid wood beam, how does it push down with respect to the supports at both ends?
7. When would a carpenter be in the most dangerous position on a scaffold in respect to the board breaking?
8. Suppose a main beam in a barn has a center post, how much of the weight of the barn does the center post support?

Experiment 7

PARALLELOGRAM OF FORCES

Name __________________

Date __________________

OBJECT: To study the principle of parallelogram of forces.

MATERIALS: Two spring balances, a weight of two pounds, string, paper.

DIRECTIONS: When a carpenter or a fireman climbs a ladder, it is subjected to several stresses. Cranes, derricks, and other mechanical devices are acted upon by forces at a point. A knowledge of the principle of forces is necessary to operate the various machines safely and

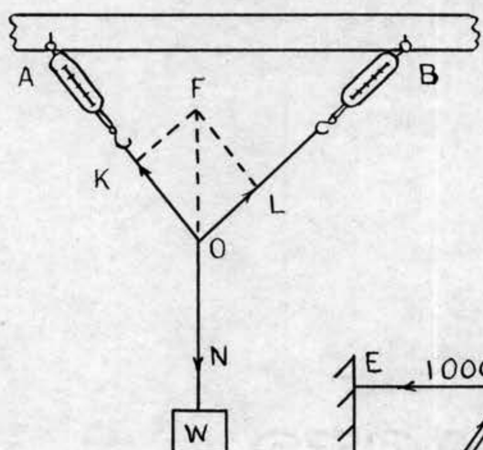


Fig. 1

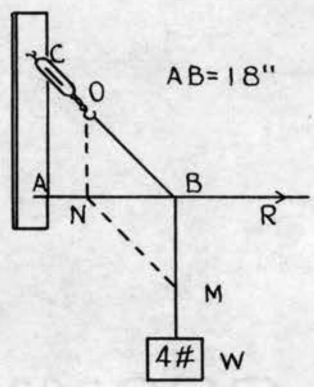


Fig. 2

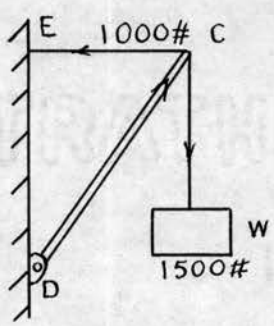


Fig. 3

successfully.

(a) At the top of the blackboard are two hooks which are twenty-four inches apart. From the hooks, hang two spring balances, A and B, as in Fig. 1. Slip a string about a yard long through a small ring and tie the ends of the string to the spring balances. Now suspend a weight of two pounds from this ring with another string. The three forces acting at point C are OK, ON, and OL which are represented by the strings. Draw lines on the blackboard behind the strings to represent the direction of each of the three forces. Record the tension of each string which is shown by the weight of W and the readings of the spring balances. Remove the apparatus and complete the parallelograms as shown by the dotted lines in Fig. 1. Read page 168 of the first reference, and choose some convenient scale for the magnitude of forces. Measure on OW the distance ON which represents the weight W, and place an arrow at N to indicate the direction the force is acting. In the same way, measure on OA the distance OK corresponding to the reading of the spring balance on that side. Place an arrowhead at K and locate L on OB. Then construct a parallelogram on OK and OL by drawing KF parallel to OL and FL parallel to OK. Measure the diagonal OF. What is it called? How does it compare in length with ON?

(b) Arrange a brace as in Fig. 2. Hold a drawing board covered with paper behind the apparatus and draw lines AR, OB, and BW. Using a convenient scale, draw a parallelogram and calculate force on AB.

RESULTS:

(a) Weight of W ______________________

Tension on string OA ______________________

Tension on string OB ______________________

Length of line OF ______________________

(b) Weight W ______________________

Tension on string BC ______________________

Magnitude of AB ______________________

REFERENCES:

Black and Davis: Elementary Practical Physics, pp. 167-178.

Jameson: Elementary Practical Mechanics, pp. 40-44.

Heisler: Elementary Science for the Student of Industry, pp. 59-60.

CONCLUSION:

1. What is force? An opposing force? Forces in equilibrium?
2. When a carpenter hits a nail with a hammer, what does the resulting force produce? Why?
3. What is a parallelogram? What is the law of the parallelogram of forces?
4. What must be known in order to determine the resultant of two or more forces?
5. When is the resultant the shortest? What does this mean in terms of magnitude of force?
6. How many forces are acting upon a basement door frame that is plumbed and stayed, ready for the mason to lay the adjacent wall? What are they?

7. In part (a) of the experiment, how does the magnitude of line OF compare with the weight of W? Account for this.

8. The arm of the crane CD is attached to the wall of a building under construction for lifting the heavy rafters as in Fig. 3. The weight lifted is 1000#. The tension on the horizontal cable CE is 500#. What is the force exerted on CD? Solve by drawing a parallelogram.

9. A man, who weighs 150#, has started to climb a ladder twenty feet long, that has been placed away from the side of the building at a distance one fourth the length of the ladder. Draw to scale this parallelogram of forces.

10. Fig. 4 below represents an unloading derrick. The boom XY is 24 feet long, and the wire rope XZ happens at this instant to be 8 feet long and in a horizontal position. While it is holding the two ton load, what is the tension on the guy wire rope? What is the force on the boom?

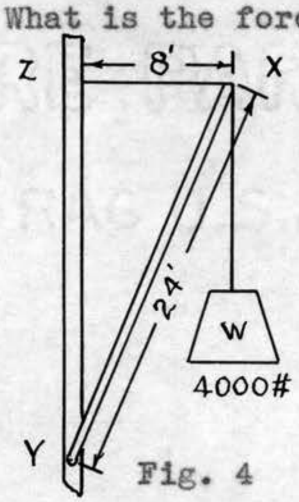


Fig. 4

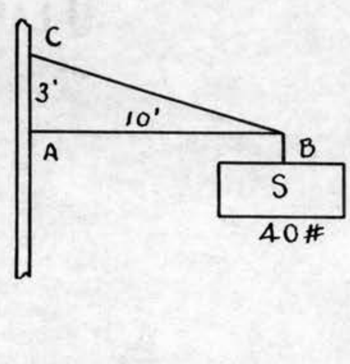


Fig. 5

11. A sign in front of a cabinet shop weighs 40#, see Fig. 5. It is hung from a post which is 4" square by a wooden bracket (AB) that is ten feet long. A tight wire BC is fastened to the post at C which is three feet above A. What force is exerted on the wire BC?

Experiment 8

LEVER

Name ________________

Date ________________

OBJECT: To study the claw hammer as a lever in pulling nails.

MATERIALS: Claw hammer, nails, board, 25 pound spring balance.

DIRECTIONS:

Fig. 1

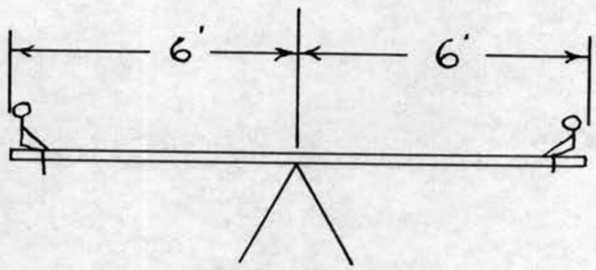


Fig. 2

The world of ours is full of devices with which to aid man in accomplishing the necessary tasks of life. The hunter uses a gun, the butcher a knife, the carpenter a hammer, etc. Perhaps the simplest of these tools or machines is the lever of which the seesaw is a good example.

An explanation of the seesaw, Fig. 1, will aid us in studying the hammer. If the point of turning (fulcrum) is exactly in the center of the plank and the boys are the same weight, they balance, or if one boy is heavier than the other, he would go down. If the fulcrum were not in the center, the boy on the long end would go down. If the boys weighed sixty pounds each, and the plank is twelve feet long, a statement like this could be made:

Boy X 6 ft. of plank = Boy X 6 ft. of plank, or

60 X 6 = 60 X 6

If one boy moved within four feet of the fulcrum, and the other boy remained at six feet from the fulcrum on the opposite end, the statement would be:

60 X 4 = 60 X 6

240 = 360

Thus, the boy six feet from the fulcrum would go down.

The claw hammer is a lever that is bent so that the two arms do not form a straight line. Drive an ordinary shingle nail in a block of wood. Place the hammer as in Fig. 2. Attach the spring balance at end of handle B. Pull the nail, and record spring scale reading. Measure distance FB, which is the perpendicular distance from effort to fulcrum, as in the seesaw. Measure distance FA. Find the resistance by using:

Scale reading X distance BF = Resistance (R) X distance AF.

Then find mechanical advantage by using the hammer to pull the nail by dividing the resistance by the effort.

RESULTS: Data Table

Scale reading (E) ______________________

Distance BF ______________________

Distance AF ______________________

Resistance R ______________________

Mechanical advantage ______________________

REFERENCES:

Heisler: Elementary Science for the Student of Industry, pp. 26-31.

Black and Davis: Elementary Practical Physics, p. 26.

CONCLUSIONS:

1. Define fulcrum. Where is it on the hammer?
2. What are the two shapes of levers mentioned in the experiment?
3. Why is the hammer used in pulling nails?
4. In gaining an advantage with the hammer, the effort is less than the resistance. Compare the distances moved.
5. In securing a mechanical advantage with the claw hammer, would distance be gained or lost?
6. Where is the force applied on the hammer?
7. Would a wrecking bar be considered a lever? How many ways can it be used as such?

Experiment 9

PULLEYS

Name ____________________

Date ____________________

OBJECT: To study the principle of the sash cord window pulley.

MATERIALS: Window pulley fastened in a 1" X 4" pine board, 4 feet of window sash cord, weight, 15 pound spring balance.

DIRECTIONS:

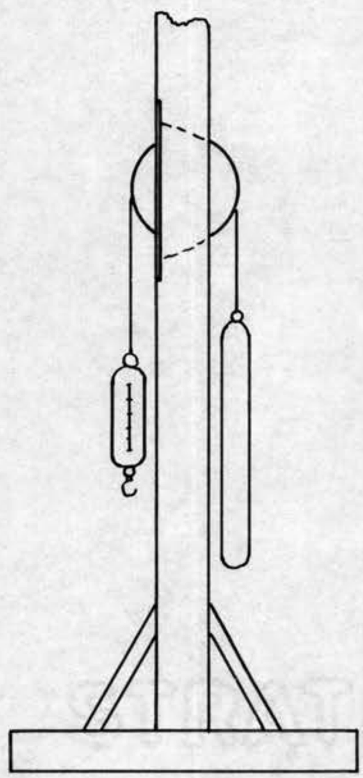


Fig. 1

The pulley has many uses in different places. In shops, it is used for lifting heavy steel shafts, raising motors, moving machinery; outside the shops, the pulley is frequently used for jobs such as furniture moving, raising and lowering painter's scaffolds, etc. These are just a few of the many uses of this simple machine.

