CONSTRUCTING AND EVALUATING PRACTICE EXERCISES IN MATHEMATICS FOR STUDENTS OF VOCATIONAL AGRICULTURE IN ARIZONA

DISSERTATION

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By

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CHAPTER I.

INTRODUCTION

Need For The Study

With the rapidly increasing volume of subject matter available for use at all levels in the educational program, the problems of selecting content and maintaining efficiency in teaching procedures are more important than ever before.

The content for certain service courses, such as English and mathematics may be roughly divided into two groups, namely, those specific abilities needed in certain vocations and the more general abilities needed by all individuals in the regular civic and personal responsibilities of everyday living. While it is not difficult to isolate the abilities in mathematics needed for a well defined vocation, educators in general have not used this approach in developing course content, but have built courses upon the concepts and traditions of the past. As Brueckner points out, "the problems found in texts do not arise out of a felt difficulty or real problematic situation for the learner."¹

^{1.} Brueckner, Leo J., "The Nature of Problem Solving," Journal of The National Education Association, Vol. XXI, No. 1, Jan., 1932, pp. 13-14.

It is the opinion of educators and laymen alike that our present methods of teaching mathematics are not developing the essential abilities either for the vocations or for solving the problems of everyday living.

The Ohio Survey of Elementary Mathematics by Wood¹ shows the general lack of ability in the basic processes. He analyzed the scores of 5363 pupils who took the Ohio Scholarship Test in Arithmetic in 1931. The possible score in the test was 58. The summary of results are as follows:

> 99% of the pupils made less than 28.3 90% of the pupils made less than 19.2 50% of the pupils made less than 12. 25% of the pupils made less than 8.6

While these scores are very low, other studies of this nature show similar conditions.

A study was made by the author to determine the ability of seniors in vocational agriculture to solve common farm problems in mathematics. This was done by analysis of test scores made by high school seniors who took the College of Agriculture scholarship examination at Ohio State University in 1938. This examination was made available to all seniors in Ohio high schools. A total of 373 students took the examination in competition for 20 scholar-

Wood, E. R., "A Report of the Degree of Mastery of The Needed Elementary Tools of Mathematics," <u>Bulletin of</u> <u>The Ohio State Department of Education</u>, No. 24, Columbus, 1931, p. 65.

TABLE I.

SUMMAR	RY	OF	SCORES	ON	S	CHOLARS	SHIP	EXAMJ	INATION	I
GIVEN	ΒY	- C(OLLEGE	\mathbf{OF}	AGI	RICULTI	URE,	OHIO	STATE	
			UNIVER	SIT	Υ,	APRIL	, 193	38		

فالمحمانة المحماد المتعادي والفانية المتقاصية وينتقي ويلهون	والمراجع المحاط والمحاط والمحاط والمحاج والمحاج المحاط المحاط والمحاج والمحاط المحاط	فنعد منصبات سيكفا المستحمال متلكر بمباغ والمسيات	ومحارب والمحارب والمتراج والمتحاد والمحافي والأراد المعاقبات	والبالي ويشرون بيري والمراجع والمراجع والمستوال	
	Scores for 352 Agriculture students		Scores for total group 373 students		
	Mathematics	Total	Mathematic	s Total	
	Score	Score	Score	Score	
Possible Mean Median	12 6.1448 5.9512	100.5 58.0511 61.500	12 6.1738 6.5000	100.5 58.4090 61.5000	
Correlation	•66	356	•6	677	

ships which the College of Agriculture offered to the students making the highest scores. Since there were about 70,000 students graduated from Ohio high schools in 1938 these students represent a rather select group as to scholarship, and 223 of the group taking the test indicated they would enter college in the fall of 1938. The students were largely from farms and 352 of the group studied vocational agriculture in high school. Most of them completed the four year course.

An analysis of the scores are given in Table I. Both groups, those who studied vocational agriculture, and the group as a whole, made correspondingly lower scores on the mathematics section than they did on the entire examination.

Expressing the scores in percentage, the agricultural group made 51.206 on the mathematics section and 57.762 on the entire examination.

The scores on mathematics were analyzed to determine the types of problems most difficult for the students participating in the examination. This was accomplished by tabulating the problems solved correctly by 100 students selected at random from the total list of 373.

The twelve problems used in the examination are listed in the order of their difficulty with the percentage of students that were able to obtain the correct answer to the problem.

Problem 1. 20 percent

Find the average number of eggs for all breeds in the following problem.

In an egg laying contest conducted by the New Jersey Experiment Station the total eggs produced in one year for each of the breeds represented were as below.

Breed	No. of Birds	Total eggs per year	Average eggs per bird for year
Barred Plymouth Rock	9 8	19,213	
White Plymouth Rock	20	3,806	**
Rhode Island Red	127	25,368	and all and the
Single Comb White Leghorn	595	123,579	
Single Comb Black Minorca	20	2,982	

Problem 2. 26 percent

A dealer buys 92 heads of cattle for \$3036. He sells 30 at 8% profit and 35 at 15% profit; he loses 3 and sells the rest at cost price. How much does he gain?

Problem 3. 36 percent

If 40 cattle eat 280 bushels of corn in 112 days, 60 cattle will eat 350 bushels in how many days?

Problem 4. 38 percent

A group of farmers consigned cooperatively a car load of fat cattle weighing 28,860 pounds to a commission firm who sold them at $8\frac{1}{4}$ cents. Their commission for selling the load was \$22.00 plus an extra charge for grading of \$3.00 and a charge of \$2.50 for prorating the returns. What was the commission firm's gross charge per pound for selling the cattle?

Problem 5. 39 percent

In a right triangle the side opposite the right angle is called the hypotenuse. A theorem in geometry says the hypotenuse is equal to the sum of the squares of the other two sides. What is the length of the hypotenuse of a right triangle whose sides adjacent the right angle are 36 feet and 40 feet?

Problem 6. 54 percent

A farmer's wife purchased a washing machine for \$125.00 and then it saved \$1.00 per week in wages. If the machine depreciated \$25.00 per year, what rate of income does she make on the investment?

Problem 7. 57 percent

What would a steer weighing 1325 pounds and purchased at $6\frac{1}{2}$ cents per pound have to sell at per pound dressed to equal the purchase price if it dressed 62%?

Problem 8. 58 percent

What is the cost of owning a binder for one year if the cost is \$225.00, the depreciation is 9% and money is borrowed at the rate of 7% to make the purchase?

Problem 9. 58 percent

If there is required \$2500.00 to equip a 120 acre farm that cost \$5000.00, what must be the added returns to the farm in order to meet the interest of 5% on equipment, and a 5% depreciation charge on the equipment?

Problem 10. 65 percent

A steer weighed on foot 1165 pounds and dressed out 65.5 pounds for each 100 pounds live weight. What was the dressed weight? Give answer to the third decimal.

Problem 11. 74 percent

If 190 bushels of apples make 16 barrels of cider, how many barrels of cider will 38 bushels of apples make?

Problem 12. 91 percent

Find the average number of eggs per bird produced for each of the breeds in problem No. 1.

The analysis substantiates the findings of similar efforts to determine the types of problems most difficult for students. The difficulties are not identified with specific operations in mathematics but with complexity and relationship of the operations within the problem. For example, problem one which only 20 percent of the pupils could solve involved the same principles of percentage as problem 12 which 91 percent solved correctly. The only difference was the variation among the quantities involved in the five items of the problem. The difficulty seems to be with the students' inability to understand the practical meaning of the problem and to select the mathematical operations to use in its solution.

Objectives of the Study

The practice of agriculture in this country is rapidly becoming an exact science in which mathematical abilities are playing a role of increasing importance. The national program for agriculture with its controlled production and conservation has brought to the producer new and varied problems of economics.

Teachers and students of vocational agriculture in the secondary schools have discovered serious weaknesses in our present plan of training for specific abilities in mathematics needed for the vocation of farming. The objective of instruction in vocational agriculture is the development of efficient individuals in their several

branches of agriculture. There are certain essential abilities required before the learner can proceed with the sosolution of a farm problem. Too often the learning activity is blocked until the student can master the required ability. Thus the teacher of agriculture must become a teacher of service mathematics for his field. Through constant contact with this situation the writer was prompted to undertake this study.

The objective of this study therefore may be stated as follows:

- 1. To construct a list of practice exercises for students of vocational agriculture in Arizona to be used in improving the abilities to solve mathematical problems commonly found in farming.
- 2. To improve the practice exercises as a result of actual use in classes of agriculture.

Further analysis of the objectives reveal a number of secondary problems on which the study should give some information. The following are some of the more important questions.

- What types of abilities in mathematics do farmers in Arizona need most?
- 2. What types of problems can best be used to

develop these abilities?

- 3. Does the use of practice exercises increase the learner's ability to solve crucial agricultural problems involving mathematics?
- 4. Will students of vocational agriculture be interested enough in the practice problems to use them effectively?
- 5. Will the problems increase student interest in the study of crucial farm problems involving mathematical processes?
- 6. Are the exercises appropriate to the needs of a group of young men engaged in farming?
- 7. How many problems should be included in a set of practice exercises for students of vocational agriculture?
- 8. In what ways may the practice exercises be improved?
- 9. What is the best plan of using the practice exercises in an educational program?

Some Basic Assumptions

Whenever possible, evidence will be given in this study in support of the assumptions, but they are set forth at this point in the work as fundamental premises upon which appropriate techniques and procedures for the study may be projected.

- There are certain abilities in mathematics that are essential to a successful farming business.
- 2. These abilities are somewhat peculiar to the agriculture of Arizona and the Southwest.
- 3. Problems including mathematical abilities representative of the vocation can be found in the current agricultural literature and obtained from successful farmers and specialists in agriculture.
- 4. A selected group of experienced, well educated farmers are able to evaluate the problems.
- 5. Three criteria, (a) Significance of the problem in the successful operation of a farming business, (b) frequency with which the mathematical problems are used in farming, and (c) difficulty of the problems, are adequate criteria for use in evaluating the problems.
- 6. A list of appropriate practice exercises will be of value as a device for developing abilities in agricultural mathematics.

CHAPTER II.

REVIEW OF RELATED LITERATURE

Studies Relating To Content

Recent studies in determining abilities in mathematics for certain vocations have done much to make instruction in this field more functional. In general the abilities needed require far less complicated mathematical operations than those contained in the traditional course in mathematics.

The mathematical processes essential for physics in Ohio High School were studied by Berger.¹ He discovered 1779 problems, 70% of which required merely arithmetic treatment for solution.

Tyler's study of the mathematics of commerce courses at The Ohio State University, shows the need for understanding the problem as a basis for developing ability in the more common mathematical operations. He concludes,

> In general, however, the students' difficulty is not how to perform arithmetic operations in solving problems but rather which operation to use in a given problem. The analysis of the

^{1.} Burger, Harvey O., The <u>Mathematical Processes Essen</u>-<u>tial for Physics in Ohio High Schools</u>, (Master's Thesis), The Ohio State University, 1934, p. 57.

problem so as to determine the operations to perform it is the major difficulty.¹

He also found that,

Very little algebra beyond simple linear equations is involved in any of the problems but arithmetic operations are involved in all the problems.²

Beyond the four fundamental operations with whole numbers percentage, and decimal fractions are most frequent.³

While the number of studies is meager in the field of consumer mathematics the findings likewise indicate that the simpler operations in mathematics are adequate for general needs.

