1941

The workbook in physics.

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THE WORKBOOK IN PHYSICS

RICHARDSON - 1941

THE WORKBOOK IN PHYSICS

by

JESSE O. RICHARDSON

A Problem in Partial Fulfillment of the Requirements
for the Master of Science Degree

Massachusetts State College

1941

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THE INTRODUCTION

CHAPTER I

The Introduction

The place of science in the curriculum has become increasingly more important since the beginning of the present century. The influx of new scientific developments has created a much more complex world than existed a generation ago. We are living in an age in which rapid changes are the usual thing, rather than the exception. It has become necessary to prepare the present-day pupil to meet and cope with rapidly changing social problems, most of which have their origins in science or technology. The boys and girls of this age must be able to understand these forces and their ramifications if they are to live most effectively. From its first beginnings as a study of the more obvious aspects of nature, science as a part of the curriculum has been expanded bit by bit until now it includes many separate sciences, such as Biology, Physics, Chemistry, Botany, Zoology, Bacteriology, Electronics, and many others. In the teaching of any one of the sciences, the method used should enable the student to attain certain goals so that his adjustment to the problems of life about him may be effective and complete.

(1) Aims of Science Teaching: The aims of science teaching should be to enable the student first, to form accurate generalizations; second, to appreciate

the background, the history of scientific development and the biographies of its great men; third, to help develop desirable attitudes on the part of the student; fourth, to develop the very effective scientific method of attack on problems. Science has played an important part in bringing about many of our social problems, and probably will continue to influence our social trends for some time to come. Therefore, science is obligated to the pupil to give to him those values which will help him make his adjustments so that he will be most benefited by them. In order to insure that these goals of science teaching are to be attained, the teacher should select those methods and materials which will be most effective for the particular branch of science that he happens to be teaching.

(2) Need for Effective Physics Teaching: The presentation of the subject of physics to the student involves the collection of laws or generalizations and their practical applications, the demonstration that many common everyday devices are governed by these laws, and the fact that many problems that seem difficult at first can be easily solved by the application of these laws. Also, the student must develop the scientific method of problem solution, which will be valuable to him after the completion of his school training. It is the contention of many that the above cannot be entirely accomplished by the use of a textbook alone; some

supplementary material is needed which will give practical applications of physical laws, guide the student in problem solution, and develop the scientific methods of adaptation and thought needed today. Such a supplementary teaching aid is the physics workbook.

(3) Stated Advantages of a Workbook: The workbook is usually designed for use with any textbook. This makes for versatility and utility, and allows the instructor to arrange the class work so that it will be most effective. The workbook provides a comprehensive, tested group of laboratory experiments and supplementary exercises covering the complete course in physics. Noll[1] makes this statement:

> The principle....that workbooks, although they seldom seem to, result in greater learning as measured by objective tests of achievement in science.....depends therefore on the assumption that workbooks are worth using because they stimulate pupils to self-activity, that they present a well-organized and comprehensive set of problems and that they result in feelings of greater accomplishment and satisfaction on the part of the pupil. There seems little room to question these assumptions.

The workbook is designed to present the material clearly, accurately, and attractively, thus arousing the interest of the pupil, training him to think logically, with a definite purpose in view. As compared with a textbook, the workbook is more flexible, allowing the

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[1] Noll, Victor H. The Teaching of Science in Elementary and Secondary Schools; pp. 51-52

instructor to adapt the material to his particular group of students and teaching situation, so that the pupil will get the most from his learning experiences.

(4) Definition of a Workbook: The necessity for defining the term "workbook" has arisen. For the purposes of this study, a workbook is defined as any type of supplementary material, bound as a volume, designed to be used with a textbook and serve as a guide to study, problem solution, and experimental procedure, as in the case of physics or other sciences.

(5) This Study: This study is concerned with an attempt to present objective information about the value of a workbook as a teaching aid in general physics. More especially, this study attempts to discover the extent to which the workbook has influenced the learning process in general physics. The method of this study involves a consideration and comparison of test grades of pupils using the workbook with the grades of pupils not using the workbook. The workbook chosen for this study is the "Directed Activities in Physics", by W. O. Brooks, instructor in physics of the Science Department, Technical High School, Springfield, Massachusetts.

STATEMENT OF THE PROBLEM AND PROCEDURE

CHAPTER II

Statement of the Problem and Procedure

As indicated in the preceding chapter, the purpose of this study is to measure the effect of using a workbook on achievement in physics in Grade 10. The problem to which an answer is sought is as follows:

(1) Statement of the Problem: Does the use of a workbook increase the effectiveness of teaching in Elementary General Physics in Grade 10?

(2) The School: The Technical High School is located in the city of Springfield, Massachusetts. The high school, consisting of about two thousand pupils, emphasizes technical and industrial training, preparing its graduates for either college study or jobs in industry where such training is a necessity. The study of Physics is a required part of the curriculum, giving the students basic preparation in mechanics, heat, sound, light, and electricity. The Physics course may be said to be a typical one.

(3) The Subjects and Groups: The subjects, sixty-nine boys, were the members of two freshmen classes taking General Physics. This presented an ideal situation, using one class for the control group, and the other for the experimental group. The naming of the groups was done arbitrarily, the class meeting during the third daily period being chosen as the control group, and the class meeting during the seventh daily period being chosen as

the experimental group. Not all the pupils of the two classes were participants in the experiment, the paired pupils being the actual participants. In all, twenty-eight pairs were involved, one member of each pair in the control group and the other member in the experimental group.