It will be your task to examine the window sash pulley. Thread the pulley with window cord rope. Weigh the window weight, fasten weight to cord. Hook the spring balance to the opposite end of cord, raise the weight, and read on the balance the number of pounds of force required to raise the weight. In raising the weight one foot, how far did the effort or balance travel? Physics defines 1 foot pound of work done when 1 pound is raised 1 foot. It is easier to pick up a heavy 2" X 10" beam and hold it than it is to carry it. More work is done in the latter case because the weight is being carried through a greater distance.

RESULTS:

Load (window wt.)	______________	
Effort (spring balance)	______________	
Load distance	______________	
Effort distance	______________	
Load X load distance	______________	ft. lbs.
Effort X effort distance	______________	ft. lbs.
Mechanical adv. of pulley	______________	

REFERENCES:

Dooley: Science in the Metal and Wood Trades, pp. 33-37.

Heisler: Elementary Science for the Student of Industry, pp. 35-37.

CONCLUSION:

1. What is a pulley?
2. In raising the window weight one foot, how far did the effort force (spring balance) move?
3. Compare the spring balance reading with the weight of the pulley. How do you account for this?
4. Does a single pulley give a mechanical advantage? What is the purpose of the use of a single pulley?
5. Is the effort and the load on the pulley in equilibrium? Of what advantage is this in raising and lowering the window?
6. Give two uses of the single pulley in your trade.

Experiment 10

MECHANICAL DEVICES

Name ____________________

Date ____________________

OBJECT: To study the advantage of arranging pulleys as needed for lifting or pulling as in moving a house.

MATERIALS: Single pulley, barbed wire stretchers, two triple sheaved pulleys, small rope, weights as bricks, pieces of iron, 25 pound spring balance.

DIRECTIONS:

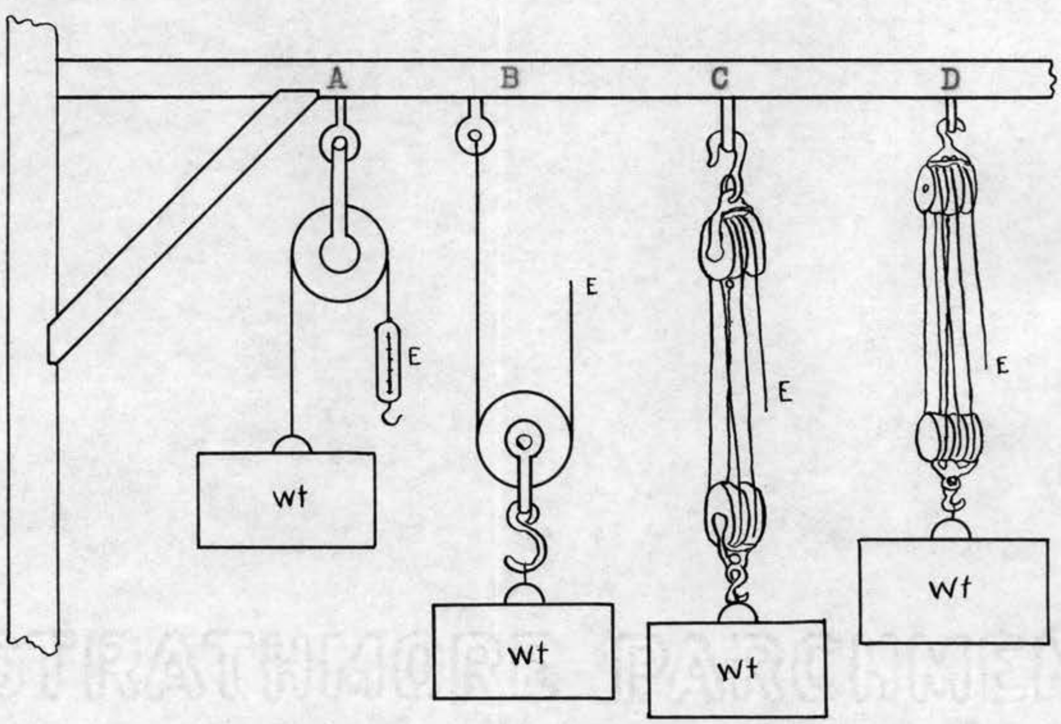


Fig. 1

In house moving, a block and tackle is a very necessary tool. By fastening the block and tackle to a dead-man (anchor placed in the ground from which to pull), and by fastening it to the house to be moved on the moving trucks, a reasonable amount of force can be used to move the house.

(a) Through a knowledge of the principle of the single pulley, the carpenter can easily make application to the heavier pulley systems used in moving a house. Mount a single sheave pulley as in A, Fig. 1. Tie approximately twenty pounds to one end of the rope, and tie the spring balance to the other end. Pull the rope down by means of the spring balance until the weight is raised free from the floor. Now raise the weight one foot from the floor, record length of rope pulled down, and the force required to pull it down.

(b) Follow directions given in (a), and set up pulleys as shown in Fig. 1 for B, C, and D.

RESULTS:

A

Trial	No. ropes on movable pulley	Force needed to lift weight	Distance moved		Mech. adv.
			Weight	Force	
1					
2					
3					

B

Trial	No. ropes on movable pulley	Force needed to lift weight	Distance moved		Mech. adv.
			Weight	Force	
1					
2					
3					

C

Trial	No. ropes on movable pulley	Force needed to lift weight	Distance moved		Mech. adv.
			Weight	Force	
1					
2					
3					

D

Trial	No. ropes on movable pulley	Force needed to lift weight	Distance moved		Mech. adv.
			Weight	Force	
1					
2					
3					

REFERENCES:

Sears: Essentials of Physics, p. 135

Heisler: Elementary Science for the Student of Industry, p. 37.

CONCLUSION:

1. What is the advantage of the arrangement of the pulley in A? In B? In C? In D?
2. What is a block and tackle? Of what use is it in moving a house? Where else is it used?
3. What is mechanical advantage?
4. How can a carpenter tell what mechanical advantage his block and tackle will give?
5. What is a truck driven winch, and how does it operate? Go to an automobile agency, and secure a picture of one. Try to find where one is in use, and learn its principle by seeing it operate.

6. Go to the auto mechanics shop, and get permission to experiment with a truck differential. What is a worm gear? Where is the worm gear located? Which turns the easier, the drive shaft or the axle? How many times does the drive shaft turn to one turn of the axle? What make of truck differential did you use?
7. Is the worm gear of the winch connected to the power take off of the truck. Why?
8. How many pounds will some of the large winches pull? Is that enough force to pull an ordinary six room house? Answer by asking a lumberman how much such a house weighs.

Experiment 11

WEDGE

Name ____________________

Date ____________________

OBJECT: To study the principle of the wedge.

MATERIALS: Five pound hammer, sharp mortise chisel, very blunt mortise chisel of same brand, white pine trial board, four wedges (Fig. 3), four wedges (Fig. 4), heavy object to be lifted, sawhorse, ten pound weight, 1/4 inch rope.

DIRECTIONS:

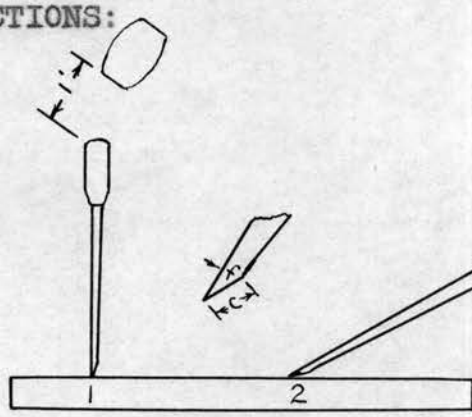


Fig. 1

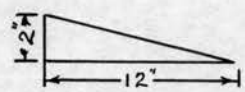


Fig. 3

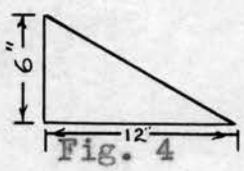


Fig. 4

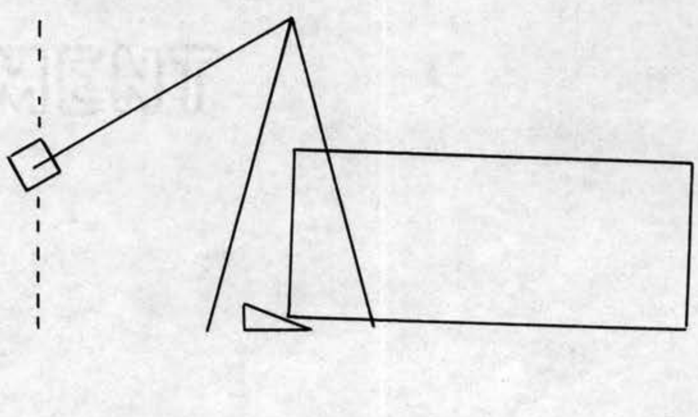


Fig. 2

The wedge is a very common example of one of the simple machines, which is a tapered device made of iron, wood, or some other strong material. It is driven by blows or by a steady force. All cutting and piercing instruments, such as the ax, chisel, carpenter's plane, and nails act as wedges. The carpenter uses wedges to fasten the heads of hammers and axes on their handles. The window sash lock is another example of a wedge, and thus, the list could be continued.

(a) In order to learn about this device to determine its mechanical advantage, measure the distance c and f of the sharp chisel. With hammer at position shown in 1, Fig. 1, drive the chisel into the wood with one blow. Measure depth chisel went into wood. Repeat directions using blunt chisel.

Repeat procedures holding chisels in position 2, Fig. 1.

(b) Place sawhorse at the corner of weight to be lifted with wedges. Attach a ten pound weight to the 1/4 inch rope, and tie to sawhorse so that it will strike all of the wedge. Start wedge Fig. 3 under corner of weight with hammer. Bring the weight back to a measured position at h in Fig. 2. Count the blows that strike wedge from this position to drive the wedge in flush with weight. Measure the distance through which the force moves, and the distance through which the load moves. The distance that the force moves is the horizontal distance that each wedge slides along the floor, and the weight distance is the vertical distance the weight rises. Record data obtained in table.

Repeat directions using wedge Fig. 4.