In a study of consumer uses of arithmetic Bowden found that sixty percent of the people participating in the study used little, if any, arithmetic beyond the four fundamental operations. He concludes that,

> We have been teaching more than 85% more arithmetic than is required for use in life situations, i.e., store buying, making change, reading, investing savings, writing letters and traveling.4

In selecting course content the problem of finding

^{1.} Tyler, R. W., "The Mathematics of Commerce Courses," Unpublished Manuscript on file in the reference library, Bureau of Educational Research, Ohio State University, p. 4.

^{2. &}lt;u>Ibid</u>., p. 2. 3. Tyler, R. W., <u>loc</u>. <u>cit</u>.

^{4.} Bowden, A. O., "Consumers Uses of Arithmetic," New York, Teachers College, Columbia University, Contributions to Education, No. 340, 1929, p. 47.

the most crucial teaching situations is of major importance. The final list of problems may be reduced by careful selection of types.

Osburn and Drennon found that "there is also marked transfer even in the case of pupils of low intelligence." They recommend to "teach a few of the more important types thoroughly and depend upon transfer for the remainder."¹

In a study of the mathematics of Dairy Technology, Frutchey listed 470 problems from an analysis of the literature. All the problems but one could be solved by ordinary arithmetic and elementary algebra. He concludes, "Evidently there is no need for a knowledge of higher mathematics in the solution of these problems."² A course in college algebra and plane geometry are required in the Dairy Department intended to assist the students in solving problems in Dairy Technology. The study shows,

> The progress of students was the same whether they have had college mathematics or not during the experiment. For the control group those with college mathematics and those without college mathematics made the same progress. The same holds true for the experimental group.³

Frutchey further obtained splendid results from the use of practice exercises in a test with ninety-eight stu-

3. Frutchey, F. P., loc. cit.

^{1.} Osburn, W. J. and Drennan, L. J., "Problem Solving in Arithmetic," <u>Educational Research</u> <u>Bulletin</u>, Vol. X, No. 5, March 4, 1931, p. 128.

^{2.} Frutchey, F. P., The Construction and Evaluation of Practice Exercises in Mathematics Pertaining to Dairy Technology, (Doctor's Thesis), The Ohio State University, 1932, p. 71.

dents of Dairy Technology in five colleges. In one institution the experimental group showed a mean increase of 4.39 problems, as compared with an increase of 2.43 problems for the control group. In the other four institutions the experimental group increased in ability by 4.17 problems per student as compared with an increase of 2.02 problems for the control group.

Studies Relating to Methods of Teaching

Any program for the improvement of functional abilities in mathematics must contain new approaches to method as well as the use of more appropriate content. The following studies on this phase of the problem offer some suggestions for formulating such a program for students of vocational agriculture.

A plan of teaching functional mathematics should use some effective means of teaching an appropriate vocabulary. How can the learner solve the problem if he is unable to understand its meaning?

Washburne¹ found that a knowledge of the problem situation was one of the most important factors in the difficulty of a problem. From an experiment with 500 pupils Dresher concludes that,

^{1.} Washburne, Carleton, and Morphett, Mabel Vogel, "Unfamiliar situations as a Difficulty in Solving Arithmetic Problems," Journal of Educational Research, Vol. 18, No. 3, Oct. 1928, pp. 220-24.

Apparently, vocabulary training does help the pupil to understand and work concrete problems. Pupils cannot work problems if they cannot understand them; they cannot understand the explanation of problems if they do not understand the terminology used.

In a study of the Teaching Unit in mathematics Wapples and Stone listed the four major difficulties encountered by students in solving problems, one of which was "Difficulties in vocabulary."2

The traditional course in mathematics does not give the learner practice in recognizing the significance of the problem in its natural setting, and yet this is the ability most needed in solving the large majority of problems both in the vocations and daily living.

This condition is well expressed by Schaffer who states,

> So many of us have come up through a course in mathematics that has been merely a series of routine drills to establish skill in juggling symbols and signs and which has blinded us to the fundamental concepts involved and to the universality of their application.3

A thorough study of the individual and his rate of

^{1.} Dresher, Richard, "Training in Mathematics Vocabulary," Educational Research Bulletin, Vol. XIII, No. 8,

Nov. 14, 1934, p. 203. 2. Wapples, Douglas and Stone, A. S., <u>The Teaching Unit</u>, <u>A Type Study in Mathematics</u>, New York, D. Appleton Company, 1929, p. 108. 3. Schaeffer, N. F., "Teaching Mathematics Through Exper-

iences," Practical Educator, Sept. 1931.

progress is necessary in adjusting methods of teaching to individual needs. On this point a statement by Neiden in a recent article on a remedial program in mathematics is appropriate.

> To understand fully the true achievement and progress of the pupils, one must have known and studied them personally by means of their daily oral and written work, their changed attitudes and by a comprehensive study and understanding of their individual record sheets; in short, by knowing what they came in with and what they went out with.¹

It is very important that the student understand the setting and situation of the problem. This undertaking is best accomplished by selecting appropriate problems rather than through the efforts of the writer to familiarize the student with the case through a word picture or elaborate description.

The ineffectiveness of this plan is shown by Wheat's study of performance of students of arithmetic in the intermediate grades. He concluded that extra explanation neither hindered nor helped in the solving of problems. The pupil must provide for himself whatever of imaginative elements that is needed. The problems may therefore be stated briefly and concisely.²

^{1.} Neiden, Benjamin, "A Remedial Mathematics Program," <u>California Journal of Secondary Education</u>, XIII, No. 7, Nov. 1938, pp. 435-440.

^{2.} Wheat, H. G., <u>The Relative Merits of Conventional and</u> <u>Imaginative Types of Problems in Arithmetic, Teachers</u> <u>College, Columbia University.</u> <u>Contributions to Educa-</u> <u>tion</u>, No. 359, 1929, p. 121.

According to Richardson there are three rather well defined methods of teaching mathematics. The first is extremely academic and shuns all application to the practical as being unworthy of minds capable of understanding abstract mathematics. The attitude seems to be that,

> No vulgar application shall be brought to destroy the beauty, harmony and superlative logicality of this body of absolute truth.

The second plan and the one in most common use today is to present definitions, axioms, and principles near the beginning of the chapter or lesson, then to use practical illustrations to clarify and adorn the principles. Drill exercises are set up to develop skill in the application of the principles. One need only examine the socalled practical illustrations or problems of a textbook to discover that they are far from real. This situation prompted the statement by Comstock that, "No one outside of geometry classes ever draws a perpendicular after the method of the books."²

The third plan develops mathematical concepts and principles from problem situations and experiences of the learner. Many instructors accept this plan in theory but in practice they still make the traditional principles

^{1.} Richardson, Marion W., "Mathematics for Vocations," <u>Pro-</u> ceedings of The High School Conference, November 18, 19 and 20, 1926, Urbana, University of Illinois, 1927, p.263.

^{2.} Comstock, C. E. "The Mathematical Laboratory," <u>School</u> <u>Mathematics</u>, <u>Supplement to School Science</u> I, April 1903, p. 14.

the center of their teaching activities.

Appropriate practice exercises in the mathematics of agriculture should implement the third plan of teaching, in two ways. First, they should be of value to the teacher of mathematics by offering a selected list of practical problems from the vocation of the learner and his family. Second, such a list should aid in remedial teaching to the extent of stimulating self-improvement through practice on the problems when the learner actually needs to use the mathematical operations in the vocation.

Frutchey says,

The term practice exercise has a broader meaning than the word 'drill' and covers all types of learning in which some practice is involved.¹

Summary

A review of the literature as well as first hand observation emphasizes a need for a more efficient approach to the whole problem of training for the common abilities in mathematics. The more important situations which seem to substantiate this statement may be summarized as follows:

1. Students who have successfully completed the usual school courses in mathematics are not

^{1.} Frutchey, F. P., "The Significance and Application of Practice Exercises," <u>Educational Research</u> <u>Bulletin</u>, Volume XI, No. 3, Feb. 3, 1932, p. 65.

efficient in solving the more practical problems encountered either in the vocations or everyday living.

- 2. Content in mathematics courses has been developed for its continuity and function as a school subject rather than for usefulness in the life of the learner.
- 3. Students in general are limited in their ability to apply principles and operations in mathematics to the more complex problematic situations even though they are skillful in using such operations in the more simple exercises.
- 4. A knowledge of higher mathematics is not necessary for solving the majority of problems found in the vocations and the regular duties of everyday living.
- 5. Analyses of fields of work for discovering needed abilities in mathematics has increased the efficiency of training programs for such responsibilities.
- 6. Courses should be composed of type problems set into situations as closely related to the learners experience and background as possible.

- 7. Technical vocabulary is an important item in the development of abilities to solve mathematics problems in any given field.
- 8. Practice exercises have been used with good results in the field of Dairy Technology.

CHAPTER III.

COLLECTING AND EVALUATING THE PROBLEMS

Collecting And Consolidating The Problems

At least two methods could be used in collecting a list of mathematical abilities pertaining to farming. They could be secured directly from successful farmers engaged in the various branches of agriculture or they may be obtained by analysis of the literature.

The latter source was used mainly, because the literature is rather complete and contains problems involved in the newer practices of farming. The problems are definitely stated and the literature is readily available for study. Some use was made of farmers on problems of local importance pertaining to practices of recent origin, on which little written matter could be located. Another valuable supplement to the literature was the information received from specialists at the College of Agriculture, and teachers of agriculture in the state.

All problems which seemed to have any bearing on the agriculture of Arizona, were collected from literature. Books, bulletins, farm magazines, and periodicals were used. Special attention was given to the publica-

tions of the State Experiment Station and College of Agriculture, also the publications of neighboring states where problems in agriculture are similar to those of Arizona. It was necessary to set up some criteria to use in making a selection of problems. Therefore, a problem for this case was defined as a problematic situation pertaining to some phase of agriculture, with certain assumptions given so that it might be solved by mathematical processes.

Several hundred problems were isolated before beginning the work of consolidating or telescoping. In this process, type problems were selected as being similar in mathematical operations and content within the problems. The following problems are rather similar as to mathematics involved since both deal with simple percentage.

> An acre of potatoes produced 285 bushels, 252 bushels of which graded number 1. What percentage of the crop was number 1 grade?

The list price per ton of fertilizer is \$46.50. The price per ton, cash with the order, is \$44.25. What percentage of the regular price is saved by paying cash?

While it is desirable to give the student practice in as many types of problems as possible, the final list must be kept small enough that sufficient drill can be given to fix the type abilities as a part of the learner's experience. The list was finally reduced to 104 problems. Since the abilities involved in the more important type problems were finally set in practical farming situations as practice exercises, this should facilitate the transfer of abilities from one problem to another and thus tend to decrease the number of types needed in the final practice exercises.

The list is not intended to be complete for all situations that arise in connection with the agricultural practices carried on in the state. It does, however, represent some of the more important problems according to the literature and the opinion of certain specialists in the field of agriculture.

Evaluating the Problems

The vocation of farming covers a broad field, and includes such a vast number of mathematical problems that some method of selection and elimination must be followed in setting up a list of usable exercises. The exercises in mathematics textbooks of today are selected largely by tradition and from opinions of writers who are primarily mathematicians rather than agriculturists. The problems are far from practical as the following examples from textbooks on agricultural arithmetic¹ will illustrate.