(4) Pairing of the Subjects: Pairing of the pupils was done on the following basis:

(a) Chronological age (range of three months)
(b) Intelligence quotient (within five points as shown by the Henman-Nelson Group Test of Mental Ability)
(c) General average of all school marks in the ninth grade (by letter grades)
(d) Ability in physics (within two points as determined by the Torgerson-Rich-Ranney Tests in High School Physics)

(5) Materials: The materials used in the study were as follows:

(a) The Torgerson-Rich-Ranney Tests in High School Physics was test chosen for this study. Form A was used as the pretest and Form B as the final test. This test is compiled "so that it may be used as a general survey test or as a diagnostic test covering all details, not only for a whole semester's work, but also for any one of the main divisions. Also, it may be used to test the information gained by the student, or to test the student's ability to apply his knowledge (by use of the problem tests) or both."[1] The authors feel that the test is not only valid as a whole, but its separate sections when used by themselves, are also valid. "All means, statistical and otherwise, were used to insure the high reliability, validity, and objectivity that the test and its divisions enjoy."[2]

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[1] Manual of Directions, Torgerson-Rich-Ranney Tests in High School Physics

[2] Ibid.

(b) Directed Activities in Physics, by W. O. Brooks, was the workbook used by the experimental group. This workbook covers a full year of physics; because the experiment was to be for only one semester, the first section of the workbook, covering Mechanics and Heat, was the only part of the workbook used. Letters of commendation from physics teachers in many parts of the country have been received since the workbook was published. Because of this, it was felt that the book is representative of accepted procedure, and was satisfactory for use in this experiment.

(6) Textbook: The textbook used by both the control and experimental groups was Modern Physics, by Dull, one of the standard physics texts used in the Springfield Senior High Schools.

(7) Procedure: The procedure used was as follows:

(a) The pretest having been given and the other data relative to the pairing having been collected, the pupils were paired according to the arrangement in the section of the chapter entitled "Pairing of the Subjects"
(b) The experiment was begun on October 21, 1940. This date was selected because it was the beginning of a new marking period.
(c) The workbook was issued to the members of the experimental class.
(d) The experimental group used the workbook in conjunction with the textbook. The control group used the textbook without any supplementary material. Everything else as far as possible was kept similar in both groups. The subject matter and the teacher were the same for both classes. The only variable was thus the use of the workbook by the experimental group. The pupils had no knowledge of the experiment or its purpose.
(e) The experiment covered a period of twelve weeks, dealing with the subjects of Mechanics and Heat. In all, eighteen units were completed at the rate of three every two weeks. The customary teaching schedule

was maintained throughout the experiment.

(f) On October 21, 1940, Form A of The Torgerson-Rich-Ranney Test in High School Physics was given to both groups. Form B of the same test was administered at the conclusion of the experiment on January 27, 1941, after twelve school weeks of investigation.

The results of the study are shown in the following chapters.

RESULTS OF THE PAIRING

CHAPTER III

Results of the Pairing

In any experimental study of this kind it is necessary that all items, expect the variable under consideration, should remain constant. What are the items which might affect the results of this study? At once the matter of intelligence, chronological age and school marks come to mind. These were used as the basis for pairing the pupils. The following tables show the success in controlling these items.

(1) Results of Pairing for Intelligence: Table I shows the results of pairing for intelligence.

Table I

The Results of Pairing for Intelligence

Intelligence Quotient	Control group	Experimental Group
125	2	2
120	1	3
115	3	3
110	6	6
105	8	6
100	4	4
95	2	3
90	2	0
85	0	0
80	0	1
Mean	108.6	109.5
Standard Deviation	8.9	10.5

Table I shows the mean intelligence quotients to be 108.6 and 109.5 for the two groups. This difference is

considered insignificant so far as the results of the experiment are concerned.

(2) Results in Pairing for Chronological Age: Table II shows the results of pairing for chronological age.

Table II

The Results of Pairing

for Chronological Age

Chronological Age	Control Group	Experimental Group
16-7	1	2
16-4	2	
16-1	2	3
15-10	3	3
15-7	5	3
15-4	2	9
15-1	6	2
14-10	4	3
14-7	2	2
14-4	1	1
Mean	15-6	15-6
Standard Deviation	6.9	6.7

Table II shows the mean ages to be 15-6 and 15-6 for the two groups. Since the two means are the same, it can be assumed that so far as chronological age is considered, the two groups are identical in nature.

(3) Results in Pairing for Average Ninth Grade Marks: Table III shows the results of pairing for average ninth grade marks. It will be noted that the marks are letter grades instead of numerical grades. As a result, the pairing due to these values is not as accurate as

the results from Table I or Table II. However, the accuracy is sufficient to allow the results to be used for pairing purposes.

Table III

The Results of Pairing

for Average Ninth Grade Marks

Average Ninth Grade Marks	Control group	Experimental group
A	1	1
B	5	4
C	15	14
D	7	9
E		
Mean	C	C

It will be noted from Table III that the means are the same, showing that the two groups are approximately the same as to the average ninth grade marks.

It is now evident that the two groups pair up very closely in all of the three criteria used in the pairing process. Any differences in the means of either Table I, Table II, or Table III are so small that they can be considered insignificant.