RESULTS:

(a)

	Chisels			
	Position 1		Position 2	
	Sharp	Dull	Sharp	Dull
Force required (wt. of hammer)	_____	_____	_____	_____
Distance chisel went into wood	_____	_____	_____	_____
Length of wedge (chisel's bevel, c)	_____	_____	_____	_____
Thickness of wedge (f)	_____	_____	_____	_____
M. A. $\frac{\text{Length (c)}}{\text{Height (b)}}$	_____	_____	_____	_____

(b)

	Wedge Fig. 3	Wedge Fig. 4
Amount of slope	little	increased greatly
Amount of force required (number of blows)	_____	_____
Vertical distance weight moved through (m)	_____	_____
Distance force moved through (n)	_____	_____
Mechanical advantage (n divided by m)	_____	_____

REFERENCES:

Griffith: Carpentry, p. 25.

Foley: College Physics, pp. 110-111.

Black and Davis: Elementary Practical Physics, pp. 48-49

Dooley: Science Training for Metal and Wood Trades, pp. 506-512.

CONCLUSION:

1. What is a wedge?
2. Which chisel drove the easier? Which the harder? Which has the greater mechanical advantage?
3. Explain the cutting action of the chisel in position 2.
4. Why does the carpenter sharpen a stake before driving?
5. What other simple machine is similar to a wedge? Why?
6. Which wedge drove the easier in the experiment? Why?
7. Which wedge took the more blows to drive? Why?
8. Which of the two wedges has the greater mechanical advantage? How is the mechanical advantage found?
9. To what class of machines do the following belong: ax, chisel, carpenter's plane, nails.
10. In using the wedge of Fig. 3 as in b, does the force have to be applied through a greater or lesser distance than that of the Fig. 4? Why?

Experiment 12

JACK SCREW

Name ________________

Date ________________

OBJECT: To study the jack screw that is used in house moving carpentry.

MATERIALS: Two small builder jack screws, grooved wheel with two feet diameter attachable to the head of the jack screw, 50 pound weight, 10 pound spring balance, rope with 1/4" diameter and 8' length.

DIRECTIONS:

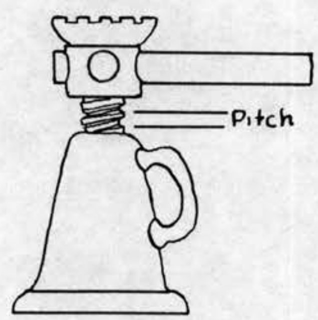


Fig. 1

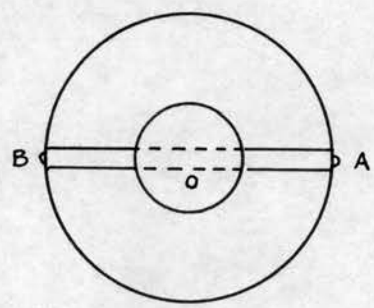


Fig. 2

In the building trades the jackscrew is used extensively, especially by the moving carpenter, who raises the buildings upon rollers.

(a) Measure the outside diameter of a grooved rim. Mount this rim on the ends of the turning bar with one fourth inch set screws. See Fig. 2. Adjust the constructed wheel so that it will revolve true by moving the spoke (handle) until AO and OB are equal in length.

Wrap a small rope around the wheel rim to which a spring balance is attached. This arrangement makes possible a steady pull on the spring balance. Carefully center the 50# weight on the head of the screw. Pull gently on the spring balance, and record effort. Measure the pitch of the screw threads. See Fig. 1. Measure the amount of rope needed to go around wheel once. Neglecting friction, figure the theoretical mechanical advantage. With each complete turn of a screw the work output is equal to the weight lifted times the pitch, and the work input is equal to the effort times the distance through which it acts. This distance is the circumference of the wheel. Then the efficiency can be calculated by the formula:

$$\frac{\text{Output (Weight X pitch)}}{\text{Input (Effort X cir. of wh.)}} = \text{Efficiency}$$

RESULTS:

Pitch of threads ____________________

Diameter of wheel ____________________

Circumference of wheel ____________________

Effort applied (spring balance) ____________________

Weight lifted ____________________

Mechanical advantage ____________________

Efficiency $= \frac{\text{Output}}{\text{Input}}$ ____________________

REFERENCES:

Black and Davis: Elementary Practical Physics, pp. 49-50.

Jameson: Elementary Practical Mechanics, pp. 212-214.

Heisler: Elementary Science for the Student of Industry, p. 37.

CONCLUSION:

1. What is a screw? Give an example of a type used by the finish and trim carpenter.
2. What is a jack screw? How high will the head of a builder's jack screw rise in one complete turn of the handle?
3. Why was a wheel substituted for a handle in the experiment?
4. In lifting a house off its foundation, why do the carpenters keep the house plumb?
5. What keeps the pressure of the house from unscrewing the jack when the handle is not held?
6. From the standpoint of weight moved, how does the jack screw compare with the builder's block and tackle?
7. Why was the worm or power screw in the builder's power driven winch, used in place of an ordinary meshed gear?
8. What factors determine the ease with which a screw turns?
9. What is the difference between a continuous screw and a rapidly acting bench vise?
10. Using the same length of handle, which woodworking vise would have the greater clamping effect, one having the lead screw finely threaded, or one coarsely threaded? Why?

Experiment 13

FRICTION

Name ____________________

Date ____________________

OBJECT: To study reasons for placing casters under a table.

MATERIALS: 25 pound spring balance; table; 4 metal shoes; 4 pin, 4 ball, and 4 roller bearing casters.

DIRECTIONS:

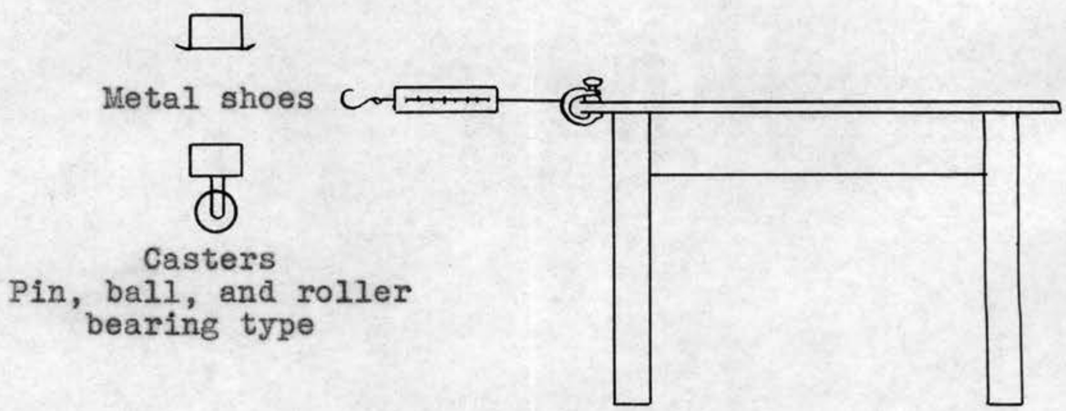


Fig. 1

The front wheel of an automobile when jacked up rolls easily, but pushing a sled along a dirt road is difficult. Most furniture that is moved about in the room has casters placed on the bottom of the legs. All of these are examples where friction is involved.

Let us find out why casters are used. Fasten the spring balance to the table without casters, and pull it at a uniform speed for about 10 feet. Record spring balance reading. Repeat as above using iron shoes on the table legs; using the various casters consecutively on the table legs. Compare the results.

RESULTS:

Force needed to move table:

Without casters on legs ____________

With metal shoes on legs ____________

With pin bearing casters on legs ____________

With ball bearing casters on legs ____________

With roller bearing casters on legs ____________

REFERENCES:

Heisler: Elementary Science for the Student of Industry, pp. 48-49.

Black and Davis: Elementary Practical Physics, pp. 58-62.

CONCLUSION:

1. What is friction? Name the kinds with which you have worked.
2. Which force proved to be greater: that in starting the table, or that applied after the table started moving?
3. Make a general statement about starting and sliding friction.
4. Would a man be helped or hindered by friction in shingling a house?
5. What kind of friction would be involved in opening an ordinary door?
6. What has been introduced in woodworking machinery to reduce friction in bearings?
7. What is the friction advantage of V belt vs. flat

belt?

8. Why use paraffin on a plane?

9. What is the purpose of lubrication?

Experiment 14

ANGULAR FORCES

Name ____________________

Date ____________________

OBJECT: To study the forces that act on a simple brace.

MATERIALS: Simple truss as illustrated, spring balance, weights.

DIRECTIONS:

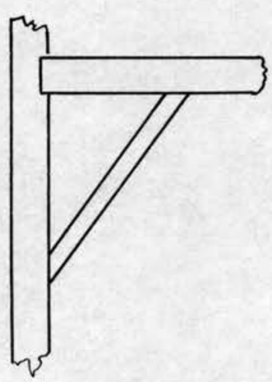


Fig. 1

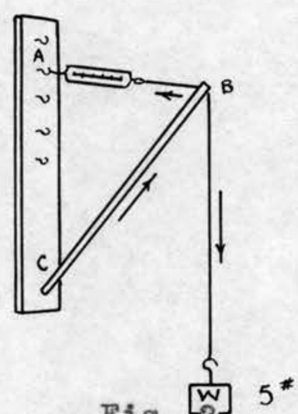


Fig. 2

The expression "this or that must be braced" has been uttered by all of us. Houses, scaffolds, and any structure that is made requires bracing to help withstand the elements. Fig. 1 is an example of a very common brace.

In this experiment the simple stick and tie brace will be studied. Arrange the apparatus as shown in Fig. 2. Place a weight of five pounds at W, and a spring balance at A. The three forces in equilibrium at point B are: the weight acting downward, and the other two forces acting in the direction of the arrows placed along the cord AB and the stick BC. Record the reading of spring balance L. Letting ½ inch equal one pound, draw a parallelogram as shown in Fig. 2. Measure BC and record on drawing. Decrease angle of stick BC with the board AC and note pull on spring balance. Increase angle of the stick BC with the board AC and note pull on spring balance.

RESULTS:

Reading spring balance ____________________

Weight W ____________________

Force BC is supporting ____________________

REFERENCES:

Sears: Essentials of Physics, pp. 147-148.

Heisler: Elementary Science for the Student of Industry, pp. 59-60.

CONCLUSION:

1. What is a parallelogram? What is the diagonal of a parallelogram?
2. State the law of the parallelogram of forces.
3. What might BC of the brace be called in respect to a parallelogram?
4. How much of a parallelogram does the brace BC represent?
5. What kind of a force is acting on a board placed in

a similar position as that of AB? Is it compression or tension?