^{1.} Stratton, W. T. and Remich, B. L., Agricultural Arithmetic, New York, The Macmillan Company, 1916, p. 186.

The length of a side of the square base of the great Pyramid of Cheops is approximately 45 rods, 10 feet. How many acres does the base cover?

Compare such an exercise with the following problem. A farmer wishes to purchase barbed wire to construct a fence of four strands around a square 40 acre field. At a price of four cents per rod, what will be the cost of wire? Forty acres is a common unit for a field in many farming sections; building and maintaining fences is an important cost item in the farm business. In solving this problem the student would tend to acquire a knowledge of facts and relationships of permanent value in the vocation of farming. Two additional exercises from a textbook for students of agriculture will further support this point of view.

> A baseball weighing 5 3/16 ounces was dropped from one of the windows of Washington's Monument and caught 4 feet from the ground by a professional catcher. Compute the work done by the ball, assuming the window to be 545 feet from the ground.

A horse weighing 1250 lbs. sustains 700 lbs. on his front feet. The distance between fore and hind feet is 48 inches. Where is the line of gravitation?²

The probable usefulness of a situation in the vocation will therefore be an important consideration in se-

Rasor, Samuel Eugene, <u>Mathematics for Students of Agri-</u> <u>culture</u>, New York, The Macmillan Company, 1921, pp. 245.
Ibid., p. 265.

lecting content for service mathematics in agriculture.

A criterion commonly used in selecting content for vocational use is the frequency with which it is encountered on the job. Another factor of equal importance is that of crucial significance. There are problems in agriculture that do not arise at frequent intervals but when they do appear their solution is crucial to the success of the whole undertaking. According to Eaton,¹

> The first criteria of selection of content are significance and probability.

The situations in a vocation, the meeting of which successfully means most to society or to the producer and those productive situations which most probably the prospective worker will meet, should obviously have first consideration in the selection of what should be taught to prepare anyone for a vocation.

Since exercise problems are to be used following examples, some criterion must be used for determining the number of exercises to use with each type problem. Obviously this would depend largely upon the difficulty of the problem. Therefore a third factor, difficulty, was included in the list. This criterion was used only as a guide to the number of exercises to include under each problem. It was not used as a basis of selecting type problems for the final list.

1. Eaton, T. H., Education and Vocations, New York, John Wiley and Sons, 1926, p. 167. An adequate analysis for selection of content of a service course should not only find the significant problems but it should also aid in eliminating from the training content abilities that will normally be acquired by the student through experience, and observation in the course of activities on the farm, and abilities that are not needed in the vocation. Concerning this point Charters¹ states,

> If he (the instructor) believes in the service idea, he will include nothing that he cannot validate either as prescribed or connective tissue. If he is committed to the service idea, he will see that no matter what he may teach, the students will have the specified materials.

The next step in the investigation was the selection of a group of judges to evaluate the list of type problems. This task involved two decisions. First, what criteria should be used in the selection of judges? Second, how many judges should be used? One of the basic assumptions of this study included the statement that the agricultural problems of Arizona and the Southwest were somewhat peculiar to the region. From this premise the judges should be well experienced in the various phases of agriculture in the state. The following list of criteria were developed as a basis for selecting the judges.

^{1.} Charters, W. W., "Constructing Service Courses," Educa tional Research Bulletin, Volume XII, No. 5, April 12, 1935, p. 117.

- Should be well experienced in the agriculture of Arizona and, preferably engaged in farming at the present time.
- 2. Should be well educated in the newer practices and trends in the agriculture of the state and the Southwest.
- 3. Should be somewhat specialized in some important branch of Arizona agriculture.

On the basis of these criteria a group of men were selected to serve as judges. The Director of The Agricultural Extension Service for Arizona, and other agricultural leaders offered valuable suggestions in selecting the group. The final number to be used was not determined until the returns from eight judges had been received and tabulated. Five judges were visited and the purpose of the study explained. A written explanation of the procedure to be used in evaluating the problems was also explained and a demonstration given to each judge on the procedure to use in evaluating the problems. The following list of suggestions was used as a guide in evaluating the problems.

Suggestions for Evaluating the Problems

The following is a list of problems from the literature in the field of Agriculture. They are to be evaluated on the following criteria; frequency, importance, and difficulty. It is suggested that you check all problems on the first criterion before going to the second. After you have read a sampling from the list, read them carefully and evaluate as follows:

1. In the column headed F (frequency) mark the problems according to the frequency with which you believe they occur in the duties of a farmer.

> Rarely or never encountered. Place 'l' before problems which occur very rarely and those that to your knowledge never occur in farming.

Occasionally encountered. Place '2' before the problems occasionally met in farming, at least once each year.

Most often encountered. Place '3' before the problems met most often, several times a year in the regular duties of farming.

II. In the column headed I (importance) mark the problems according to significance in the successful operation of the farm business. Some problems occur very rarely in farming but upon their solution rests the future success of the business. While other problems in the list occur quite often on the farm.

Least important. Place 'l' before the problems believed to be of little importance in farming. Those which have a minimum of influence in determining the success of any farm operation or decision.

Average importance. Place '2' before the problems of average importance. Those which always make a contribution to the success of the enterprise under consideration. Most important. Place '3' before the problems you think to be of the greatest importance, those which are crucial factors in the success of the farm business.

III. In the column marked D (difficulty) rank the problems according to difficulty of mastering the operations in solving the problem. This criterion largely determines the amount of time that must be given to drill in developing the abilities.

Least difficult. Place 'l' before the problems you believe to be most easily solved; those that can be mastered from training on other problems, and would scarcely need to be included in an organized course of instruction.

Average difficulty. Place '2' before the problems which require systematic instruction and drill for effective mastery. Those which most students can solve with a minimum of errors after they have been given instruction.

Most difficult. Place '3' before those which most students are unable to solve after completing the usual high school courses in mathematics.

After the returns from five judges had been received these were analyzed according to the procedure indicated in Table II. The percentage of agreement between judges was found to be rather high. Returns were then secured from three additional judges and the percentage of agreement determined for five of the eight judges. Only seven judges evaluated the problems on difficulty. On the basis of the findings indicated in the Table it was decided that eight

TABLE II.

SUMMARY OF JUDGES' RANKING OF MATHEMATICS PROBLEMS USED IN THE PRACTICE EXERCISES

	Frequency	Importance	Difficulty
Percentage of problems on which three of a group of five judges agreed	76	72	50
Percentages of problems on which five of a group of eight judges agreed	48	43	57*

*This figure represents the opinion of four judges in a group of seven.

was a sufficient number of judges to use in evaluating the problems.

The ratings on all problems by the eight judges were summarized and the totals for each problem determined. The totals by problems for the three criteria, frequency, importance and difficulty are contained in Appendix A. Only the criteria of frequency and importance were used in making the final selection of problems to include in the practice exercises. Therefore the highest score any problem could receive from the group of eight judges would be a total rating of 48. As a basis for selection, a minimum of 32 was arbitrarily set up. By this procedure a list of 49 problems was selected from the group of 104 problems
TABLE III.

SUMMARY OF JUDGES' EVALUATION ON MATHEMATICS PROB-LEMS SELECTED FOR USE IN THE PRACTICE EXERCISES

	Evaluation on	Eveluation on	Total score
Problem	frequency	importance	on problem
number	(Possible 24)	(Possible 24)	(Possible 48)
5	17	17	34
6	17	16	33
7	15	17	32
8	21	23	44
13	16	17	33
14	17	18	35
17	21	22	43
18	17	19	36
21	17	16	33
23	17	17	34
24	17	17	34
38	19	20	39
39	22	21	43
40	24	41	45
46	21	19	40
48	23	19	42
49	19	21	40
50	20	22	42
50	10	22	40
02 54	10 15	10	57
0 1 55	16	19	2 4 70
56	10	15	ひん マワ
58	18	18	36
60	16	17	33
63	19	18	37
67	17	18	35
68	21	20	41
69	16	17	33
70	19	22	41
71	20	24	44
72	18	21	39
73	20	20	40
74	21	23	44
75	22	22	$\overline{44}$
81	22	20	42
82	17	15	32
83	20	16	36
85	20	20	40
86	16	16	32

TABLE III. (Continued)

	SUMMARY OF JUDGES '	EVALUATION ON MATHEM	ATICS PROB-
	LEMS SELECTED FOR	USE IN THE PRACTICE	EXERC ISES
		• •	
87	18	18	36
88	18	18	36
89	17	18	35
94	15	19	34
95	18	21	39
96	19	20	39
101	16	21	37
102	15	18	33
103	15	19	34

1. For a complete list of the problems and a summary of the judges' rating on Frequency, Importance and Difficulty see Appendix A.

evaluated by the judges. This list, with the total rating, and score for frequency and importance on each problem, is contained in Table III. From this list the examples to use in the practice exerciseswere selected.

The criterion of difficulty was used as a basis for determining the number of problems to include under the several examples in the practice exercises. The ratings on each of the 49 problems as to difficulty are shown in Table IV. The data in Table III and IV therefore offer adequate bases for the work of constructing the practice exercises.

TABLE IV.

SUMMARY	OF	JUDGI	ES !	EVAL	UAT:	ION	I ON	MATHE	MATICS	PROB-
		LEMS	REI	ATIVI	E T(0 I	DIFFI	CULTY	-	

Problem number	Total score
5	14
6	7
7	9
8	12
13	12
14	15
17	
14 01	10
21 23	10
20	10
27 38	15
39	9
40	8
46	8
48	12
49	16
50	14
51	13
52	9
54	15
00 54	8
58	8
60	10
63	10
67	12
68	ĩĩ
69	11
70	12
71	12
72	15
73	14
'/4 NG	12
75	9
80 01	13
83	13
85	9 1 7
86	10 10
87	13

TABLE IV. (Continued)

88	9
89	8
94	14
95	11
96	15
101	14
102	12
103	12

SUMMARY OF JUDGES' EVALUATION ON MATHEMATICS PROB-LEMS RELATIVE TO DIFFICULTY

Summary

A list of approximately 300 problems in mathematics pertaining to farming was obtained from the literature, specialists in various phases of agriculture and farmers. These problems were consolidated on the basis of similarity of mathematical operations and content, into a list of 104 type problems.

This list was submitted to a total of eight judges for evaluation on frequency importance and difficulty of the problems as they occur in the vocations of farming and livestock production in Arizona. The judges were selected on the basis of educational training in the agriculture of Arizona and the Southwest, actual farm experience, and specialization in some specific phase of the field of agriculture.

Type problems that ranked high on either frequency or difficulty were included in the final list to be used as examples in the practice exercises. The third criterion, difficulty was not used in making the selection of the problems but was used later as a guide to the number of practice problems to include under each ex-Only seven judges evaluated the problems on diffiample. culty. As a basis for making the final selection of type problems, an arbitrary minimum standard of 32 was set up. All problems that did not rank 32 or higher out of a possible score of 48 were discarded. On the basis of this plan of selection, 49 type problems were selected from the original list of 104 submitted to the judges. The reliability of the ratings by the judges was established in two ways, first, on the basis of the criteria used in their selection, and second, by a comparison of the ratings assigned by various members of the group. Comparisons were first made between the scores on the problems by a group of five judges and the total group of eight judges. Three of the five judges agreed on 76 percent of the problems as to frequency and 72 percent on importance. The percentages of agreement for five of the group of eight judges were 48 and 43 respectively. On the criterion of difficulty three of a group of five judges agreed on 50 percent of the problems, and four in a group of seven agreed on 57 percent.