(4) Other Items and Their Control: Several other items also may affect the results of a study of this kind. They are:

(a) Time of day of class periods.

The time of the class periods was not the

same for the two groups. The control class met during the third daily period, and the experimental group met during the seventh and last daily period. This would tend to place the experimental group at a disadvantage, due to the factor of fatigue, which tends to slow down the learning process as the school day progresses.

(b) The size of classes

If the sizes of the two classes differ appreciably, the rate of learning might differ with the two. However, the sizes of the control group and the experimental group were thirty-six and thirty-three respectively. This difference is so small as to have little effect on the results.

(c) The instructor

The instructor for both classes was the investigator, so that any chance of variability in the value of instruction was eliminated.

From the information shown in this chapter regarding control the conclusion is suggested that one variable and only one variable is present and that any additional gains accruing to any group are due to the presence or absence of a workbook.

RESULTS OF THE STUDY

CHAPTER IV

Results of the Study

The evaluation of the effects of the workbook was made by means of a testing program. A pretest gave the position of the classes before the experimental work began; a final test showed the achievement at the end of the experiment. The results of these testings are shown below.

(1) The Pretest: The pretest given was Form A of The Torgerson-Rich-Ranney Test in High School Physics and was administered on the day that the experiment started. The results are shown in Table IV.

Table IV

The Results of the Pretest

Score	Control group	Experimental group
26	0	1
24	1	1
22	4	0
20	2	1
18	1	1
16	3	4
14	4	6
12	3	5
10	3	5
8	7	4
Mean	14.6	14.0
Standard Deviation	5.3	4.5

The fact should be noted that there is a difference of 0.6 between the means in the favor of the control

group, showing that the achievement of the control group on the pretest was slightly higher than that of the experimental group.

(2) The Final Test: The final test was Form B of The Torgerson-Rich-Ranney Test in High School Physics and was administered on the last day of the experiment. The results are shown in Table V.

Table V

Result of the Final Test

Score	Control group	Experimental group
55		
50		1
45	1	1
40	3	7
35	2	9
30	9	6
25	6	3
20	5	1
15	2	
Mean	30.8	36.5
Standard Deviation	8.6	6.5

It will be noted that there is a difference of 5.7 points between the means in favor of the experimental group. This difference, when compared with the difference in the pretest scores, shows a net gain for the experimental group of 6.3 points. The fact should be noted that the rate of increase of the experimental group was more rapid than that of the control group.

This would tend to show that the achievement of the experimental group had increased more than that of the control group. This fact will be borne out in the next table.

(3) Comparison of Gains: Since the means of the two groups on the pretest were not exactly equivalent one further computation remains. That is to compare the gains of the two groups. This comparison is shown in Table VI.

Table VI

Comparison of Gains

of Experimental and Control Groups

Gains	Control group	Experimental group
32	0	1
29	1	1
26	0	4
23	1	6
20	5	9
17	8	4
14	5	2
11	2	1
8	4	0
5	2	0
Mean	16.1	22.3
Standard Deviations	5.8	4.5
Standard Error of Means	1.1	0.85
Standard Error of Difference between Means		1.42
Critical Ratio of Difference between Means		4.52

Table VI shows that so far as achievement in physics is concerned, as indicated by the comparative gains made on test scores by the control group and the experimental

group, the experimental group using the workbook made a considerably larger gain than did the group using only a textbook. The critical ratio of 4.52 is large enough so that one can have confidence that the difference is reliable. The critical ratio must be at least 3.0 to be statistically reliable.[1] If the experiment were to be repeated, it can be assumed that the gains would again favor the use of a workbook as supplementary material.

A summary of the findings of this chapter is found in Chapter V.

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1 Garrett, Henry C. Statistics in Psychology and Education p. 134

SUMMARY AND CONCLUSIONS

CHAPTER V

Summary and Conclusions

The problem which this study sought to answer was as follows:

(1) The Problem: Does the use of a workbook increase the effectiveness of teaching in Elementary General Physics in Grade 10?

(2) The Method: The method utilized in getting an answer to the problem was the equivalent group method in which all possible variables were controlled except the one variable under consideration; the workbook. The success of the control is shown in Chapter III.

(3) The Conclusions: The conclusions derived from the tabulation of results are as follows:

(a) The use of a workbook brought about an additional increment of gain for the experimental class over the control class.

(b) The additional gain was sufficiently large as to be statistically reliable.

(c) The results were in favor of the experimental group despite the assumed disadvantage of this group in being scheduled the last period of the day and the suggested fatigue factor involved.

(d) The results of the experiment are sufficiently promising to encourage the use of the workbook in physics and to encourage additional experimentation to discover the categories of abilities of pupils particularly aided by the workbook.

(4) Limitations: The limitations of a study of this kind are those usual concomitants of the experimental method in schools, such as:

(a) the fact that the usual schedule of classes permits only small groups to be compared.

(b) the fact that the tests measure only the tangible and objective phases of the work.

(c) the fact that the personal bias of the instructor may lead to increased enthusiasm favoring one method.