6. What kind of force is acting on the brace BC?
7. The brace BC takes the place of what other two boards? (Look at your constructed parallelogram).
8. Design a properly braced one-half height door. Explain reason for your bracing.

Experiment 15

COUNTERACTING FORCES

Name ____________________

Date ____________________

OBJECT: To determine the forces which exist in the members of a roof truss.

MATERIALS: Apparatus as shown, weights, spring balance, turn buckle.

DIRECTIONS:

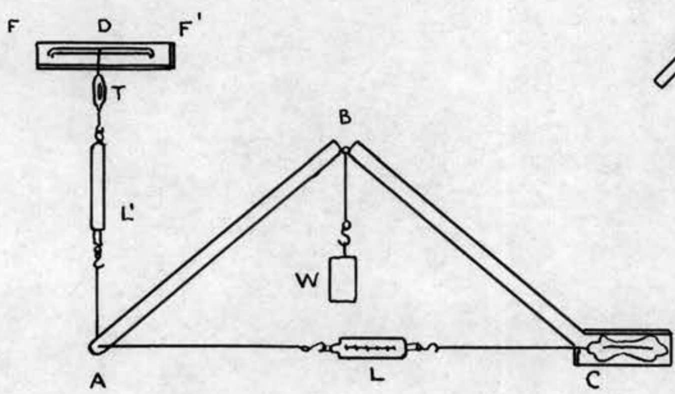


Fig. 1

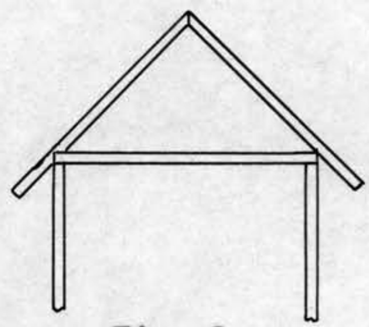


Fig. 2

The beams or timbers that support the roof of a simple wooden house or barn form an A, Fig. 2. The weight of a roof, and in winter the additional weight of snow upon the roof, tend to make the timbers spread at the bottom and the ridge-pole to sink. The apparatus, Fig. 1, that is used in this experiment is a similar truss. W weighs 30 pounds. The truss is pivoted at B and at C. A 15 pound spring balance is placed at the end of the cord that connects A with C, and another similar balance is placed between A and D. A turn buckle is placed between the spring balance and D to help raise and lower A. The hook D slides along the rod F F^1, so that DA can be made vertical when desired. Adjust the apparatus so that AC is horizontal and DA is vertical. Ask the instructor for the weight of each one of the two wooden members of the truss. Place a piece of cardboard behind the truss at B, and draw the angle ABC upon it. Measure and record the value.

The downward force at B is the weight W plus 1/2 the weight of each of the members AB and BC. The other half of the weight of member AB is pushing down vertically at A, and the other half of the weight of BC is pushing down vertically at C. On a sheet of paper, draw a vertical line to represent the downward force at B. Make it as many units long as there are pounds in the downward force at B. Call this line BW. At B construct an angle equal to angle ABC. Be sure to have half the angle on the right side of BW, and the other half on the left side. Complete the parallelogram. Draw the horizontal diagonal of the parallelogram. Find the value of the horizontal diagonal in force units. Half this value should equal the reading of spring balance L. Why? What is the value in force units of one half the vertical diagonal? This represents the vertical component at A of the force BW. There is a downward force at A equal to one half the weight of the member AB. Then add one half the weight of AB to the vertical component at A to get the total downward force at A. Compare this total force with the reading of spring balance L^1. What line in your force diagram represents the compression in AB? Measure that line, and find its value in force units. Show the value of all forces on the diagram.

RESULTS:

Weight hung at B	________________
Spring balance L	________________
Spring balance L^1	________________
Angle ABC	________________
Weight of each member of the truss	________________

REFERENCES:

Sears: Essentials of Physics, pp. 147-148.

Heisler: Elementary Science for the Student of Industry, pp. 59-60.

Black and Davis: Elementary Practical Physics, pp. 167-177.

CONCLUSION:

1. What is the name of a roof forming an A?
2. Answer all questions asked in the directions.
3. Of what value is the joist in this form of roof?
4. In framing openings for French doors in houses, the opening is quite often trussed above it. Why?
5. Fig. 3 represents a pair of sawhorses. If the same load is applied to each horse, tell from the

sketches which sawhorse is more liable to collapse under increasing loads.

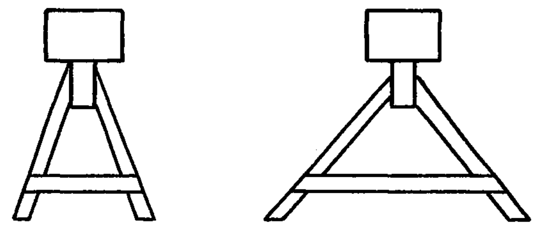


Fig. 3

Experiment 16

CENTER OF GRAVITY

Name ____________________

Date ____________________

OBJECT: To show that the entire weight of the hammer may be considered as acting at a single point (center of gravity), and to study the relation of the position of the center of gravity to an object's stability.

MATERIALS: Claw hammer, device as shown, board 1 X 6 X 18", two cylinderical blocks as shown in Fig. 2, string, and weights.

DIRECTIONS:

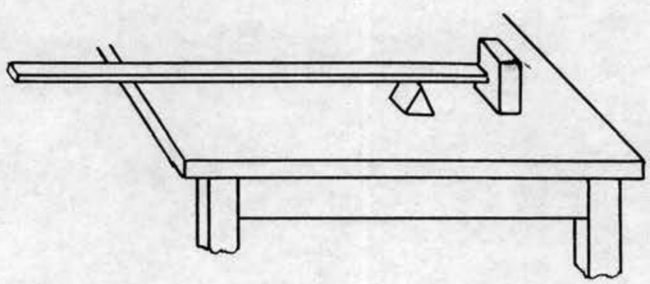


Fig. 1

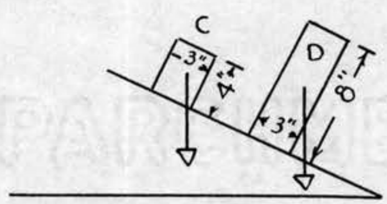


Fig. 2

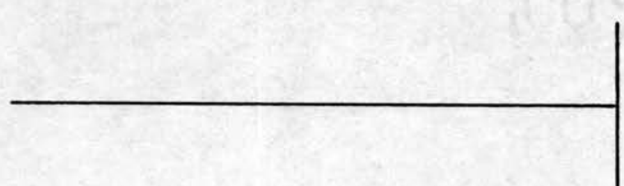
Workers have their favorite tools. Two hammers that look alike to a non-tradesman may feel entirely different to the hand of a tradesman. Our job is to find the reason for this.

(a) Balance the long irregularly shaped body, similar to a hammer, on the edge of a triangular prism as shown in Fig. 1. Measure the distance from the end without weights to the center of gravity, and record on diagram.

(b) The idea of the center of gravity also helps to understand the problem of stability. Find the center of gravity of the two cylinders, Fig. 2, by balancing over knife and then drive a shingle nail at this point. Fasten a plumb line from this center of gravity on each cylinder. Incline board by laying on a thick block or other object. Place block C on the inclined plane (board) so that the plumb line will swing free. Note the line falls within the base of the block. Now place on the same inclined plane cylinderical block D, which has the same base but twice the height of C. The plumb line from its center of gravity will fall outside the base. What happens?

RESULTS:

(a) Diagram:



(b)

	Block C	Block D
Center of gravity from inclined plane	______	______
Did block tip over?	______	______

REFERENCES:

Heisler: Elementary Science for the Student of Industry, p. 60.

Sears: Essentials of Physics, pp. 116-117.

Black and Davis: Elementary Practical Physics, pp. 30-33.

CONCLUSION:

1. What is meant by the center of gravity?
2. How many inches was the center of gravity from the end of the handle?
3. If the experimental apparatus represented a claw hammer or tack hammer, and the center of gravity was not concentrated at a single point, would the hammer be hard or easy to use? Can you think of one word that would describe the working qualities of such a tool?
4. Do you like to use one of your father's hammers better than another? Does your father have a tool that he likes to use, but you do not like it? What and why?
5. Does every tradesman want the center of gravity of his hammer in the same place? Why?
6. How does the manufacturer change the center of gravity of his tools?

7. Measure and record the center of gravity of a: hammer, chisel, wrecking bar, screw driver, hatchet.
8. Which block tipped over, C or D? Was its center of gravity higher or lower than the other block?
9. By the plumb line method, what is the statement concerning the stability of an object?
10. Two houses, a single story house and a two story house, were built on the same size foundation. Which house was the more stable? Why?
11. As a rule objects that have heavy flat bases are more stable than taller objects of similar design. Why?
12. Why are many buildings longer than they are high?
13. Why are storm caves built almost level with the ground?

Experiment 17

MECHANICS OF LIQUIDS

Name ____________________

Date ____________________

OBJECT: To study the factor of water pressure in building cofferdams and water tanks.

MATERIALS: One galvanized well casing six inches in diameter and five feet long, and one three inches in diameter and five feet long; water pressure guage; rule; pet cocks.

DIRECTIONS:

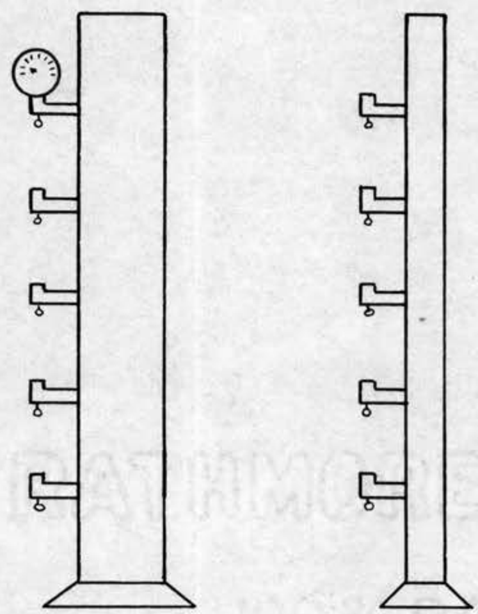


Fig. 1

Water exerts pressure on the body while swimming. Ocean divers wear strong, heavy suits to keep the water from crushing them. In bridge building, the carpenter has the problem of building structures, such as a cofferdam, that must withstand the pressure of the water at the bottom of rivers.