Since the judges were carefully selected as to

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qualifications and there was a high percentage of agreement on the problems, eight was a sufficient number of judges for evaluating the problem.

CHAPTER IV.

CONSTRUCTING AND WRITING THE PRACTICE EXERCISES

Formulating The Practice Problems

The work of constructing and writing the practice exercises is considered one of the most important parts of the study. This teaching-learning device will be used largely as a supplement to regular courses in mathematics and vocational agriculture and as an aid to self-improvement on the various abilities included in the problems. Therefore, it is necessary that the exercises deal with the crucial problems of the learner in a clear, concise, and interesting manner. In the light of these basic principles the following criteria were formulated to serve as guides in writing the exercises.

- The exercises should give practice in the types of mathematical activities used in the business of farming in the region.
- The problems in the exercises should be set in situations appropriate to the training, experiences, and background of the learner.
- 3. The examples used in illustrating the type problems should be clear and contain suffi-

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cient detail to serve as a guide for the student who uses the exercises for self-improvement.

- 4. The examples should be representative of type situations.
- 5. The problems should aid in developing a clear understanding of the entire problem as well as the mathematical abilities in-volved.
- 6. A sufficient number of practice problems should be used under each type, to fix the habits and abilities involved in solving the problems.

7. Answers to all problems should be available.

From a review of studies and observations of teachers, many difficulties in agricultural mathematics encountered by students seem to fall into two large groups, namely, problems in mensuration and those having to do with percentage. On the basis of this conclusion eight problems on mensuration and eight problems dealing with simple percentage were selected from the list of 49 type problems previously selected by the judges. Problems for use as practice under the several examples were selected largely on the basis of practical value in the agriculture of the state. Here again it was necessary to consult the literature, specialists, and farmers to obtain usable situations. Teachers of agriculture offered valuable assistance with some of the sections. Several of the judges compiled lists of problems which they thought to be important in the training of farmers. Some were secured through direct interviews with leading farmers.

Writing the Problems

From the criteria set up as guides in constructing practice exercises, it is important that explanation be given on all problems and procedures. An introduction, planned to serve as a review of basic principles and facts was written for each of the sections in the exercises. A procedure appropriate for solving any problem was set up. It is based upon a simple analysis of the problem into three basic decisions as follows: What does the problem ask me to find? What facts are given? How can I arrange the facts to solve the problem? All examples were explained in full, and the simplest and most practicable plan known was used in the solution of the problem. On this point the author consulted practical teachers of mathematics. Formulas were used wherever they seemed to simplify the operations and all related information needed in solving the practice problems was given. The sections on Mensuration and Percentage each contained eight examples with a total of 46 practice problems in both sections. The 16 problems used as examples represented a sampling from the entire list of 49 problems. They were selected for use with students of agriculture as a means of testing their value as a teaching-learning device. Since the students were to use the practice exercises for only one semester, largely outside of regular class time, it was important that the list be moderate in length.

In preparing the practice exercises valuable suggestions were received from teachers of agriculture and mathematics, specialists in various branches of agriculture and high school students of vocational agriculture. A sampling from the 46 problems was tested in several classes of agriculture before they were released to the schools. This served as a means of improving and refining the final list of problems.

It will be noted from the list, (Appendix B) that many of the problems are peculiar to the agriculture of the region. As an illustration, exercises four and five, example I on mensuration have subject matter value in addition to the mathematical situations involved. The student is drilled on the fact that cotton averaged 520 lbs. per acre, that Arizona produced 161,000 bales, that yield of barley is measured in units of sacks, that a sack weighs about 108 pounds and that the yield is about 14 sacks per acre. The bushel is never used as a unit of grain in this section.

A similar problem is found in example II exercise two under General Percentage. The student learns that cotton often yields one and one-half bales per acre, that percentage of lint is about 38 to 40, and the approximate distance that cotton could be hauled for the additional two percent of lint cotton. He is also introduced to the term "turnout" commonly used in designating the percentage of lint secured from seed cotton. All of these facts have important implications for successful management of the farm business, and are most valuable for the learner when used in the mathematical situations with which they are normally associated. The exercises were designed mainly to introduce the student to this plan of problem solving in the hope that he would be stimulated to draw upon his own experiences and environment for similar problems in the further development of his ability to solve problems in the vocation of farming.

Summary

On the basis of opinion and some experimental evidence found in the literature, the author set up seven criteria to be used as guides in writing the practice exercises. These indicate that the problems should give practice in the mathematical operations used by farmers, they should be set in situations familiar to the learner, and the examples should be clear, complete, and representative of type situations in farming. They should promote an understanding of the entire problem as well as the mathematical operations involved. The list should contain a sufficient number of problems to fix habits and skill. Answers to all problems should be available. A sampling of 16 type problems with 46 practice problems was written for use with students of agriculture in the experiment. The problems were grouped under two headings, Mensuration and General Percentage. A review of principles and suggestions for solving problems was written as an introduction to each of the two sections. Answers to all problems were included in the back of the bulletin.

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CHAPTER V.

EVALUATING THE PRACTICE EXERCISES

Statistical Evaluation

The next step in the study was to evaluate the practice exercises under actual working conditions in the schools, in order to determine if the use of the problems would increase the student's ability to solve mathematical problems commonly found in farming. To do this it was necessary to select a representative sampling of students to be used in the experiment.

The twenty-nine departments of vocational agriculture in the state were studied as to type of student, size of high school, number of years of vocational agriculture offered, and type of farming in the community. Finally eight high schools were selected as offering an adequate sampling for the work. The schools were located at the following towns in the state: Amphitheater, Chandler, Florence, Gilbert, Pima, Snowflake, Tempe, and Yuma. The locations of these points are shown in Illustration I. No first year students were used in the experiment since they would not be familiar with the objectives of instruction in vocational agriculture and it would have been impossible to secure adequate reliable information on

ILLUSTRATION I

LOCATION OF SCHOOLS USED IN THE MATHEMATICS EXPERIMENT

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Schools with departments of vocational agriculture. Schools used in the experiment.



the group for purposes of pairing. They had no experience with farm practice programs as such and would have limited appreciation of the significance of the problems in the practice experiences. The sampling of 182 students at the beginning of the experiment represented 15.71 percent of the advanced students in the state. A total of 15.71 percent of the students finished the experiment, 7.85 percent used the practice exercises, and 27.6 percent of the schools were represented in the experiment. These data are shown in more detail in Tables V, VI and VII. Since the schools and students within the schools were carefully selected to represent an accurate cross-section, this sampling is sufficiently large to insure adequate reliability for purposes of this study.

A list of students enrolled in second, third and fourth year classes of vocational agriculture was secured for each of the eight schools. Information to be used in pairing the groups for the experiment was secured for each student. The items on which information was obtained are listed in Appendix C. The item on reading test score gave no returns, and intelligence test scores were available on a limited number of the students. The latter item is included in the summary in Table VIII since it gives some indication of the performance of the two groups on such tests. Table VIII contains a summary of the data used in pairing

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TABLE V.

NUMBER OF DEPARTMENTS OF VOCATIONAL AGRICULTURE AND ENROLLMENT BY GRADES FOR ARIZONA, 1938-1939

Total number of departments	29	-
Enrollment by grades (years) First year students Second year students Third and fourth year students	565 467 182	
Total	1214	
Number enrolled in second, third and fourth year classes1	649	-

1. No first year students were used in the mathematics experiment.

TABLE VI.

NUMBER OF DEPARTMENTS OF VOCATIONAL AGRICULTURE AND STUDENTS USED IN THE MATHEMATICS EXPERIMENTS

		-
Number of departments used		
in the experiment	8	
Total number of students used		
in the experiment		
At the beginning	182	
At the completion of experiment	102	
Number of students who used the practice ex-		
ercises in mathematics	51	
Number of students in the control group	51	
Total number from which the experimental and		
control groups were selected	649	

TABLE VII.

PERCENTAGE OF DEPARTMENTS OF VOCATIONAL AGRICULTURE AND STUDENTS IN ARIZONA USED IN THE MATHEMATICS EXPERIMENT

Percentage of departments in the state 1938-1939 used in the experiment	27.6
Percentage of advanced students partici-	
pating in the experiment at the	
time of completion	15.71
Percentage of advances students who used	
the practice exercises and comple-	
ted the final test	7.85

the groups. Individuals were first paired, and then the totals for the two groups were used as a basis of pairing the experimental group with the control group.

The number of students completing the experiment was only 102 as compared with 182 at the beginning. This loss in number was due to students leaving school, absence from school when one of the tests were given, or similar irregularities. A comparison of means on the various items used in pairing the control and experimental groups is shown in Table VIII. According to the data, the control group was slightly better qualified since it ranked higher than the experimental group on four of the six items. This condition was reflected in the pre-test scores; the control group making a score of 2193 as compared with 1873 for the experimental group. This represents a mean difference of 6.2 points in favor of the control group. The two groups were still adequately balanced for purposes of this experiment for the following reasons:

- The two groups were rather evenly balanced on the more significant items, namely, grades in mathematics, grades on high school subjects and teachers' estimate of the student.
- 2. Attainment in the experiment was measured in terms of mean progress of the two groups, rather than total attainment at the end of the experiment.
- 3. The balance of the two groups was slightly in favor of the control group which would tend to increase the significance of the mean progress attained by the experimental group.

The number of students who used the practice exercises seemed to be adequate. The following facts are offered in support of this opinion.

> A total of 51 students in eight schools used the exercises. This represented 7.85 percent of the total student population in the state available for such work.
> The standard error of the mean for pretest scores on the control and experi

mental groups as shown in Table XIII were 2.81 and 2.93 respectively. From these data the critical ratio for the two groups was found to be 1.59.

The sampling was a representative cross-section of the students in the state relating to:

- 1. Size of schools and departments of voca-
- 2. Types of farming in the state.
- 3. Types of instructors as to training experience, and success as a teacher of vocational agriculture.
- 4. Scope and quality of farm practice programs.
- 5. Quality of work in general throughout the high school.

Now that the personnel for the two groups had been selected the next approach was to construct and administer a pre-test. This was done by sampling the mathematical operations represented in the list of problems selected by the judges. The test, see Appendix D, consisted of fifteen problems representing a wide range of abilities and content. The problems within the test were weighted and a score of 93 assigned to the entire test. The pre-test was given near the middle of the first semester of 1938,

TABLE VIII.