APPENDICES

SAMPLE PAGES FROM THE WORKBOOK

SURVEY QUESTIONS

1. Define the term work in its scientific sense.....
   .....
2. If one pushes against a heavy box without moving it, does one accomplish any work?..... Explain .....
   .....
3. What is the difference between work and power?.....
   .....
4. How was the unit called the horsepower derived?.....
   ....
5. How much work is done by 1 horsepower in 1 minute?....
   .....
6. What is the difference between kinetic and potential energy?.....
7. Give an example to show how potential energy may be transformed into kinetic energy.....
   .....
8. State the Law of Conservation of Energy..... .....
   .....
9. Name six simple machines. (a)..... (b).....
   (c)..... (d)..... (e) ..... (f).....
10. Explain the three ways in which machines may make it easier for man to perform work. (a).... .....
    (b)..... (c).....

THE INCLINED PLANE

Data

Trials	Resistance	Effort	Height	Length
1				
2				
3				
4				

Results

Trials	Mechanical Advantage		Input	Output	Efficiency
	theoretical	actual			
1					
2					
3					
4					

Related Questions

1. How is the mechanical advantage of an inclined plane determined from its measurements? .....
   .....
2. How is the mechanical advantage of an inclined plane determined by experiment? .....
   .....
3. Why is the mechanical advantage by experiment usually less than the theoretical result? .....
   .....
   .....

EXERCISE TO SUPPLEMENT THE LABORATORY WORK

I. WORK

1. Work, in the scientific sense, means the overcoming of .....

2. Unless a body is ....., there is no work accomplished.

3. The common unit for measuring work in the English system is the .....

4. This unit is equal to the work done in raising.... ..... a distance of .....

5. The corresponding unit in the metric system is the ... .

6. A farmer loading his truck raises 100 lb. of grain a distance of 4 ft. The farmer does ..... ft.-lb. of work.

7. The absolute unit for measuring work in the English system is the .....

8. The amount of work required to raise a certain object a given distance in Boston is (more than, less than, equal to) ..... the amount of work required to raise the object the same distance in Miami. Because of the fact illustrated by this, accurate measurement of work in the English System requires the use of the unit called the .....

9. In the metric system the absolute unit of work is the .....

SAMPLE UNIT FROM THE COURSE OF STUDY

ELEMENTARY PHYSICS I
Mechanics of Fluids

Unit 1 - Properties of Matter

The nature of this subject makes it a good one in which to make use of the pupil's own experiences, and these should be fully drawn upon. There should be little problem work in this general course, but a liberal use of diagrams drawn on the board by the teacher and pupils.

References

Dull - Modern Physics, pp. 1-15
Black and Davis - New Practical Physics, Chap. VIII
Henderson - The New Physics in Everyday Life, pp. 2-4, 126-152
Higgins - Introductory Physics, Chap. II

Visual Aids

Much apparatus
Lantern slides
Exhibits of materials
Charts
Many diagrams

Apparatus and Materials

Diamond glass cutter
Quartz crystal
Soap solution
Olive oil
Alcohol
Glass capillary tubes
Tank of liquid CO_2
Eudiometer tube
Molecular model of mercury in glass tube
Wire tester
Lantern slide of gold leaf
Wires
Wire die
Spring balance
Beam balance
Thirty pound iron ball pendulum
Inertia apparatus
Glass adhesion plates
Glass funnel

Procedure

Demonstrate and discuss the following:

1. The three states of matter
   Heat iodine. Make dry ice if a carbon dioxide tank is at hand
2. Viscosity
   Heat glass rod to show pasty state
   Illustrations - glacier flow, oil in engine

3. Diffusion
   Vapor from ammonia bottle
   Use in ventilation
4. Molecular constitution of water
   Expt. Eudiometer half full of water, then filled up with alcohol. After mixing, the total volume is less than the sum of the parts.
   Expt. Heat the mercury molecular model to show the dance of the molecules as imitated by the glass bits in the tube.
5. Porosity
   Intermolecular spaces. Gold will absorb mercury. Diagram on block before and after compression.
6. Cohesion
   Attraction among like molecules
   Variation in solids, liquids, gases
   Effect of heat on cohesion
7. Properties dependent on cohesion
   Tenacity - Break wire in testing machine
   Hardness - Exhibit diamond glass cutter, cut with it, quartz crystal. Test by scratching
   Brittleness - Peanut brittle as an example
   Malleability - Lantern slide of gold leaf. Show book-lot of gold leaf.
   Ductility - Exhibit wire. Show die through which the wire is drawn.
8. Elasticity - Rubber bank, spring
   - Uses - Clock spring, balance, pneumatic tire
9. Crystallization
   Project in lantern the crystallization of salt or other common substance that will crystallize.
   Exhibit crystals of quartz and other examples obtained from the chemical laboratory.
   Uses - to purify substances, gems.
10. Weight
    Attraction of the earth for a mass
    The beam balance. The spring balance.
    Weight - a measure of the amount of matter in a body
11. Inertia
    The "laziness of matter"
    Suspend heavy ball as a pendulum and operate by pulling thread gently. Then break the thread by sudden pull, showing ball "hang-back" Use two ball rotating apparatus of Chicago Apparatus Co., snap card from under steel ball.
    Emphasize tendency of matter to resist having its state of rest or motion changed.

12. Adhesion
Attraction of unlike molecules
Chalk adheres to blackboard. Compare with cohesion
Adhesives such as glue, solder, tape, cement, painting.