To find out something about water pressure, assemble the apparatus as shown in Fig. 1. It consists of two individual pipes of the same height with different diameters fitted with petcocks and with a guage. First, make sure that all of the petcocks are closed tightly; then fill the large pipe to the top with water. Record pressure from guage at the various places provided along the pipe, starting at the top of the pipe. Repeat the procedure by using the pipe of smaller diameter.

RESULTS:

Pressures
(lbs. per sq. in.)

	Large pipe	Small pipe
1.	______________	______________
2.	______________	______________
3.	______________	______________
4.	______________	______________
5.	______________	______________

REFERENCES:

Black and Davis: Elementary Practical Physics, pp. 71-87.

Heisler: Elementary Science for the Student of Industry, pp. 13-14.

CONCLUSION:

1. Where was the water pressure the least? The most?
2. Compare the top and bottom pressure of the two pipes. How do we account for this variation?
3. Does the amount of water in a river or pond have any relation to the pressure of the water at the bottom? What is the determing factor of the pressure?
4. When a hole is bored into a wooden tank, what causes the water to spurt out?
5. What is the total force on the bottom of a coffer-dam 15 feet in diameter and 20 feet long, if it is sunk to the bottom of a river 15 feet in depth? If the water is very salty, what is the total force at the bottom of the river? (Get density from the table in the book of the second reference). Use the formula: Total force (lbs.) equals (area in sq. ft.) (depth in ft.) (density).
6. In a cylindrical tank, erected by a tank building carpenter, why are the bands spaced closer at the bottom?

Experiment 18

EXPANSION OF WOOD

Name ________________

Date ________________

OBJECT: To study the expansion of wood resulting from moisture.

MATERIALS: Water, rule, one piece of pine and one piece of cypress each 1" X 6" X 18".

DIRECTIONS: The carpenter, in shingling a roof, allows for the expansion of shingles during wet weather to keep them from buckling and cracking. It is necessary for him to know how much wood expands when it becomes wet. Measure accurately the thickness, width, and length of the two blocks. Weigh each piece. Place them in a tank of water until thoroughly wet. Measure again, weigh, and record. Leave the wood in the water during the entire class period. Measure again for further expansion.

RESULTS:

	Pine		Cypress	
	Dry	Wet	Dry	Wet
Weight	____	____	____	____
Thickness	____	____	____	____
Width	____	____	____	____
Length	____	____	____	____

Note: Make corrections if the wood in the water expanded any more by the end of the class period.

REFERENCES:

Dooley: Science Training for the Metal and Wood Trades, pp. 497-500.

Griffith: Carpentry, pp. 102-103.

CONCLUSION:

1. What causes expansion of wood due to moisture?
2. What is the effect of the weather on lumber?
3. How does a carpenter make allowance for expansion in shingling?
4. Of what value is expansion of wood to the tank carpenter?
5. Why is building paper laid between the rough floor and the finish floor?
6. What makes drawers in furniture hard to open in damp weather? How does the cabinet maker allow for this in constructing furniture?
7. How may wood be treated to prevent expansion?

Experiment 19

WOOD SHRINKAGE

Name ________________

Date ________________

OBJECT: To study the shrinkage of wood.

MATERIALS: Rack with hooks for hanging wood samples, screw eyes to screw into ends of wood samples, rule, scales, green oak.

DIRECTIONS: Wood to be used in furniture construction must be seasoned. The moisture content must be reduced to a minimum, or the furniture will warp out of shape and not give reasonable service.

(a) Prepare two samples of green oak. The samples should be from eight to twelve inches long. One piece should be five or six inches wide, and the other about two inches wide. Carefully measure the thickness, width, and length of each sample. Weigh each sample and record weight. Then place a screw eye in end of sample, and hang on rack. Identify samples. Measure and weigh samples each day for one week. Weigh samples again in two months.

(b) Weigh a piece of green oak, approximately 2" X 8" X 8". Place it in an oven, and heat over low fire until thoroughly dry. Weigh again, and calculate percent of moisture evaporated.

RESULTS:

(a) Sample 1

	1	2	3	4	5
Thickness	______	______	______	______	______
Width	______	______	______	______	______
Length	______	______	______	______	______

Sample 2

	1	2	3	4	5
Thickness	______	______	______	______	______
Width	______	______	______	______	______
Length	______	______	______	______	______

(b) Green Oak

Weight before placing in oven ____________

Weight after placing in oven ____________

Percent of moisture ____________

REFERENCES:

Dooley: Science Training for Metal and Wood Trades, pp. 487-490.

Hunt: Handwoodworking, pp. 153-158.

CONCLUSION:

1. What causes shrinkage of wood? How does it effect furniture and cabinet making?
2. What is the cause of the rapid change of size and weight during first week?
3. How much will a green oak board eight inches wide shrink in drying down to five percent moisture content?
4. What are the two methods of drying wood? How long does it take?
5. How much of the weight of freshly cut lumber is

moisture?

6. Is the moisture content of cabinet woods always constant? Why?
7. What causes warpage in a board? Can the furniture maker stop this by finishing? Why?
8. Which way does wood shrink the more, radially or tangentially to annular ring?
9. What is the percent of moisture in kiln dried wood?
10. Why do large cabinet shops have a small kiln?
11. Will paint keep a board from shrinking? Why?
12. What causes wood to crack if allowed to dry in the stick?

Experiment 20

TRANSMISSION OF HEAT

Name ____________________

Date ____________________

OBJECT: To study heat insulators used in house construction.

MATERIALS: Special box as shown, asbestos, magnesia, rock-wool, paper, uninsulated dipper, thermometers.

DIRECTIONS: Heat always tends to pass from warmer objects to cooler objects. Through a knowledge of the properties of heat insulators, it is possible to save much heat that is lost otherwise. The carpenter builds the walls of the house with an air space to prevent waste of heat.

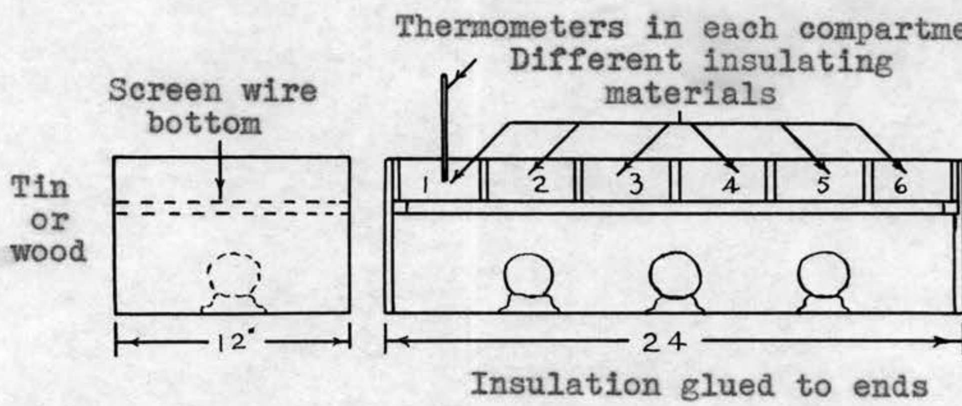


Fig. 1

Recently, carpenters have begun to construct houses with insulating materials, as rock wool and celotex, by putting it between the walls and under the roof.

This experiment will supply some information relative to the ability of common insulators to prevent conduction of heat.

Fill the compartments of the tray with: 1. asbestos

2. magnesia, 3. rock wool, 4. paper, 5. spun glass, 6. uninsulated. Place thermometers in each to the same depth in the insulating materials. In the uninsulated compartment, suspend the thermometer by a string. Turn on lights and take readings every five minutes for thirty minutes.

Prepare a table showing for each set of readings the elapsed time from the start, and the corresponding temperature.

RESULTS:

Time	Asbestos	Magnesia	Rock wool	Spun glass	Uninsulated
5					
10					
15					
20					
25					
30					

REFERENCES:

Black and Davis: Elementary Practical Physics, pp. 255-260.

Heisler: Elementary Science for the Student of Industry, pp. 94-101.

CONCLUSION:

1. Prepare a graph showing the curves of cooling, by using time as the abscissa (horizontal line) and temperature as an ordinate (vertical line).
2. From data obtained, name the three best insulators in order of their excellence.

3. What are the three ways that heat is transmitted? Give a practical example of each.
4. In which heat transmission method is the insulation carpenter most interested? Why?
5. From what is rock wool made?
6. What is meant by a dead air space in the walls of a house? Of what value is it in conserving heat?
7. If a house is properly insulated to keep in heat, will it be cool in summer? Why?

Experiment 21

SEASONING LUMBER

Name ________________

Date ________________

OBJECT: To learn the principles of seasoning lumber.

MATERIALS: Green, checked, casehardened, and honeycombed pieces of wood, approximately 2 X 8 X 18"; microscope; slides (cross sections of oak, pine, and walnut).

DIRECTIONS: Many carpenters have the duty of selecting lumber according to strength, texture, and beauty. Through a knowledge of the principles of seasoning lumber, this problem can be made easier and more accurate.

(a) Examine the microscopic slides. Hold them toward the light. What do you observe? In making these slides, a very thin piece of tree trunk is placed between two pieces of glass. By looking through the microscope at the slide, an enlargement of the wood is seen. Ask the instructor to help set up the microscope. Examine carefully the magnified parts of the different tree trunks.

(b) Observe carefully each piece of defective lumber. Draw accurate sketches of blocks containing seasoning defects. Label each.

RESULTS: Make drawings on a separate sheet of paper.

REFERENCES:

Mersereau: Materials of Industry, pp. 32-42.

Hunt: Manual for Hand Woodworking, pp. 153-156.

Dooley: Science Training for Metal and Wood Trades, pp. 487-490.

CONCLUSION:

1. What is the smallest unit of a tree? How large is it, and what is its shape?
2. Under the microscope, did the tree trunk appear to be hollow or solid? What do the hollow spaces of a live tree contain?
3. What is green wood? What happens to the cell sap when a tree is cut? Does this cause the tree to shrink or expand? Why?
4. Why do carpenters demand seasoned lumber?
5. Can the kiln foreman control the shrinkage of the lumber? Why?
6. What are the two methods of seasoning lumber?
7. Which type of seasoning is used for the general run of lumber for carpenters? How dry does this method season lumber?
8. Which method is used for seasoning interior and cabinet woods? Why?
9. How is lumber stacked for open air seasoning to permit air circulation and prevent warping?
10. Why is air circulation needed in seasoning lumber?
11. What is a lumber kiln? What are the factors that must be controlled in operating it? To produce good lumber, who must operate a kiln?
12. Why does wood check when subjected to dry hot air? How do carpenters overcome this factor in Oklahoma?