COMPARISON OF PAIRING FACTORS USED IN SELECTING THE EXPERIMENTAL AND CONTROL GROUPS FOR TESTING THE PRACTICE EXERCISES

	Mee	ng fon	Maa	ng fon	
	182	naired			
	for	the	105	the	
	exp	eriment	exn	eriment	
	Control	Experimental	Control	Experimental	
	group	group	group	group	
Years com- pleted in vo- cational					
agriculture	1.95	1.92	1.69	1.47	
Years com- pleted in					
mathematics	5.83	5,90	5.75	5,19	
Average grade in all mathematics					
courses	3.29	3.28	2.80	2.84	
Average grade in all high school	••••			~~~~	
subjects	3.28	3.47	3.05	2.90	
Teacher's es- timate of					
student	3.28	3.35	2.92	2.80	
Intelligence					
test score	97.8	92.7	98.2	92.7	
(number of					
<u>cases</u>)	(11)	(15)	(4)	(4)	

under conditions as nearly uniform as possible. The students were requested to do the work to the best of their abilities and were allowed sufficient time to solve all problems for which they seemed qualified. After the test had been collected, copies of the practices exercises were made available to all the students in the experimental

TABLE IX.

PRE-TEST	AND	FIN	AL	TEST	SCORES	FOR	THE	EXPERIMENTAL
GRO	OUP]	IN T	HE	MATHE	EMATICS	EXPE	ERIME	ENT

			Points
Student	Score on	Score on	increase or
number	pre-test	final test	decrease
	70	05	~
4	32	25	/
	32 77	20	= 7
12	71	02	71
14	02 00	04 70	2 קר
20	<i>22</i> 00	27 20	<u>፲</u>
24 09	22 41	09 76	17 25
20	41 77	70 85	20 Q
30 30	() 50	40	- 10
30 70	52	91 	- 10
40	59	88	20
40	ט <i>ט</i> קו	91	20
72 AA	49	65	16
46	27	61	34
48	26	ĩŝ	- 10
50	69	ล้า	12
52	12	18	
54	44	85	41
56	79	77	- 2
58	14	36	22
60	51	38	- 13
62	35	35	Ō
72	42	27	- 15
80	42	46	4
82	19	63	44
86	30	36	6
88	0	21	21
90	20	26	6
94	18	24	6
96	0	5	5
98	9	16	7
100	30	30	0
130	55	57	2
132	41	66	25
134	14	65	51
136	38	75	37
138	55	75	20
140	61	68	7
142	21	65	44

s,

TABLE IX. (Continued)

	,		,
144	26	58	32
146	6	63	57
154	31	71	40
156	0	63	63
158	5 8	73	15
162	36	70	34
168	22	66	44
170	10	55	45
172	78	82	4
174	60	66	6
178	24	30	6
182	7	44	37
Totals	•		
51	1873	2778	905
Mean	36.73	54.47	
Median	32.25	62.77	

PRE-TEST AND FINAL TEST SCORES FOR THE EXPERIMENTAL GROUP IN THE MATHEMATICS EXPERIMENT

group. The name of the student was written on each copy, and each was requested to prevent other students from having access to the problems. These were given to the students near the beginning of the second semester 1939.

The purpose of the experiment was to test the practice exercises under conditions comparable to those in which they would be used when completed. Therefore no special effort was made on the part of the teacher or the author to have the students solve the problems, except to explain the problems, tell how they had been collected and the possible value to be derived from practice in solving them. The students were informed that a final test

TABLE X.

Charlent Canna an Canada	
Student Score on Score on increase	or
number pre-test final test decrease	
• • • • • • • • • • • • • • • • • • • •	
1 50 28 22	
3 0 0 0	
5 62 36 26	
17 40 45 5	
19 33 59 26	
21 33 56 23	
25 47 62 15	
29 41 29 - 12	
31 64 55 - 9	
33 75 73 - 2	
3 7 5 3 4 8 - 5	
3 9 3 7 2 5 - 12	
41 48 40 - 8	
43 68 61 - 7	
45 50 44 - 6	
47 64 45 - 19	
51 3 20 17	
53 58 46 - 12	
55 91 73 - 18	
59 45 45 0	
61 0 5 5	
67 45 56 11	
69 40 46 6	
73 65 16 - 49	
75 15 54 39	
77 20 37 17	
85 22 6 - 16	
87 9 4 - 5	
89 30 37 7	
95 40 28 - 12	
99 34 29 - 5	
123 78 73 - 5	
125 64 54 - 10	
129 34 34 0	
133 14 66 52	
137 58 75 17	
139 50 64 14	
141 36 61 25	
145 36 75 39	

PRE-TEST AND FINAL TEST SCORES FOR THE CONTROL GROUP IN THE MATHEMATICS EXPERIMENT

TABLE X. (Continued)

147	26	65	39
149	38	56	18
151	57	55	- 2
153	36	67	31
155	49	64	15
157	55	70	15
159	29	66	37
161	54	75	21
163	21	65	44
169	58	71	13
173	70	49	- 12
175	58	72	14
Totals			
51	2203	2485	282
Mean	43.20	48.73	
Median	44.75	54.25	

PRE-TEST AND FINAL TEST SCORES FOR THE CONTROL GROUP IN THE MATHEMATICS EXPERIMENT

would be given on the work near the end of the semester but the score would not be revealed unless the student so desired and that it would have no bearing upon school grades. The author visited several of the experimental groups and introduced the problems. The students were free to secure any help needed in solving the problems but were requested to study the examples thoroughly before seeking help. Most of the work on the problems was carried outside of school time. Several teachers worked with the students as a group where common difficulties were experienced. All of the members of the experimental group solved some of the problems in the practice exercises. Those who were

TABLE XI.

PERCENTAGE OF POSSIBLE INCREASE IN FINAL TEST SCORES OVER THE PRE-TEST SCORES FOR THE EXPERIMENTAL GROUP

Student number	Score on pre-test	Possible increase on final test	Actual increase or decrease
number 4 8 12 14 20 24 28 30 32 38 40 42 44 46 48 50 52 54 56 58 60 62 72 80 82 86 88 90 94 96 98 100 130	32 32 32 32 32 71 82 22 41 77 52 53 59 71 49 27 26 69 12 44 79 14 51 35 42 19 30 0 9 30 0 9 30 55	final test 61 61 22 11 71 71 52 16 41 40 34 22 44 66 67 24 81 49 14 79 42 58 51 51 74 63 93 75 93 84 63 38	$ \begin{array}{r} - & 7 \\ - & 7 \\ - & 7 \\ 11 \\ 2 \\ 17 \\ 17 \\ 35 \\ 8 \\ - & 10 \\ 31 \\ 29 \\ 20 \\ 16 \\ 34 \\ - & 10 \\ 29 \\ 20 \\ 16 \\ 34 \\ - & 10 \\ 12 \\ 6 \\ 41 \\ - & 2 \\ 22 \\ - & 13 \\ 0 \\ - & 15 \\ 4 \\ 44 \\ 6 \\ 21 \\ 6 \\ 6 \\ 5 \\ 7 \\ 0 \\ 2 $
132 134 136 138 140 142 144	41 14 38 55 61 21 26	52 79 55 38 32 72 67	25 51 37 20 7 44 32

TABLE XI. (Continued)

PERCENTAGE OF POSSIBLE INCREASE IN FINAL TEST SCORES

	OVER	THE	PRE-TEST	SC ORES	FOR	THE	EXP	ERIMEN	FAL	GROUP	
146			6			87				57	
154			31			62				40	
156			0			93				63	
158			58			35				15	
162			36			57				54	
1 6 8			22			71				44	
170			10			83				45	
172			78			15	•			4	
174			60			33				6	
178			24			69				6	
182			7			86				47	-
Total	.8										
51			1873		28	870				905	
Perce	ntage	of	possible	increas	e or	<u>fir</u>	nal	test ;	31.5		-

limited in ability to perform the mathematical process were able to solve only a limited number of the problems. This is indicated by the low scores made by some members of the experimental group on the final test. Many students solved every problem in the list. No exact record was obtained as to the number actually solved by each student but interviews with a sampling of the students indicated that each had worked according to his own interest and ability. The students of superior ability were able to solve all of the 46 problems in a period of about 20 to 25 hours working time. The time spent by the students of lower ability varied widely from a few hours for some to more than 25 hours for others. The same test as that used for the

TABLE XII.

PERCENTAGE OF POSSIBLE INCREASE IN FINAL TEST SCORES OVER PRE-TEST SCORES FOR THE CONTROL GROUP

		Pagaihle	Actual
Student	Score on	increase on	increase or
number	pre-test	final test	decrease
1	50	43	- 22
3	0	93	· 0
5	62	31	- 26
17	4 0	53	5
19	33	60	26
21	33	60	23
25	47	4 6	15
29	41	52	- 12
31	64	29	- 9
33	75	18	- 2
37	53	40	- 5
39	37	56	- 12
41	4 8,	45	- 8
43	68	25	- 7
45	50	43	- 6
47	64	29	- 19
51	3	9-	17
53	58	35	- 12
55	91	2	- 18
59	45	4 8	0
61	0	9 3	5
67	45	48	11
69	4 0	53	. 6
73	65	28	- 49
75	15	78	39
77	20	73	17
85	22	71	- 16
87	9	84	- 5
89	30	63	7
95	40	53	- 12
99	34	59	- 5
123	78	15	- 5
125	54	39	- 10
129	34	59	0
133	14	79	52
137	58	35	17
139	50	43	14
141	36	57	25
145	36	57	39

TABLE XII. (Continued)

147	26	67	39
149	38	55	18
151	57	36	- 2
153	36	57	31
155	49	44	15
157	55	38	15
159	29	64	37
161	54	39	21
163	21	72	44
169	58	35	13
173	70	23	- 21
175	58	35	14

PERCENTAGE OF POSSIBLE INCREASE IN FINAL TEST SCORES OVER PRE-TEST SCORES FOR THE CONTROL GROUP

Total

51		2193		25	50		2 8 2	
Percentage	of	possible	increase	on	final	test		11.0

pre-test was given near the end of the school year 1938-1939, to all students in both the experimental group and the control group.

From the test scores and other significant data on the two groups, the more important findings are presented in a series of tables. On the basis of these data some conclusions may be drawn as to the effectiveness of the practice exercises as determined by results of a pretest and final test. The performance of the experimental group is shown in Table IX and that for the control group in Table X. The control group increased by a total of 282 points in the final test while the group that used

the practice exercises increased by a total of 905 points. Table XI indicates the percentage of possible increase attained by the experimental group and Table XII the same information for the control group. The possible increase on the final test was obtained by subtracting the pre-test score from 93 which was the total possible score on the test. A complete statistical summary of the experiment is contained in Table XIII. The mean increase of the control group was 5.53 while the experimental group increased by 17.74. In terms of percentage of possible increase, the attainment of the experimental group was about three times that of the control group. The figures were 3.15 and 11.0 percent respectively. Forty-two of the 51 students in the experimental group increased on the final test, while only 26 in the control group increased. It should be stated that the latter figure was high owing to an abnormal situation in one of the experimental groups. The teacher of the class was much concerned about the low scores of all the students in the pre-test. He developed interest among the members of his class in the improvement of their abilities in mathematics and considerable time during the year was spent in drill on practical problems. While members of the control group did not have free access to the practice problems, they did solve many of them with the result that fourteen of

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TABLE XIII.