13. Surface tension
Place greased needle on water.
Expt. Soap film across wire frame with thread loop. Break thread inside loop. Show film elastic and stretched.
Expt. Blow soap bubble with glass funnel. Watch film contract and crawl up the tube. Use castile soap powder and cold water.
Suspend oil drop between water and alcohol in a beaker.
Explain why surface layer of molecules is stronger.
Practical application - making of lead shot. Picture of shot tower.

14. Capillarity
Name hair-like tube. Pass capillary tubes around the class. Put tubes in water. Ask class to observe close at hand. Use lantern projection if possible. Repeat for mercury.
Examples - Thermometer tubing, oil in wicks, sap in trees, ink in blotters, moisture in soil.

15. Density
The mass per unit volume of a substance.
Show lead and aluminum cylinders of volume. Pass around the class.

Testing

Give a ten minute written lesson at the beginning of each period. One full period test per marking period, at least. This may well be a new type test, quickly scored. Some form of laboratory test is advised, sample of which is attached. This test may well be given after the entire unit of liquid pressure is completed.

Minimum Results

A better understanding of the nature of matter that will be of decided help while considering many topics of later work.

SAMPLE OF THE PRETEST

Score in Mechanics.....

Score in Heat.....

Total Score .....:.....

THE TORGERSON-RICH-RANNEY TESTS IN HIGH SCHOOL PHYSICS

Test 1 Form A

THE C. A. GREGORY COMPANY
345 Calhoun Street, Cincinnati, Ohio.

MECHANICS AND HEAT

Pupil's Name..... Grade.....

Age: Years.....**Months**..... **Boy** .....**Girl** .....

City or Post Office.....**Name of School**.....

Teacher's Name.....**Date: Year**.....**Month**.....

This test consists of four parts: Completion Test in Mechanics, Problems in Mechanics, Completion Test in Heat, and Problems in Heat. Place all answers and formulas at the right of the columns where it says "Put your answers here," except where it says to place them in the figures or drawings.

The student should be equipped with two sharp pencils. Read the statements thoughtfully. Do not spend too much time on any one item which you cannot readily complete, but go on to the next item. If time permits, return to the items that caused difficulty.

The following examples will show you how this is to be done.

	Put your answers here
1. One horse-power equals———— kilowatts.	Answer three-fourths
2. Six horse-power will lift———— pounds 3 feet high in 10 seconds.	
Formula $H.P.=\frac{\text{lbs.} \times \text{ft.}}{550 \times \text{sec.}}$	
Or $H.P.=\frac{\text{ft. lbs./sec.}}{550}$	
Answer	11,000 lbs.
3. An ordinary suction pump———— be used to pump water from a well 60 ft. deep.	Answer cannot
4. The atmospheric pressure at sea-level on the top of a cube 6 inches square is ————.	Answer 529.2 lbs.

COMPLETION TEST (MECHANICS)

Time 15 minutes

Put your answers here

1. Energy is ability to do————. ————

2. To make the clock run faster, the length of the pendulum must be————. ————

3. The output in a machine is always ————than the input. ————

4. If one kg. weight stretches a spring one inch, six kg. will stretch the same spring————inches. ————

5. A body floating in a liquid displaces its————in the liquid. ————

6. The resistance which a body offers to being moved over another body is called————. ————

7. The density of water is one gram per cc., or————lbs. per one cu. ft. ————

8. The upward force upon a body submerged in a liquid is called————. ————

9. Milk and cream are separated by the cream separator. The process illustrates ————force. ————

10. The tendency of a body to remain at rest or continue in motion in a straight line is called————. ————

11. The "Laws of Motion" were developed by————. ————

12. Density equals————divided by ————. ————

13. The weight of a book is————at the equator than at the poles. ————

14. The pressure of the air will support a column of mercury about————inches high in a barometer at sea level. ————

Put yo answers

15. One inch equals————cm. ————

16. Momentum is a product of———— ————

17. A submerged body displaces its ————in liquid. ————

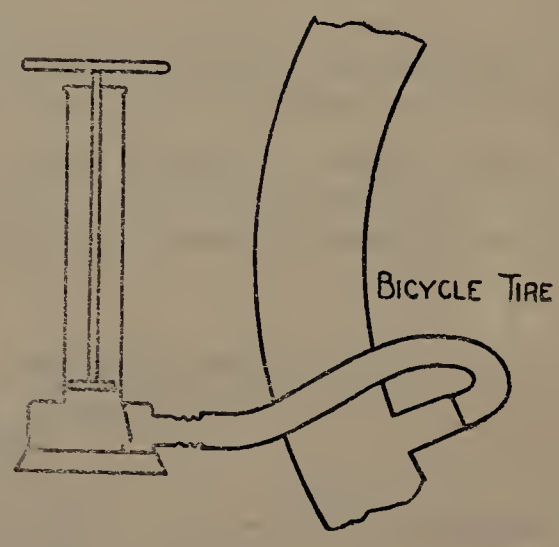
18. The force of molecular attraction within a substance is called————. ————

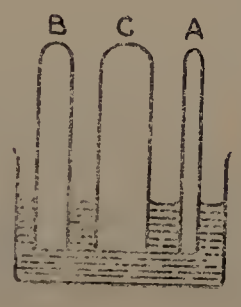
19. The force which imparts to a gram of mass an acceleration of 1 cm. each second is called a————. ————