13. Why does wood warp in drying?

14. In the seasoning process, how is wood prevented from checking in a kiln?

15. What is casehardening? How is it prevented in the kiln?

16. What is honeycombing? How is it prevented in kiln drying? Why does the carpenter reject lumber having this defect?

17. What causes decay? Which does it occur more readily in, seasoned lumber or unseasoned? Why?

Experiment 22

ELECTRICITY

Name ______________________

Date ______________________

OBJECT: To study the principle of the electric motor used by the sawyer.

MATERIALS: Iron filings, #18 copper wire, #22 copper wire, 2 bar magnet, 4 dry cells, cork, old electric motor which has 1/4 H. P.

DIRECTIONS:

Fig. 1

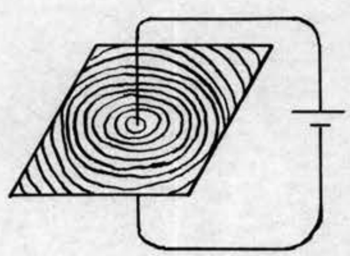


Fig. 2

The carpenter that operates the power saw must maintain it. This includes making simple repairs on the electric motor when necessary. To do this, he must know something about electricity, and something about the principle of the electric motor.

(a) Place a bar magnet between two blocks of wood each 6" wide by 18" long and as thick as the magnet. Lay a sheet of notebook paper over the magnet and board. Scatter iron filings lightly over the paper above the magnet. Observe the appearance of the field of force about the magnet. Note which end of the magnet is marked N, and which is marked S, which means North and South poles of the magnet. Repeat the procedure, by using two permanent magnets placed about two inches apart, in the place of one between the boards. Sprinkle iron filings as before and observe. Place two magnets as previously placed, but have like poles near each other and repeat experiment.

(b) Place a piece of #18 copperwire through a sheet of notebook paper, and connect wire to four dry cells. See Fig. 2. Sprinkle iron filings around the wire and observe the field of force about the wire.

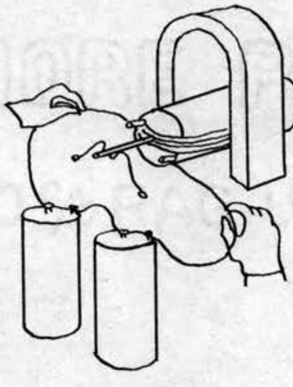


Fig. 3

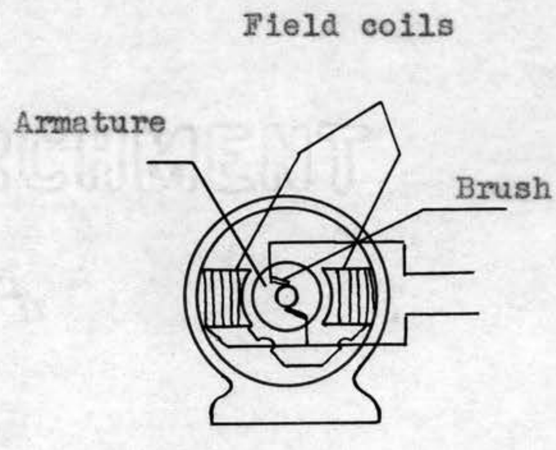


Fig. 4

(c) The principle of the electric motor requires an understanding of the fields of force about magnets and wires possessing electrical energy.

Around a cork about two inches long, wrap twenty turns of #22 insulated wire. Cut two pieces of bare copper wire about #18. Push them into the ends of the cork, and fasten the ends of the coil to the short wires. See Fig. 3. Thrust a knitting needle through the cork so that it projects from both ends. The coil on the cork forms the armature. Stand a horseshoe magnet over the armature, and connect the dry cells as shown. Touch the ends of the bare copper wires to the short wires of the armature. If the motor armature does not move, add more dry cells and magnets.

The electric motor operated by the carpenter has the same principle as the toy motor above. Electromagnets are substituted for the permanent magnet to give a stronger magnetic field, as the strength is determined by the number of turns of wire used, and by the amperage and voltage of the current that flows into the motor. In operation, the armature of the motor is attracted by a south pole of the field magnet, and then by a north pole, etc., in rapid succession. See Fig. 4 and reference one pages 464 to 465. Disassemble the 1/4 H. P. motor. Read the name plate. Locate: armature, brushes, and field coils.

REFERENCES:

Black and Davis: Elementary Practical Physics, pp. 463-468.

Heisler: Elementary Science for the Student of Industry, pp. 111-118.

CONCLUSION:

1. What is electricity?
2. What are the two common types of magnets? Which is used in the 1/4 H. P. electric motor?
3. Which poles attract, like or unlike? Which repel?
4. How many poles does each magnet have?
5. Why have the electro-magnets replaced the permanent magnets in motors?
6. Why does the armature of a motor have to be cleaned with sand paper occasionally?
7. Why are brushes used in a motor?
8. How many poles have to be in the field coil of a motor before it runs?
9. What is a volt? How many volts does the motor need to operate? See name plate. What is an ampere?
10. Explain the reaction, if a carpenter in relocating his saw, hooked the motor of the saw to a 550 volt electric line.
11. If the motor stops operating suddenly, where does the operator look for the trouble first?
12. What are the purposes of fuses? Name the two kinds.
13. If a woodworker came in contact with a power line and was severely shocked, what kind of treatment should be given?

Experiment 23

STRENGTH OF MATERIALS

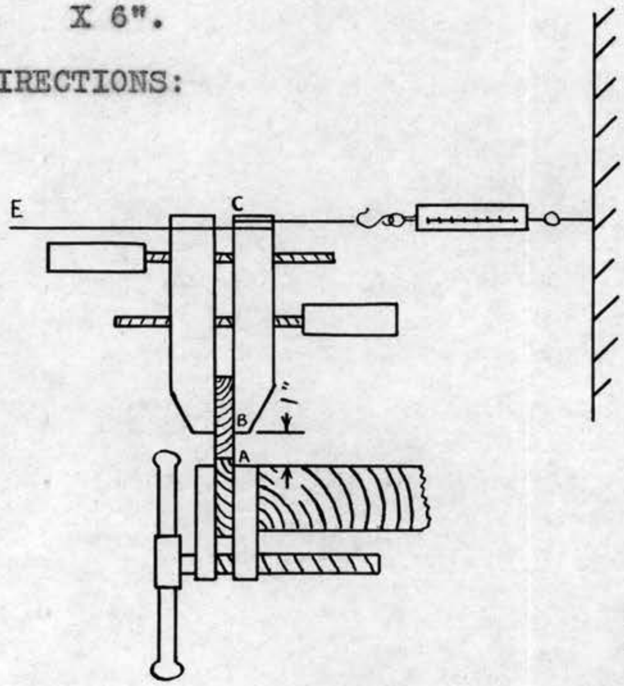
Name ____________________

Date ____________________

OBJECT: To determine the strength of a glue joint.

MATERIALS: Wood hand screw; steel bar clamps; eight pieces each of oak, white pine, and walnut which are 1" X 4" X 6".

DIRECTIONS:



Effort Arm - AC
Resistance Arm - AB

Force needed to break:
AC X spring balance reading equals AB X R.

Fig. 1

In cabinet work and interior carpentry, glue is a standard fastening material. A glued joint, to be satisfactory, must be as strong as the wood and very durable. In this experiment several glue joints are to be tested.

Prepare two fresh pots of animal glue. Make one of proper consistency labeling No. 1, and the other of very thick consistency labeling No. 2. Join the edges of two pieces of the same kind of wood with glue from pot labeled No. 1. Apply pressure using a steel bar clamp. Glue similarly two pieces of the same kind of wood with glue from pot labeled No. 2.

After the joints have dried four or five days, clamp in a vise and arrange apparatus as in Fig. 1. Apply pressure at C and test to destruction. Calculate resistance offered by wood or glued joint using the principle of the lever.

Repeat procedure using casein glue.

RESULTS:

Animal Glue

	Glue		Wood or joint broken		Force applied	
	Regular No. 1	Thick No. 2	No. 1	No. 2	No. 1	No. 2
Oak	_____	_____	_____	_____	_____	_____
White Pine	_____	_____	_____	_____	_____	_____
Walnut	_____	_____	_____	_____	_____	_____

Casein Glue

	Glue		Wood or joint broken		Force applied	
	Regular No. 1	Thick No. 2	No. 1	No. 2	No. 1	No. 2
Oak	_____	_____	_____	_____	_____	_____
White Pine	_____	_____	_____	_____	_____	_____
Walnut	_____	_____	_____	_____	_____	_____

REFERENCES:

United States Department of Agriculture: Bulletin #1500 pp. 47-73.

Heisler: Elementary Science for the Student of Industry, pp. 26-29.

CONCLUSION:

1. Which principle of physics is used in gluing, adhesion or cohesion? Varify.
2. What is the composition of animal glue? Of casein glue?
3. What does the cabinet-maker consider good shearing strength for an animal glued joint made of oak? Of white pine? Of walnut?
4. What does the cabinet-maker consider good shearing strength for a casein glued joint made of oak? Of white pine? Of walnut?
5. Why are the tests you made, a good test of the success of the gluing operation?
6. What are two other tests used by the manufacturer of glue to prepare a satisfactory glue for the carpenter?
7. Which proved to be the better, the glue of thick consistency or the glue of thin consistency? Why?
8. Where does the woodworker need a water proof glue joint?
9. What effect does the quality of wood have on the strength of the glued joint? Of the kind of wood?
10. Where is fish glue used? Of what is it made?

Experiment 24

BEAM DEFLECTION

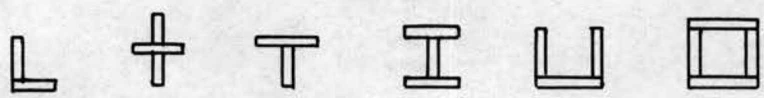
Name ____________________

Date ____________________

OBJECT: To study beam deflection of various kinds of beams.

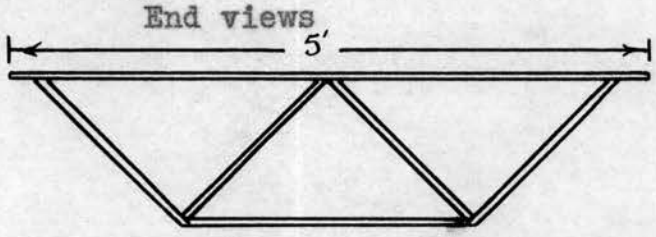
MATERIALS: Beams of different cross sections; truss made of slats, 1/4" X 2" X 60"; weights; sawhorses.