PROGRESS OF EXPERIMENTAL GROUP AND CONTROL GROUP ON SOLVING PROBLEMS IN AGRICULTURAL MATHEMATICS

	Control	Www.endwenderl
	COULLOT	Experimental
	group	group
Total score on pre-test	2203	1873
Median score	44.75	32.25
Mean	43.20	36.73
Standard error of mean	2.81	2.93
Total score on final test	2485	2778
Median score	54.25	62.77
Mean	48.73	54.47
Standard error of mean	2.86	3.26
Mean increase in final test		
score over pre-test score	5.53	17.74
Total possible increase	2550	2870
Actual increase	282	905
Percentage of possible		•
increase attained	11.0	31.5
Number of students whose		
scores increased	26	42
Number of students whose		
scores decreased	. 22	7
Number of students whose		
scores remained the same	3	2

the fifteen students in the control group increased their scores on the final test. Therefore this group contained more than half of the 24 students in the total control group whose scores increased on the final test.

Since the mean difference in performance of the two groups is based upon test scores the significance of these figures is largely predicated upon the reliability of the testing instrument. For purposes of determining the coefficient of reliability the pre-test was divided into sections A and B. Since the problems were weighted

TABLE XIV.

numberPart APart Bscore11535503000427532534286281616321239327114463662171822401918143320148222118153324517222519284728271441292714412036312152312152333637753726275338332053392512374027325941331548423536714332366844311849452624504620727473133644812142650393069513306952841255464591564138795810414	Student	Score on	Score on	Total
1 15 35 50 3 0 0 0 4 27 5 32 5 34 28 62 8 16 16 32 12 39 32 71 14 46 36 82 17 18 22 40 19 18 14 33 20 14 8 22 21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 29 27 14 41 20 36 41 77 31 32 32 54 32 31 21 52 33 20 53 39 25 12 37 40 27 32 59 41 43 32 <th>number</th> <th>Part A</th> <th>Part B</th> <th>score</th>	number	Part A	Part B	score
1 15 35 50 3 0 0 0 4 27 5 32 5 34 28 62 8 16 16 32 12 39 32 71 14 46 36 82 17 18 22 40 19 18 14 33 20 14 8 22 21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 33 20 53 39 25 12 37 41 33 15 48 42 35 36 66 44 <td></td> <td></td> <td></td> <td></td>				
3 0 0 0 4 27 5 32 5 34 28 62 8 16 16 32 12 39 32 71 14 46 36 82 17 18 22 40 19 18 14 33 20 14 8 22 21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 29 27 14 41 29 27 14 41 29 27 14 41 29 27 32 52 31 21 52 53 38 33 20 53 39 25 12	1	15	35	50
427532534286281616321239327114463682171822401918143320148222118153324517222519284728271441292714413036417731323254323121523338377537262753383315484235366641331649452624504620727473133644812142650393069513003528412533325585423214455464591564138795810414	3	0	0	0
5 34 28 62 8 16 16 32 12 39 32 71 14 46 36 82 17 18 22 40 19 18 14 33 20 14 8 22 21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 29 27 14 41 30 36 41 77 31 32 52 54 32 31 21 52 33 38 37 75 37 26 27 53 39 25 12 37 40 27 32 59 41 35 36 68	4	27	5	32
81616321239327114463682171822401918143320148222118153324517222519284728271441292714413036417731323254333837753726275338332053392512374027325941331548423536714332366644311849452624504620727473133644812142650393069513003528412533325585423214455464591564138795810414	5	34	28	62
12 39 32 71 14 46 36 82 17 18 22 40 19 18 14 33 20 14 8 22 21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	8	16	16	32
14 46 36 82 17 18 14 33 20 14 8 22 21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 39 25 12 37 40 27 32 59 41 33 15 48 422 35 36 68 44 31 18 49 45 26 24 50 46 12 14 26 50 39 30 69 51 3 33 25 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	12	39	32	71
1718 22 40 19 1814 33 20 148 22 21 1815 33 24 5 17 22 25 19 28 47 28 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 10 4 14	14	46	36	82
1918143320148222118153324517222519284728271441292714413036417731323254323121523338377537262753383320533925123740273259413315484235366844311849452624504620727473133644812142650393069513332558464591564138795810414	17	18	22	40
20148 22 21 1815 33 24 517 22 25 19 28 47 28 271441 29 271441 30 364177 31 323254 32 312152 33 383775 37 262753 38 332053 39 251237 40 273259 41 331548 42 353668 44 311849 45 262450 46 20727 47 313364 48 121426 50 393069 51 33325 58 464591 56 413879 56 10414	19	18	14	33
21 18 15 33 24 5 17 22 25 19 28 47 28 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 10 4 14	20	14	8	22
245 17 22 25 19 28 47 28 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 10 4 14 50 21 24 45	21	18	15	33
2519 28 47 28 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 10 4 14	24	5	17	22
28 27 14 41 29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	25	19	28	47
29 27 14 41 30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 355 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	28	27	14	41
30 36 41 77 31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 56 41 38 79 58 10 4 14	29	27	14	41
31 32 32 54 32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 61 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 10 4 14	30	36	41	77
32 31 21 52 33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 61 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	31	32	32	54
33 38 37 75 37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	32	31	21 -	52
37 26 27 53 38 33 20 53 39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 61 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	33	38	37	75
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	37	26	27	53
39 25 12 37 40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	38	33	20	53
40 27 32 59 41 33 15 48 42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	39	25	12	37
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	40	27	32	59
42 35 36 71 43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	41	33	15	48
43 32 36 68 44 31 18 49 45 26 24 50 46 20 7 27 47 31 33 64 48 12 14 26 50 39 30 69 51 3 00 3 52 8 4 12 53 33 25 58 54 23 21 44 55 46 45 91 56 41 38 79 58 10 4 14	42	35	36	71
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	43	32	36	68
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	44	31	18	49
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	45	26	24	50
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	46	20	7	27
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	47	31	33	64
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	48	12	14	26
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	50	39	30	69
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	51	3	00	3
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	52	8	4	12
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	53	33	25	58
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	54	23	21	44
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	55	46	45	91
58 10 4 14 59 21 24 45 45 45 45 45 45 45	56	41	38	79
	58	10	4	14
	59	21		45

DIVISION OF PRE-TEST SCORES FOR DETERMINING THE RELIABILITY OF THE TEST

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TABLE XIV. (Continued)

DIVISION OF PRE-TEST SCORES FOR DETERMINING THE RELIABILITY OF THE TEST

880000 89 82230 90 101020 94 11718 95 172340 96 000 98 459 99 181634 100 102030 123 364278 125 323264 129 171734 130 302555 132 212041 133 12214 134 10414 136 162238 137 322658 138 312455 139 262450 140 342761 141 27936 142 21021 144 141226 145 241236	60 61 62 67 69 72 73 75 77 80 82 85 86 87	15 0 27 18 17 25 35 5 5 5 27 11 11 19 3	36 0 8 27 23 17 30 10 15 15 8 11 11 11 6	51 0 35 45 40 42 65 15 20 42 19 22 30 9
95 17 23 40 96 000 98 459 99 18 16 34 100 10 20 30 123 36 42 78 125 32 32 64 129 17 17 34 130 30 25 55 132 21 20 41 133 12 2 14 134 10 4 14 136 16 22 38 137 32 26 58 138 31 24 55 139 26 24 50 140 34 27 61 141 27 9 36 142 21 0 21 144 14 12 26	88 89 90 94	0 8 10 11	0 22 10 7	0 30 20 18
100 10 20 30 123 36 42 78 125 32 32 64 129 17 17 34 130 30 25 55 132 21 20 41 133 12 2 14 134 10 4 14 136 16 22 38 137 32 26 58 138 31 24 55 139 26 24 50 140 34 27 61 141 27 9 36 142 21 0 21 144 14 12 26	95 96 98 99	17 0 4 18	25 0 5 16	40 0 9 34
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	123 125 129	36 32 17	42 42 32 17 25	50 78 64 34
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	130 132 133 134	21 12 10	20 20 4	41 14 14
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	130 137 138 139 140	32 31 26 34	26 24 24 27	58 55 50
	141 142 144 145	27 21 14 24	9 0 12 12	36 21 26 36

TABLE XIV. (Continued)

153	21	15	36
154	22	11	31
155	18	31	49
156	0	0	0
157	22	33	55
158	27	31	58
159	21	8	29
161	33	21	54
162	15	21	36
163	12	9	21
168	16	6	22
169	27	31	58
170	5	5	10
172	43	35	78
173	35	35	70
174	35	27	60
175	28	30	58
178	13	11	24
182	5	2	7

DIVISION OF PRE-TEST SCORES FOR DETERMINING THE RELIABILITY OF THE TEST

according to difficulty and mathematical operations for the purpose of scoring, this same basis was used for splitting the test to determine reliability. The grouping of problems under parts A and B are shown in Appendix E. The scores on the halves of the test are recorded in Table XIV. From these data, by use of the Spearman-Brown prophecy formula, the coefficient of reliability of the pre-test was found to be .828. This figure indicates that the test is sufficiently reliable for purposes of this study. Since the same instrument was used for a final test and less than two semesters time lapsed between the two test, it was not necessary to make further check on the reliability of the test by means of the scores in the final test. The distribution of scores on parts A and B of the pre-test are shown graphically in Illustration II.

Social Evaluation

In addition to statistical evaluation of the practice exercises, the experiment was planned to reveal as much information as possible on other important items involved in the use of this device in the educational process. Some of the more important questions were as follows:

- 1. Will students of vocational agriculture be interested enough in the problems to use them effectively?
- 2. Will the problem increase student interest in the study of crucial farm situations involving mathematical processes?
- 3. Are the exercises appropriate to the needs of young men engaged in farming?
- 4. How many problems should be included in a set of practice exercises for students of vocational agriculture?

The opinion and observation presented in this section of the study are based upon the following:

1. The author's study of the problem in general.

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ILLUSTRATION II

DISTRIBUTION OF SCORES ON THE TEST USED IN THE MATHEMATICS EXPERIMENT

_		<u>X</u> I1	terv	als	<u>Par</u>	<u>t B</u>						
		0	5	10	15	20	25	30	35	40	45	
		4	9	41	19	24	29	34	39	44	49	
Ī	49					1						
	45								•		•	2
	44											
	40								••			2
Ī	39				[
	35						•	•••	•••	••		9
4	30											
Brt	34				••	** * * *	• • • •	•••	•			16
Ĥ	29											
5	25		•••	••••	••	••	•	••••				16
E I	24											
θrγ	20	•	• • •	••	•	••••		•				12
nt	19											
M	15		•	••	••••	• • • •	••	•	••			16
	14											-
	10	•••	••••	** * * *		•						13
	9											
	5	***	•	•	••	•						8
	4											
	0	•	••									3
ſ												
		8	14	14	11	17	9	12	9	2	1	97

- 2. Individual and group conferences with teachers and students who used the problems.
- 3. The teacher and members of a part-time class of young farmers.
- 4. High school teachers of mathematics.
- 5. Specialists in agriculture and farmers.

Each of the eight teachers made a written summary of his experiences with the problems. Some of the more significant conclusions may serve as partial answers to the questions listed under the objectives of the study.