20. The work done by a force of 1 dyne when its moves the point on which it acts 1 cm. is called the————. ————

21. The product of a force times the perpendicular distance to its point of rotation is called the————of the force. ————

22. Indicate by arrows where air enters the cylinder and where it leaves.



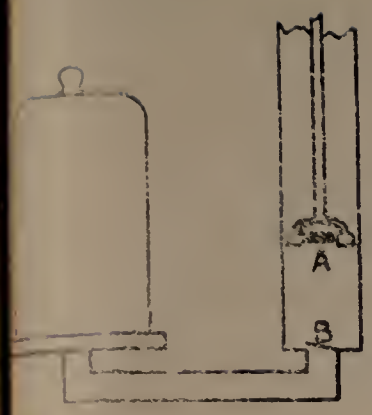


23 Rise of water in capillary tubes.

a. Water rises highest in tube————. ————

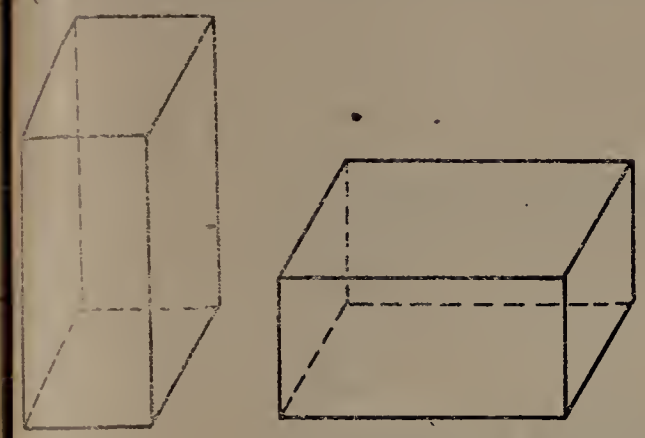
b. Water rises least in tube————. ————

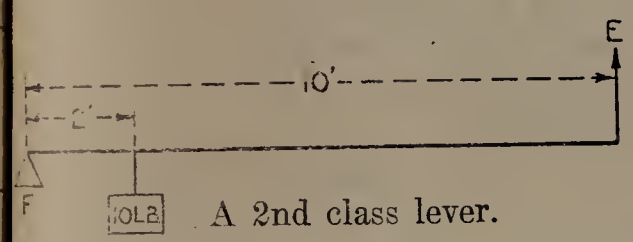
Put your answers here



24. For exhausting the air from the bell jar, upon the down stroke of the piston, valve ————is open. _____

25. Locate by a cross (X) the center of gravity in each.

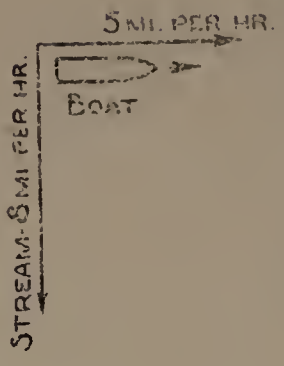




A 2nd class lever.

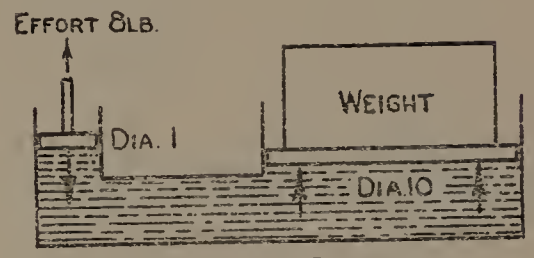
26. Find the amount of force, E. answer _____

Put your answers here



27. Show the resultant of the two component forces. Make drawing at left.

28. The diameter of the small piston at the left is 1 inch. The diameter of the piston at the right is 10 inches. If a force of 8 lbs. is exerted upon the small piston, what weight can be lifted? _____



PASCAL'S PRINCIPLE

Score=Number of correct items _____

PROBLEMS IN MECHANICS

Time 30 minutes

Place your answers and formulas on the blank lines provided for that purpose. Use the correct symbols. Do your work on blank sheets, provided. Don't spend too much time on a problem. If you cannot do a problem, go on — come back later if you have time. Name units of answer where asked.

1. How many ft. lbs. of work is done when a 10 lb. weight is lifted a distance of ½ foot?

formula _____

answer _____

2. A force of 50 lbs. is used to do 1000 ft. lbs. of work. Through what distance does the force move?

formula _____

answer _____

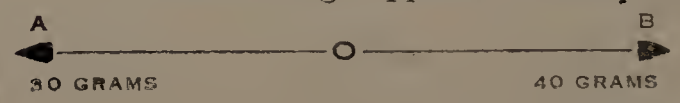
3. How many ft. lbs. of work is done when a girl weighing 125 lbs. climbs a stair 12 ft. high,

formula _____

answer _____

4. Indicate the resultant in each of the following problems.

a. Forces acting opposite directions.



answer _____

Put your answers here

b. Forces at an angle: Complete the parallelogram. Show the resultant in the space below.

c. Forces acting in parallel downward as the teeter-board balanced at the center, What force would produce equilibrium? _____