DIRECTIONS: Building contractors strive to make buildings strong enough to bear the dead and live loads without deflection (sagging). Deflection in a beam is the



1 2 3 4 5 6

End views



Front view

Fig. 1

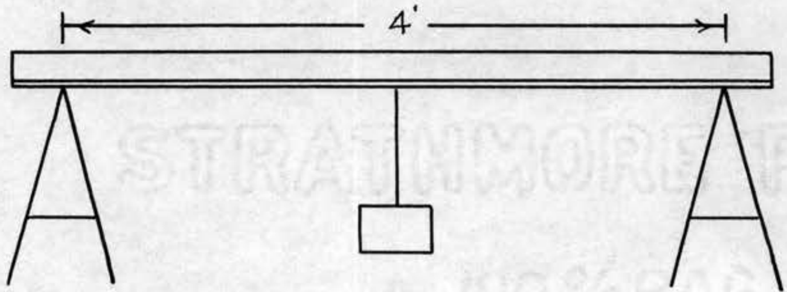


Fig. 2

distance that a beam sags below the normal horizontal level when bearing a load. Have you ever seen buildings whose beams have deflected? Where?

In this experiment different types of beams will be studied to learn how strong buildings are made. Support beam 1, Fig. 1, on two saw horses as shown in Fig. 2. Measure from bottom of beam to floor and record. From a point midway between the supports, suspend the load necessary to make beam deflect one inch. This may be a box of bricks or heavy iron weights. Observe what happens to the shape of the beam. Measure the distance from the midpoint of the beam to the floor. Substract previous measurement for amount of deflection. Repeat the procedure for each of the different beams and for the truss shown in Fig. 1. In some cases it may be necessary to nail boards in the sawhorses to keep the beams from turning.

RESULTS:

	Deflection	Pounds of force needed
Beam 1	________	________
Beam 2	________	________
Beam 3	________	________
Beam 4	________	________
Beam 5	________	________
Beam 6	________	________
Truss	________	________

REFERENCES:

Deming and Nerden: Science in the World of Work, Vol. I, pp. 117-130.

Black and Davis: Elementary Practical Physics, pp. 167-176.

Griffith: Carpentry, pp. 1-114.

Heisler: Elementary Science for the Student of Industry, pp. 120-124.

CONCLUSION:

1. What is a beam? Name two places where heavy beams are needed in building a house.
2. Which of the beams tested were the hardest to deflect? Which were the easiest?
3. How do these beams compare in flexing ability with the beam tested in a previous experiment? Why?
4. How did the truss compare in strength to the beams? How do you account for this?
5. Where is the L beam used in carpentry? Why?
6. Show where three of these beams can be used in the construction industry and tell why they are used.
7. Show different places where a truss can be used, and tell why it is used instead of a beam.
8. Is steel used for beams and truss work in buildings? In what type of buildings? Why?
9. In the building industry which is used the more, steel beams and trusses or wood beams and trusses? Why?
10. What is meant by a beam being under stress? Under strain?

Experiment 25

SOUND

Name ____________________

Date ____________________

OBJECT: To study the theory of absorption of sounds by insulating materials.

MATERIALS: Wooden box lined with insulite; battery; electric bell; squares of: celotex, insulite, felt, velvet, and plywood.

DIRECTIONS: In building construction, we not only find that it is necessary to insulate buildings to prevent heat

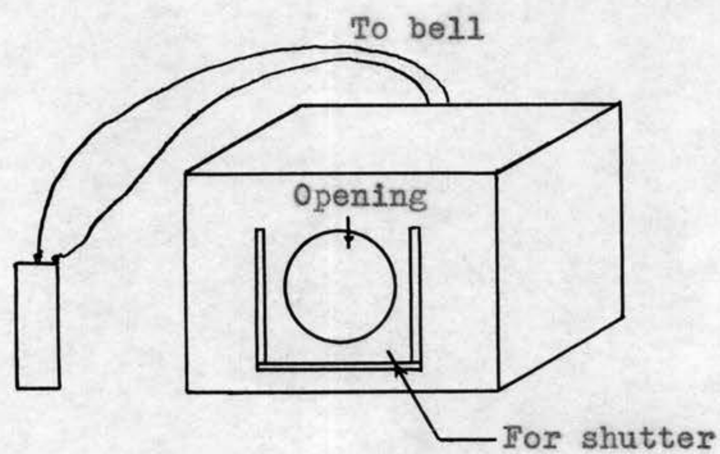


Fig. 1

losses, but in many cases to apply materials that absorb sound. Several different types of materials that absorb sound will be studied.

Connect dry cell to bell in the wooden box lined with insulite. With opening not closed, ring bell and note volume of sound produced. With the bell ringing, close opening consecutively with: plywood, celotex, insulite, felt, and velvet (stretched tightly across opening and then draped in folds over opening). Note volume in each case. List the materials according to their ability to absorb sound. Ask the local lumberman for other brands of insulating materials and test them.

RESULTS:

Insulating material	Ability to absorb sound (good, poor, fair)	Valuation of insulating materials tested
Celotex	____________	____________
Insulite	____________	____________
Felt	____________	____________
Velvet (stretched tightly)	____________	____________
Velvet (draped in folds)	____________	____________
Plywood	____________	____________

REFERENCES:

Heisler: Elementary Science for the Student of Industry, pp. 135-142

Deming and Nerden: Science in the World of Work, Vol. II, pp. 229-237.

Black and Davis: Elementary Practical Physics, pp. 502-523.

CONCLUSION:

1. What is sound? How does it travel? How fast does it travel in a room at 32 degrees F.?
2. What is meant by reflection of sound?
3. What is sound called that hits the back wall of an

auditorium and reflects back to a person in the room?

4. Compare the ability of velvet stretched tight and velvet draped in folds to absorb sound. Account for this.
5. Explain the reason for tiny holes in ceilings of sound insulated rooms.
6. What is the general statement that explains the effect any soft fibrous substance, like felt, velvet, drapes, insulate, celotex, etc., has on conduction and reflection of sound.
7. Explain why a carpenter, doing acoustical work, must cover accurately the spaces specified by the blue print.
8. Give ways in which partitions and floors can be made more nearly sound proof in tenement houses.

Experiment 26

COLOR

Name ____________________

Date ____________________

OBJECT: To study the principle of selection of pleasing colors in laying floor coverings.

MATERIALS: Assortment of colored construction paper: standard color wheel and masks to fit each of the eight commonly used color schemes.

DIRECTIONS: Study picture on next sheet, Fig. 2. The carpenter laying floor coverings, many times finds it necessary to use various colors to make different harmonizing patterns. This experiment should help make this problem easier.

(a) Look through a prism toward sunlight. Try to find all colors listed in Fig. 1. Read pages 619 to middle of page 620; 627 to 632 in reference 1. What is the source of color?

(b) Find the meaning of the following words: color, analogous, hue, complementary color, primary colors, contrast, and harmonize.

The basis of color harmony lies in the fact that when the eye perceives a color, the observer feels a need to see the remainder of the primary colors. Yellow, red, and blue are called the primary pigment colors. All other colors can be made from combinations of these three. Color harmonies are balanced relationships between the varying hues or colors of the spectrum. Two types of color combination give pleasing results: schemes of closely related colors, and those of widely contrasting colors. The majority of color schemes will show one dominating color with sufficient

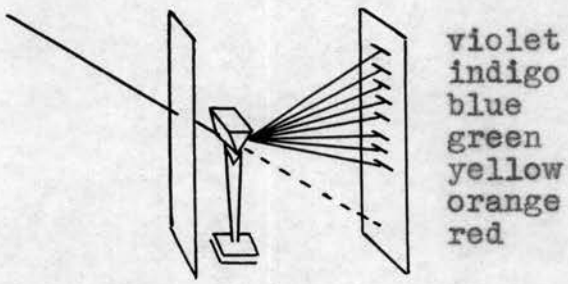


Fig. 1

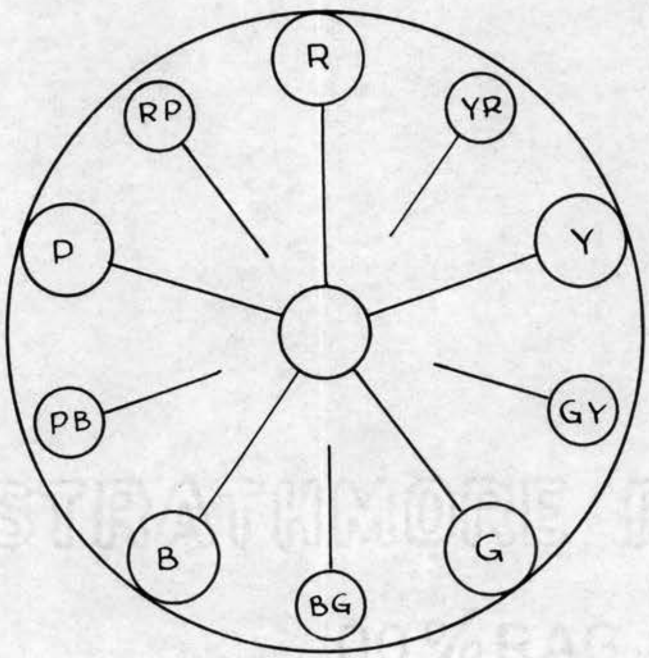


Fig. 2

contrast to the remaining colors to give point to the scheme.

Methods will be given that will greatly aid in the selection of floor coverings by showing a scheme of deriving both related and contrasting color combinations.

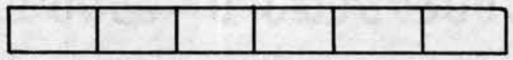


Fig. 3

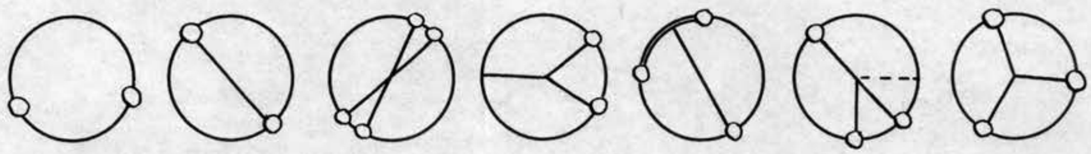


Fig. 4 Fig. 5 Fig. 6 Fig. 7 Fig. 8 Fig. 9 Fig. 10

These are:

Fig. 3. Use any number of required tints and shades of one hue.