Student Interest In The Problems

As a group the students were interested in the problems after the nature of the content had been explained. In two of the experimental schools the teachers simply handed a copy of the practice exercises to the members of the experimental group with little or no suggestion as to the nature or probable value of the exercises. On a visit to these schools it was discovered that some students were working on the problems but there was little interest. The author met with the experimental groups, solved a number of the problems on the blackboard and helped each student individually. This introduction increased interest to the point where every mem-
ber of the experimental group finished work on the problems during the semester. Students in many of the schools worked on the problems at the noon hour, before and after school, and at home. The parents of the students were alert to the practical values of the exercises. Many made favorable comments on the work. The following remark by a boy's father is typical of the reaction of this group. He said, "It is the first time any of my children have brought home from school a practical problem in arithmetic." The teachers reported that the students were interested. The advanced students and those engaged in large farming programs showed most interest. The following are some comments of teachers on this point. "I found the exercises to be very interesting to the students who have the ability to think and reason through situations. The best students enjoyed the exercises and were able to solve the majority of the problems." "The boys as a whole enjoyed the problems." "The seniors were enthusiastic about the exercise, the juniors showed fairly good interest, and the sophmore group showed little interest." "The students seemed to enjoy trying to solve the problems. A few did not have sufficient knowledge of the fundamentals of mathematics to even start working the problems. As a result their interest lagged." All the teachers reported that interest increased during the semester with all students except a limited number for whom the problems were definitely too

difficult. A number of students not included in the experiment requested that they be given opportunity to use the practice exercises.

Effect of the Practice Exercises upon Student Interest in Farm Problems that Involve Mathematics

There was evidence of increased interest in such problems as farm records, balancing rations and similar problems having a direct bearing upon the economic phases of the farm business. Students in three schools requested that some time each week be given to practice in solving timely problems involving mathematics. Several teachers reported that the farm record books of the students had been kept in better condition since the exercises were used. Others reported interest in budgeting and problems connected with marketing. All of the teachers who used the exercises reported that they will include more problems of this nature in the agriculture course for next year. One teacher stated, "The work was a challenge to the boys and interest in this type of problem increased."

The Value of the Practice Exercises for a Group of Young Farmers

The practice exercises were used with a group of 16 young farmers attending a part-time class at Coolidge,

Arizona. The work was introduced to the class because members had encountered a number of similar problems in their farming programs and experienced difficulty in solving them. As indicated by the teachers in the experimental schools, advanced students engaged in farming were most interested. This was found to be the case with the group of young farmers. They were able to draw many problems from their own farming situations, had a clear understanding of the significance of the problems and were intensely interested in the improvement of their abilities to successfully deal with problems involving mathematics. Many of the young men were high school graduates and able to make splendid progress with the problems. The first part of each class period was devoted to practice on problems set up in the exercises, after which the group continued work on their own problems. They often referred to the examples for guidance in dealing with new situations. The exercises served as an introduction to a wide range of problems that were of major importance in the agriculture of the community. This unit of the class work was the most interesting in the series and one of the most valuable, according to the comments from members of the group. The teacher of the group plans to continue the use of practice exercises as a supplement and aid to problem solving in part-time classes during the coming year.

The Number of Problems to Include in the Practice Exercises

To be of maximum value the exercises should be written for a wide range of farming situations and for students of varying ability and background both in farm experience and training in mathematics. The wide range of ability in classes of vocational agriculture is emphasized by the final test scores in the experiment, which ranged from 5 to 91 in the experimental group and from 0 to 75 in the control group. While the list of 46 problems used in the experiment was adequate for purposes of evaluation, teachers who used the exercises indicated that the list should contain a much larger number of situations appropriate to the agriculture of the region. Problems of local significance should be compiled by the teachers of agriculture and used as a supplement to the list prepared for the state or region. Three teachers reported that their students would like to have additional problems on the various phases of agriculture practiced in the several communities.

Summary

A set of 46 type problems developed as practice exercises were evaluated by actual use with 51 students of vocational agriculture in eight schools. The evaluation consisted of two parts, first a statistical evaluation

based upon student progress as determined by tests, and second a social evaluation based upon the opinions of students and teachers who studied and used the practice exercises. For the statistical evaluation, students were paired as to ability: all were given a pre-test, at the beginning and a final test at the end of the school year. The experimental group used the practice exercises for a period of about one semester, at the end of which period they showed a gain in attainment about three times as great as that for the control group. The mean increase in test score of the experimental group was 17.74 as compared with an increase of 5.55 for the control group. Forty-two of the 51 students in the experimental group increased in attainment during the test period while only 26 of the control group increased. The difference in attainment of the two groups was found to be statistically significant. In Table XIII the mean increase of the experimental group is listed as 17.74 which is more than five times 3.26 which was the standard error of the mean. When the increase is three times the standard error of the mean it is accepted as practical certainty, since there are only three chances in 1000 that the increase was due to fluctuations in sampling.1

^{1.} Wert, James E., Educational Statistics, New York, McGraw-Hill Book Company, 1938, p. 150.

The exercises were used under normal conditions: the two groups were paired as to ability, and the testing instrument showed a coefficient of reliability of .828, which is sufficiently high for purposes of the experiment. The practice exercises were subjected to the most severe test possible, in that they were not used as a part of the course, no grades were given, and little assistance was offered by the teacher. The work was simply introduced and the student left to solve the problems in accordance with his own interest as aroused by the situations in the practice exercises. The second part of the evaluation was undertaken to obtain some information on the social and educational significance of the exercises and the implications of such findings for the improvement of instruction in vocational agriculture. Students of agriculture as a group were very much interested in the problems. Interest was highest with advanced students who were engaged in farming programs. A class of 16 young men working full time as farmers showed the greatest interest of all groups. According to their opinions the problems as a whole were appropriate to their immediate needs in farming. Use of the problems in the schools increased student interest in such activities as farm cost accounting, budgeting, finding cost of production, and marketing farm commodities. Students and teachers expressed the opinion that the prac-

tice exercises should be expanded to include many more crucial situations pertaining to agricultural practices in the state.

CHAPTER VI.

IMPROVING AND USING THE PRACTICE EXERCISES

Revising The Practice Exercises

In addition to the teachers and students who used the practice exercises, suggestions were obtained from several teachers of mathematics, school principals and specialists in agriculture. Some of the most valuable suggestions were made by the teacher and the members of the part-time class. The teachers were unanimous in the opinion that the list of problems should be expanded to include a wide variety of situations in Arizona agriculture. Some areas suggested included irrigation and water, cooling the home, and marketing problems. One teacher suggested that some of the formulas should be simplified if possible and that related information needed in solving the problems be given. It was also suggested that the problems be organized around types of related activities in the farm business rather than operations in mathematics. Experience in using the practice exercises as a supplement to the course in agriculture indicated that a table of contents would greatly facilitate the use of the exercises. These findings were used as a basis for revising the practice exercises, a complete list of which is

included in Appendix F.

Using the Practice Exercises in the Educational Program

While the opinions on this part of the study are based upon rather limited experience with the practice exercises, they are recorded here as being indicative of trends in the use of this device in the educational program. Opinion as to the most appropriate plan and procedure for using the practice exercises may be classified according to four groups as follows.

- 1. The exercises may be used as a supplement to the regular courses in mathematics.
- 2. They may be used as a part of the high school course in vocational agriculture.
- 3. They may be used in classes of young farmers who have either completed high school or left high school before completion, to enter the vocation of farming.
- 4. They may be used by individuals for selfimprovement or for remedial learning, on problems pertaining to the individual

farm business.

The practice exercises were not used in classes of mathematics but they were examined by several able teachers of mathematics. They indicated that teachers of this subject have made little use of such problems in their courses, since no source of these problems is available. Few teachers of mathematics are familiar enough with the content and practices of agriculture to direct the students in gleaning such problems from the activities of a community. School administrators are often reluctant to allow teachers to vary from the content of the traditional course as represented by the text book. Two situations of this kind were discovered during the course of the study. No plan for evaluating the exercises by teachers of mathematics was set up, but those who examined the work were impressed with the possible value of the device in their courses. It was indicated that the problems would be useful in three ways: first as a source of practical situations having rich learning values for students in farming communities; second, the problems would serve as a guide to teacher and student in discovering similar problems in the community: third, the list would serve as a supply of practical problematic situations to use in testing. The extent to which such problems will be used as learning material in mathematics will depend largely upon the philosophy held by the teacher and the program followed by the school. The work should be of value for schools in agricultural areas where teachers seek to integrate content toward the development of abilities to progressively solve problems and meet new sit-

uations in the learner's environment. The practice exercises will doubtless find their greatest usefulness as a part of, or a supplement to, the regular course in vocational agriculture. There are a number of reasons for this opinion. The abilities in agricultural mathematics are definitely a part of the personal equipment of a successful farmer and cannot be isolated entirely from other content in the field of agriculture. The learning activity breaks down when the student is unable to perform the necessary mathematical operations: thus the teacher of agriculture must in some way remedy the condition if he is to further develop the ability to solve problems. The practice exercises should be used as source material for the learner at any point needed in the training program. Since the list of practice exercises should be rather complete for the agriculture of a region, many of the problems would not be mastered until the latter years in high school and some would be left for use in the part-time class after the young man leaves high school and faces the problems in his own farming operations. It was found that the mathematical abilities needed in agriculture vary widely in difficulty. The practice exercises will serve as a splendid reservoir of situations to be used in testing achievement at many levels. A series of tests representing a wide range of difficulty would enable the learner to test himself at any time and direct his study and practice toward remedial learning. The teacher and students should supplement the state or regional list of practice exercises with situations peculiar to the agriculture of the community. The exercises developed in this study should suggest additional problems of local significance. There are some problems in the list to which students will give little attention while in school since there will be limited need for the ability until the student becomes engaged in a full time farming pursuit. This practice is in keeping with the trend in vocational education toward offering the training at the time when it can be used by the learner. Just as there is need for a continuation program of education in the practices of farming, there is likewise a need for continued practice on new and advanced problems in mathematics which are a part of new methods and practices in the vocation. The practice problems for this group will deal with the more complex managerial aspects of farming and should aid the individual in dealing with somewhat specialized jobs in individual farming units. While part-time classes will give much less time than the all day class to the use of the exercises, they should make a definite contribution to this important part of the educational program in agricultural education.

The practice exercises were designed largely as an aid to individual self-directed learning. We would therefore expect them to find their maximum usefulness

when used for this purpose. This conclusion is based upon the fact that the increased attainment made by the experimental group in this study was almost entirely a result of self-directed effort. The student requested that they be allowed to keep the copy of exercises for future reference. Such a list should be valuable to the student in high school, the young man beginning his career as a farmer and the adult farmer. The list will serve as a ready reference for review of mathematical process, and a source of illustrated problems typical of those occurring most frequently in the activities of the vocation.

Summary

As a result of using the practice exercises in the schools a number of ways in which they could be improved were discovered. The list should include some additional areas in agriculture and more problems. Formulas should be simplified if possible and all related information for solving the problem included. The list of problems should be reorganized on the basis of related farm activities and a table of contents added. Four definite plans were suggested for using the exercises in an educational program. The device may be used with success as a supplement to the regular courses in mathematics in schools where teachers seek functional situations as a basis for learning ac-

tivities. The exercises will be of maximum value when used as a part of the instruction in vocational agriculture. They may supplement problem solving in agriculture at any point where they are needed, and will serve as a reservoir of situations for testing and a guide for the compilation of additional practice exercises of local significance. The exercises will be a useful source of content for part-time classes in vocational agriculture to be used largely for review purposes and as a guidein solving new and specialized problems in farming. The list may be used as an aid to self-directed learning at all levels from the beginning high school student to the adult farmer. The plan of writing the exercises was based upon the assumption that the device would be used largely as an aid to self-directed learning.

CHAPTER VII.