Where applied? _____ _____

5. A 2000 lb. car strikes a telephone pole with a velocity of 44 ft. per sec. What is its momentum?

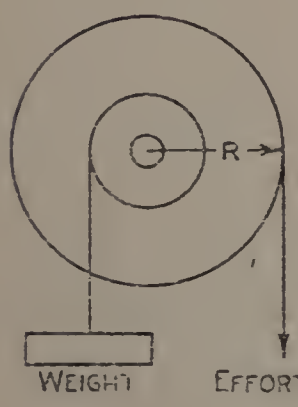
formula _____

answer _____

6. A man weighing 124.8 lbs. just floats. What volume of water would he displace when submerged?

formula _____

answer _____



7. Wheel and axle. Weight is 8 lbs.; radius of small circle 2 in.; radius of large circle 8 in. How large a weight can be lifted?

formula _____

answer _____

8. *a.* A stone falls to the bottom of a dry well in 2 sec. How deep well.

formula _____

answer _____

b. What is its final velocity as it reaches the bottom? formula _____

answer _____

Put your answers here

9. A tank 8 ft. long, 6 ft. wide, and 6 ft. deep is filled with water.

a. Find the air pressure upon the upper surface of the water. Use normal atmospheric pressure (14.7 lbs. per sq. in.)

formula _____

answer _____

b. Find the pressure per sq. ft. exerted upon the bottom by the water only.

formula _____

answer _____

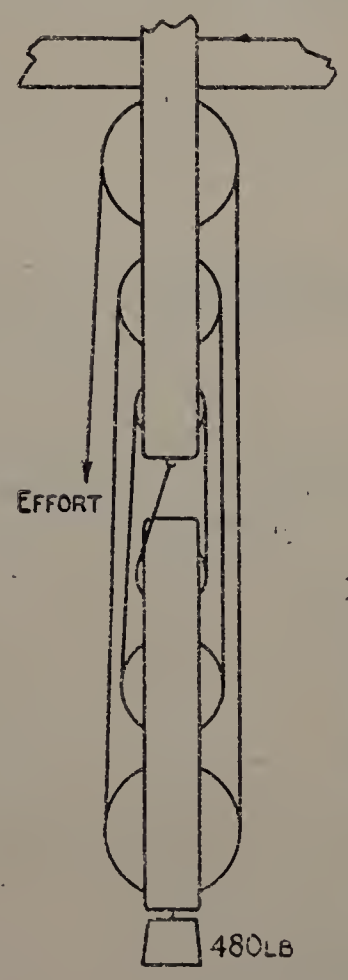
10. Find the total force exerted upon any side by the water (only) in the above tank.

formula _____

answer _____

11. A rifle weighing 5 lbs. discharges a 1-ounce bullet with a velocity of 100 ft. per sec. What will be the velocity of the rifle in the opposite direction?

answer _____



12. These multiple pulleys have 80% efficiency. How much effort is necessary to lift a 480 lb. weight?

formula _____

answer _____

Score=Number of correct items _____

Total score on Mechanics = _____

COMPLETION TEST (HEAT)

Time 20 minutes

Put your answers here

1. A thermometer is used to measure ————— ———————

2. Iron is a————conductor of heat than wood. ———————

3. If the motion of the particles of a body is increased, the body becomes————. ———————

4. The best temperature for a school room is about————degrees, Fahrenheit. ———————

5. Heat is transmitted through a vacuum by the principle of————. ———————

6. All energy can be divided into two classes; heat is classified as———— energy. ———————

7. Silver is a good————of heat. ———————

8. The freezing point of water on the centigrade scale is————degrees. ———————

9. The body temperature is about ————degrees, Fahrenheit. ———————

10. The boiling point on a Fahrenheit scale is————degrees. ———————

11. According to Charles' Law, the volume of a gas varies directly as the ————temperature. ———————

12. The amount of heat required to raise 1 gram of water 1 degree centigrade is called the————. ———————

13. The amount of heat given off when 1 lb. of water cools 1 degree Fahrenheit is called the————. ———————

14. In the first process used in determining the mechanical equivalent of heat, the experimenter produced heat by a process of churning————. ———————

Put your answers here

15. The first experimental determinations of the mechanical equivalent of heat were made by————. ———————

16. The degree of hotness or coldness of a body is called its————. ———————

17. Heat, according to the kinetic theory, is a form of motion called————. ———————

18. The circulation of air in an ice box is due to a process called————. ———————

19. Hot air rises in pipes because hot air————and is forced upward by the cold air. ———————

20. When air is heated, it————because of the pressure of the surrounding air. ———————

21. The cold air register should be placed————in a room. ———————

22. Hot water forms————currents when heated. ———————

23. When water of room temperature is heated, its————increases. ———————

24. Surfaces which are good absorbers of ether radiation are also————radiators. ———————

25. Surfaces which are good reflectors, like the polished metals are————radiators. ———————

26. The vacuum between the walls of a thermos bottle prevents heat exchange by processes of (a)————. ———————

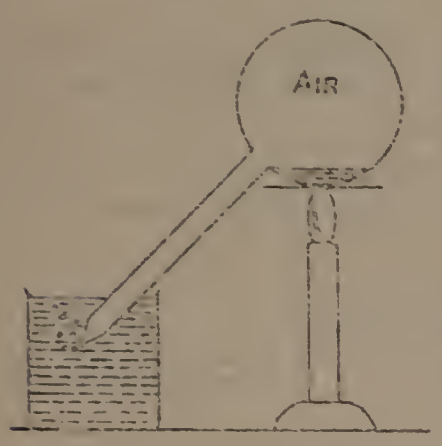
27 (b)————. ———————

Put your answers here

28. The rates of expansion due to temperature changes————in different liquids. ———

29. A definite weight of water has its smallest volume at————degrees centigrade. ———

30. When air has absorbed all the moisture possible at a given temperature, it is said to be————. ———



31. When the flame is taken away, the water will————in the tube. ———

32. This apparatus illustrates the———— of gases when heated. ———

33. The rise in the tube is due to the————as its temperature is lowered. ———

34. To melt one gram of ice requires————calories. ———

35. A comparison of the amount of moisture found in the air at a given time with the amount it could hold at that time is called————. ———