Fig. 4. Two or more hues that have the same primary color as a common factor may be used.

Fig. 5. Complementary scheme using any pair of hues which occur opposite each other on the color circle.

Fig. 6. The double complementary scheme containing any two pairs of hue occuring opposite each other on the hue circle.

Fig. 7. The split complement scheme of using three hues, any one hue and the two hues to the right and left of the complement (opposite) of the initial hue.

Fig. 8. By using the analogous complementary scheme containing three or more analogous hues and the

complement of the hue that is predominant among the analogous group.

Fig. 9. The adjacent complementary color scheme may be used, consisting of a complementary pair and third hue that may be adjacent (next to) to the right or left of either member of the pair.

Fig. 10. Triadic scheme, containing three colors which occur at three points equidistant around the hue circle.

The figures above indicate the location of the various hues needed for each of the schemes. Fasten the mask for the desired scheme to the center of the color wheel and by revolving, colors exposed are the combinations that may be used in that color scheme.

RESULTS: Make a pattern of construction paper blocks for a covering 6" X 6" for each of the color schemes.

REFERENCES:

Elizabeth Burris-Meyer: Color and Design in the Decorative Arts, pp. 58-59; 103-114.

Black and Davis: Elementary Practical Physics, pp. 619-620; 627-632.

CONCLUSION:

1. What is color? Name five different colored floor coverings that you have seen.
2. What are the colors of the spectrum (rainbow)?
3. What are primary colors?
4. What does the carpenter mean who describes a floor covering as one possessing a pleasing hue?

5. Observe the dominant color of three downtown department stores. What is it? What color combinations does each have?
6. Why is the red color red, and not green or some other color?
7. What is the physicist's definition of red, green, black, and white?

CHAPTER III

CONCLUSION

The importance of related science in industrial practice has for many years been recognized, along with related mathematics, as fundamental in efficient preparation of industrial workers. Present day workers, whose daily task deals with the practical principles of science in industry, have many deficiencies along this line. This study suggests a method of remedying these deficiencies. A compilation of experiments in physics for the related woodworking trades has been made, based upon Mr. W. Fred Heisler's study, "Elementary Science for the Student of Industry". This book is commonly used as an introduction to applied science in Trade and Industrial Programs in Oklahoma. It should be definitely remembered, however, that principles in related science which may suit one trade may be of little value to workmen in another occupation. The principles which are used in teaching related science should apply to the trade itself. The basic and abstract principles and laws that apply to the trade should be presented to the student. Supplemental experiments that further relate these principles of science definitely to the trade may then be performed in the laboratory. Students receiving such training will not only be more interested in their school work, but more interested in their trades, and will become more intelligent workers. They will then not stop with the experiments given in class, but will go into independent search of new truths. Thus, a thorough grounding in the basic principles of science from a practical standpoint and by a practical method, will be tangible assets for advancement in a trade. According to Geo. P. Hambrecht[1]:

> No community ever went bankrupt in doing something that pays.

The teaching of proper application of the principles of science is considered by many authorities as superior teaching, and as this fact is realized, science will be taught more and more as this study proposes.

Evidence collected in this study shows a lack of experiments in applied science and a need for them as well as considerable activity in the preparation of such instructional materials.

In keeping with current recommendations of industrial educators, all such proposed content should be validated by industrial committees before its final adoption in schools to see that it illustrates current practices.

The compilation of similar supplemental experiments of science for the various trades is needed as the vehicle for diffusion of the principles of science as needed by tradesmen other than woodworkers. These problems seem a worthy basis for further investigation.

It is hoped that this study will not be considered complete for the related woodworking trades, but that it is a means of better training tradesmen, and thus, will aid in helping to make a happier, more useful citizen.

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1. Geo. P. Hambrecht, "The Struggle Against Ignorance", p. 9.

BIBLIOGRAPHY

Black, Newton Henry and Davis, Harvey Nathaniel. Elementary Practical Physics. The Macmillan Company, New York, 1938.

Deming, Frank R. and Nerden, Joseph T. Science in the World of Work. Vol. I-II. McGraw-Hill Book Company, Inc., New York, 1936.

Dooley, William H. Science Training for Metal and Wood Trades. The Ronald Press Company, New York, 1937.

Foley, Arthur L. College Physics. P. Blakiston's Son and Company, Inc., Philadelphia, 1933.

Gillum, Lulu W. Color and Design. The Gillum Publishing Company, Kansas City, Mo., 1931.

Griffith, Ira Samuel. Carpentry. The Manual Arts Press, Peoria, Illinois, 1916.

Hambrecht, George P., "The Struggle Against Ignorance." Wisconsin Magazine, Feb., 1927.

Heisler, W. Fred. Elementary Science for the Student of Industry. State Department, Trade and Industrial Education, 1934.

Hjorth, Herman. Principles of Woodworking. The Bruce Publishing Company, Chicago, Ill., 1930.

Hodgson, Fred T. Modern Carpentry. Frederick J. Drake and Company, Chicago, Ill., 1913.

Hunt, Dewitt. A Manual for Hand Woodworking. Harlow Publishing Corporation, Oklahoma City, Okla., 1938.

Jameson, Joseph M. Elementary Practical Mechanics. John Wiley and Sons, Inc., 1937.

Lynde, Carleton John. Everyday Physics. The Macmillan Company, New York, 1930.

Mersereau, Samuel Foster. Materials of Industry. McGraw-Hill Book Company, Inc., New York, 1931.

Meyer, Elizabeth Burris. Color and Design in the Decorative Arts. Prentice-Hall Inc., New York, 1935.

Prosser, Charles A. and Allen, Charles R. Vocational Education in a Democracy. The Century Company, New York, 1925.

Sears, Frederick E. *Essentials of Physics*. Laurel Book Company, Chicago, Ill., 1933.

Stephenson, Reginald J. *Exploring in Physics*. The University of Chicago Press, Chicago, Ill., 1935.

United States Department of Agriculture, Bulletin No. 1500, Washington D. C., 1929.

Weed, Rexford, and Carroll. *A Workbook and Laboratory Manual*. The John C. Winston Company, Chicago, Ill., 1935.

Whitman, Walter G. *Household Physics*. John Wiley and Sons, Inc., New York, 1924.

APPENDIX

Nelagoney Public Schools
DEPARTMENT OF INDUSTRIAL ARTS
C. H. PREWETT, SUPERVISOR
Nelagoney, Oklahoma

Form I

Feb. 2, 1938

Dear Supervisor:

The students on the A. and M. Campus during the summer of 1937 were very much interested in having more related science material developed. It is the purpose of this study to ascertain the need for supplemental science experiments and applications for the state prepared reference "Elementary Science for the Student of Industry".

In order to prepare practical functioning material in applied science, it is first necessary to know specifically what is needed by students for effective vocational preparation. Will you please list your needs for material such as applied experiments: ______________________________ and other aids __________________ __________________. All information included in this study will be supplemented by studies of the writer and all suggestions in the thesis will be validated by industrialists. The results of this cooperative study, when finished, may be secured through the A. and M. College Bookstore at Stillwater, Oklahoma.

Note: The following blanks may be filled in by the supervisor, coordinator, related subjects teacher, shop teacher, or a combination of these.

Your cooperation in assisting Mr. Prewett in his study will be greatly appreciated and will enable us all to profit more from the material he prepares and submits for graduate credit.

H. A. Huntington

1. Name and position ______________________________
(One filling in blanks)
2. Address ______________________________
3. Type of vocational education program in your school system: General Industrial _____ Diversified Occupations _____ All Day Trade _____ Others _____ _____ _____ _____
4. References you use in teaching applied science:

Author	Title	Publisher
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

5. Would you prefer the material for related science classes resulting from this study to be prepared in loose leaf _____ or book form _____?
6. Please forward to the writer experiments that you use and feel would help other related science teachers, together with this blank. (These may be general or they may be applied to a specific vocation.)

Note: Please use experiment form similar to enclosed sample.

Experiment

WATER AS A SOLVENT

Statement of purpose:

Apparatus needed:

Procedure:

Picture or
illustration

Results:

Applications:

Form II

Nelagoney Public Schools
DEPARTMENT OF INDUSTRIAL ARTS
C. H. PREWETT, SUPERVISOR
Nelagoney, Oklahoma

March 12, 1938

Dear Sir:

It is believed that every science teacher has an experiment he uses that is especially practical for teaching related science in the industrial vocational field.

You have been suggested as one who would possibly be willing to cooperate in this study. You can assist by filling in and returning the enclosed blank with an experiment.

The results of this study will be made available. Do you desire a copy?

Please accept my thanks for your cooperation.

Sincerely yours,

C. H. Prewett

FILL IN AND RETURN THIS BLANK

Approved ______________

1. Name and position ______________________________
2. Address ______________________________________
3. Type of vocational education program in your school system: General Industrial ____ Diversified Occupations ____ All Day Trade ____ Others ________ ________
4. The experiment to be filled in the blank form below may be general or it may be applied to a specific vocation.

EXPERIMENT FORM

(Title)

Statement of purpose:

Apparatus needed:

Procedure:

Results:

Application:

Nelagoney Public Schools
DEPARTMENT OF INDUSTRIAL ARTS
C. H. PREWETT, SUPERVISOR
Nelagoney, Oklahoma

Form III

March 30, 1938

Dear Sir:

A manual is being prepared to accompany the textbook of related science published by the Vocational Department of the State of Oklahoma.

The purpose of this study is to find what other cities and states have done in this field.

It will be greatly appreciated if you will forward a copy of a manual or some of the experiments used by your city or state, or send names and addresses of persons that can supply available material.

The results of this study will be made available through the State Vocational Department located at Stillwater, Oklahoma.

Please advise if there are any charges.

Sincerely yours,

C. H. Prewett

Nelagoney Public Schools
DEPARTMENT OF INDUSTRIAL ARTS
C. H. PREWETT, SUPERVISOR
Nelagoney, Oklahoma

Form IV

April 10, 1938

Dear Sir:

A manual is being prepared to accompany the textbook of related science published by the Vocational Department of the State of Oklahoma located at Stillwater.

It is believed that every teacher of related science has experiments he uses that are especially practical for teaching related science in the industrial vocational field.

You have been suggested as one who would possibly be willing to cooperate in this study. You can assist by sending a manual or some experiments used by your city or state. Please advise if there are any charges.

The results of this study will be made available. Do you desire a copy?

Accept my thanks for your cooperation.

Sincerely yours,

C. H. Prewett

Typist

Golda Hamaker Prewett