36. At ordinary pressure, ice melts at zero degree centigrade. To make ice melt at a lower temperature, the pressure must be————. ———

37. Fusion means the same as ———— ———

38. The heat of vaporization of a gram of boiling water at atmospheric pressure, at its boiling point, is about———— calories. ———

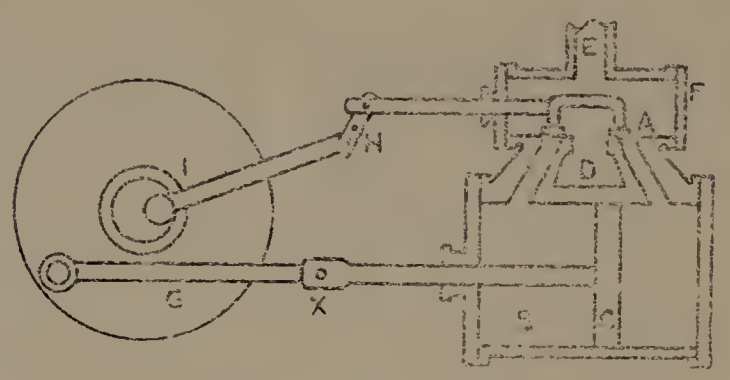
39. The total number of calories of heat required to change one gram of ice at −10 degrees centigrade into steam is about————calories. ———

Put your answers here

40. Any heating of metal, if below the melting point, causes it to————. ———

41. The steam engine was invented by ————. ———

42. Steam engines have a———— efficiency. ———



In the diagram above.

43. ————is the sliding valve. ———

44. ————is the cylinder. ———

45. ————is the piston. ———

46. ————is the steam chest. ———

47. ————is the flywheel. ———

48. The fly wheel of a engine keeps moving after the power is turned off on account of————. ———

49. ————are not used on locolarge pipes. ———

Score=1/3 Number of correct items ———

PROBLEMS IN HEAT

Time 30 minutes

Put your answers here

1. How many calories of heat are absorbed when 40 grams of water vaporize with no change in temperature?

formula _____

answer _____

2. Change 98.6 degrees Fahrenheit to centigrade.

formula _____

answer _____

3. How many calories of heat are freed or liberated when 40 grams of water freeze?

formula _____

answer _____

4. How many calories of heat are absorbed when 90 grams of water (sp. ht.= 1) are warmed 30 degrees centigrade?

formula _____

answer _____

5. Change −40 degrees Fahrenheit to centigrade.

formula _____

answer _____

6. An iron pipe 20 feet long is heated from 40 degrees to 100 degrees centigrade by steam. What will be the increase in length? (coef. of expansion is .000012)

formula _____

answer _____

7. One day the thermometer registered 15 degrees Fahrenheit. The next morning it was zero. Fnd the change in temperature in centigrade degrees.

formula _____

answer _____

8. How much heat is required to turn 100 grams of water at 10 degrees centigrade into steam at 100 degrees centigrade?

answer _____

Put your answers here

9. How much heat is required to melt 5 grams of ice and warm the water formed to 20 degrees centigrade? answer _____

10. How much alcohol at 60 degrees centigrade must be mixed with 100 grams of water at 40 degrees centigrade in order that the temperature of the mixture may be 56 degrees centigrade? (sp. ht. alcohol is .8) answer _____

11. A balloon containing 2000 cu.ft. of hydrogen gas leaves the ground partially inflated under a normal pressure of 76 cm. and at a temperature of 20 degrees centigrade. What will be its volume when the balloon has risen to such a height that the barometer stands at 50 cm. and the temperature is at 20 degrees centigrade?

answer _____

12. A gas under pressure of 750 mm. of mercury occupies a volume of 500 cc. What will be the volume at 300 mm., the temperature remaining the same?

answer _____

13. An automobile tire has 40 lbs. of pressure per sq. ft. at zero degrees centigrade. After the car was driven, the temperature was 34 degrees centigrade. What is the air pressure in the tires?

answer _____

14. Some lead shot weighing 501 grams, after being heated to a temperature of 97 degrees centigrade, were poured into a calorimeter (sp. ht.=.1) containing water at a temperature of 15 degrees centigrade. After being well mixed, the temperature of the mixture became 25 degrees centigrade. The weight of the calorimeter when empty was 105 grams. The weight of the calorimeter and the water was 207 grams. Find the specific heat of the lead. answer _____

BIBLIOGRAPHY

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It was considered of value in this study to give a bibliography of a few selected references. The selection was made with the view of meeting the needs of anyone who might contemplate continuing the investigation from where this study ended; and who, therefore, would desire to build up a background of information with regard to what has been done in the subject.

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Problem approved by:

Albert W. Purvis

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