SUMMARY AND CONCLUSIONS

Origin and Nature of the Study

In recent years a number of studies have been made for the purpose of discovering functional content in mathematics for various fields of study and vocations. Tyler's¹ study on the mathematics of commerce courses and Burger's 2 investigation on the mathematics essential in high school physics courses are illustrations of the first type. Bowden's³ study on the consumers use of mathematics represents a type designed to determine the general uses of mathematics by the laymen outside the vocations. Frutchey's⁴ work on mathematics for the field of Dairy Technology was conducted to isolate the mathematical abilities needed and to set up practice exercises for more adequate and economical instruction pertaining to this phase of the training program. Studies similar to these have been made in other fields. One of the largest programs in vocational education today is in the field of agriculture at the secondary school level. The basis of this instruction is the farm itself with its complex problems of pro-

^{1.} Tyler, R. W., op. cit.

^{2.} Burger, Harvey 0., op. cit.

^{3.} Bowden, A. O., op. cit. 4. Frutchey, F. P., op. cit.

duction and marketing. Through constant contact with these situations students and teachers of agriculture are looking for a more efficient plan for mastering the mathematical abilities in their rapidly changing vocation. The content and program of instruction in mathematics at present is not meeting their needs. This is especially true in the high schools of Arizona where the agriculture is somewhat peculiar to the region. Situations found even in so-called mathematics text books for students of agriculture are foreign to the experiences of the learner. The keen interest of students, teachers, and school administrators in this problem was largely responsible for this study.

Techniques Used in the Study

<u>Procedure used for statistical evaluation.</u> In formulating objectives for the study and the practice exercises the literature revealed both opinion and experimental evidence. The objectives were drawn largely from the objectives for the instruction in vocational agriculture since the final practice exercises were to be used largely by students in this work. The opinion of teachers of agriculture, specialists in agriculture, and leaders in agricultural education were used in arriving at a final statement of objectives. One of the basic assumptions of the study was, that crucial problems pertaining to mathematics in agriculture could be found in the literature. Therefore this was the main source used. It was supplemented by interviews with farmers on some special branches of agriculture. The problems collected in this manner were consolidated into a list of type-problems and made available to eight judges for evaluation.

Three criteria were used in selecting the judges as follows: 1. Educational training in the farming practices of the state, 2. actual farm experience in the region, and 3. specialization as to some particular branch of the agriculture of the state and region. The number of judges was determined partially by a check on their evaluation of the problems. This was done by determining the percentage of agreement of three judges in a group of five and again for five judges in a group of eight. The criteria used in evaluating the problems were frequency, importance, and difficulty. Each problem was evaluated for these factors on a scale of values from one to three. The first two criteria were used as a basis for selecting the problems to use as examples in the practice exercises. The criterion of difficulty was used as a basis for determining the number of practice problems to use under each exercise. Problems that ranked high on either frequency or difficulty were used in the final list.

A group of 182 students of vocational agriculture in eight high schools in Arizona was selected for use in

evaluating the exercises. These students were paired on the basis of certain factors which seem to indicate ability to solve problems in mathematics. These data included, year in high school, number of years completed in vocational agriculture, number of years completed in mathematics, average grade on all courses in mathematics, average grade in all high school subjects, intelligence test score, and teacher opinion as to general responsibility of the student. All students were given a pre-test on agricultural mathematics in the first semester of the school year 1938-1939. Practice exercises with problems on mensuration and general percentage were used by about half of the entire group during the second semester of the school year. Near the end of the school year a final test was given to all students in the experiment and the scores checked with those on the pre-test to determine the difference in attainment of the control group and the group using the practice exercises. The reliability of the testing instrument was determined by means of the Spearman-Brown prophecy formula.

Procedure used for social evaluation. The second part of the study was projected to determine the social and educational significance of the practice exercises. This was undertaken largely by means of interviews with teachers and students in the eight experimental schools. Others who examined the practice exercises and offered

opinion as to their value were mathematics teachers, specialists in agriculture, school administrators, and one teacher and members of a part-time class of young farmers. The parents of students who used the practice exercises also offered opinion on the value of the problems. The following procedure was used in obtaining and classifying these opinions.

- An interview was held with each teacher individually, near the end of the school year.
 The problems were discussed at length and notes made on all significant reactions.
- 2. All teachers who cooperated in the experiment met as a group with the author at the end of the school year and evaluated the problems on the basis of their educational significance.
- 3. Finally, each teacher made a written report on his reactions to the problems.
- 4. The author visited all of the schools except one during the course of the experiment and interviewed a sampling of students on the probable value of the problems.
- 5. Several teachers of mathematics and school administrators examined the problems.
- 6. Specialists in agriculture examined the prob-

lems and offered their reactions to the list of problems.

- 7. The author visited two sessions of parttime class where the problems were being used. Comments were obtained from practically every member of the class. The teacher also made a careful evaluation of the exercises.
- 8. The comments from parents were received mainly through the teacher. Some were obtained from the students. No parents were interviewed directly.

A Summary and Analysis of Findings

The object of the study was to construct and evaluate practice exercises for solving problems pertaining to the agriculture of Arizona. Pursuant to this purpose the following supporting information was revealed by the study.

> 1. Most of the important problems in Arizona agriculture, as indicated by a group of judges, involve feeding livestock, the use of farm machinery and power, the use of water, farm labor, marketing farm products, and using farm credit.

> 2. In a controlled experiment, students of vo-

cational agriculture who used practice exercises in mathematics made about three times as much progress in achievement as the group who did not use the exercises. The mean progress of the experimental group was 17.74, as determined by test scores, and for the control group it was 5.53. This increase is statistically significant because it is more than five times the standard error of the mean.

- 3. Students of vocational agriculture were interested in the problems to the extent that all worked some of them. Many solved all of them. This work, with the resultant increase in attainment was accomplished without the aid of external incentives such as, allocation of class time, grades or credit to the work. The work was done largely outside class time in direct response to each individual's interest in the problems.
- 4. There was evidence of increased interest in crucial farm problems on the part of the students who used the practice exercises. Such interest was apparent in problems on budgeting, farm cost accounting, feeding livestock, marketing and similar economic problems involv-

ing mathematical operations. This interest was not confined entirely to the group using the practice exercises but tended to permeate to some extent the entire class in vocational agriculture.

- 5. The practice exercises were used with success in one part-time class of young farmers where they served as an aid in solving the immediate farm problems of the group.
- 6. No definite figure was derived as being appropriate for the number of examples and practice problems to use, but teachers and students were unanimous in their opinion that the list should be increased beyond the total of 46 problems used in the experiment.
- 7. According to teachers and students the exercises can be improved as indicated above through the inclusion of more problems. The addition of more related information on some problems, simplification of formulas, and addition of a table of contents were other suggestions.
- 8. The practice exercises were valuable as a teaching-learning device when used in connection with organized problem solving in agriculture such as that found in a high school

class, or a part-time class of young farmers. The problems should also be useful in classes of mathematics for schools in agricultural sections, and as a guide to self-directed learning for anyone interested in the solution of farm problems. The conclusions on the latter two uses are based entirely upon group opinion, since the practice exercises were not tested through actual used by either of these plans.

CONCLUSIONS

- There is need for improvement in the educational program pertaining to the development of mathematical abilities among students of vocational agriculture in Arizona.
- 2. Teachers of mathematics in agricultural areas should make more use of practical farm situations in their courses.
- 3. Teachers of agriculture should give more attention to evaluating and developing the abilities of their students to perform the mathematical operations involved in the agriculture of the region.
- 4. Teachers and students of agriculture should use the practice exercises in mathematics as follows:
 - a) As a part of, or supplement to the regular course content in agriculture for:
 - (1) All day students
 - (2) Part-time classes of young farmers
 - b) As an aid to problem solving and self directed learning outside of school time.
 - c) As a source of situations for constructing a series of tests to be used in evaluating student attainment at various levels.
 - d) As a guide in locating and formulating mathe-

matical problems of crucial significance in the agriculture of the community and region.

Contributions

The following are some contributions of the study toward the attainment of objectives in agricultural education, when the practice exercises are used in the program of instruction.

- There is a decrease in the amount of teacher and student time required to master the abilities in mathematics pertaining to the farm business.
- 2. There is an increase in the functional integration of content, which results in the development of effective techniques for problem solving on the part of the learner.
- 3. There is an increase in the number of, and accuracy with which improved farm practices are used.

Suggestions for Further Study

Investigation on the following questions would reveal information appropriate to the furtherance of the program suggested in this study.

- 1. What is the total number of examples and practice problems needed for developing the abilities pertaining to the agriculture of a region?
- 2. At what points in the training program should the several abilities be developed? How should they be allocated among the elementary, high school, and post-high school periods?
- 3. What results may be obtained from using the practice exercises in classes of mathematics?
- 4. What type of testing program should be used as an aid to student achievement?

Concluding Statement

The agriculture of Arizona is complex and highly specialized. Capital investments and costs of production are high because of expenses incident to land reclamation and transportation of farm commodities and supplies. Only the well trained individual can successfully operate a farm business under these conditions. It is the author's hope that this study may aid the school in the development of vocational efficiency and thus contribute to the attainment of a more satisfying way of life for a people who earn a livelihood in a land of little rain.

AUTOBIOGRAPHY

I, Russell Walter Cline was born near Newton, North Carolina, December 6, 1899. I received my elementary education in the rural schools of Caldwell Township, Catawba County and the secondary school education at Startown Farmlife School. My undergraduate education was received at North Carolina State College from which I obtained the degree of Bachelor of Science in 1924. I served on a fellowship in the Department of Agricultural Education at Virginia Polytechnic Institute during the year 1926-1927 and received the degree of Master of Science from that Institution in 1928.

From 1924 to 1926 I taught vocational Agriculture in the Alexander Wilson School, Graham, North Carolina, and served as superintendent of schools for one semester. During the school year 1927-1928, I served as Assistant State Supervisor and Assistant Teacher Trainer in Agricultural Education at North Carolina State College. In 1928 I was appointed instructor in Agricultural Education at the University of West Virginia. I served as critic teacher and taught courses in Agricultural Education. From 1933 to 1936 I served as Teacher Trainer in Agricultural Education.

I secured a leave of absence for the school year

1936-37 and spent four quarters at Ohio State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

In September 1937, I was appointed Head of The Department of Agricultural and Home Economics Education at the University of Arizona. From this position I have secured leave for further work at Ohio State University during the summers of 1938 and 1939.

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APPENDIX A

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JUDGES' RATING ON TYPE PROBLEMS IN MATHEMATICS ON FREQUENCY, IMPORTANCE AND DIFFICULTY

- F. I. D.
- 14 17 11 1. How many fruit trees are needed to plant an acre when the trees are spaced 25 ft. apart each way?
 - 9 12 13 2. How much 16% superphosphate and 50% muriate of potash should be added to 150 tons of barnyard manure to make the same proportions of plantfood as contained in a 5-10-5 fertilizer? How much of the balanced manure per acre should be used to equal in plantfood 400 lbs. of 5-10-5 commercial fertilizer per acre?

Analysis of cow manure in Pounds of plantfood per ton. Nitrogen - 12 Phosphorus - 5 Potash - 10

10 11 12 3. How many pounds each of the following fertilizer materials would be required to mix a ton of 4-10-6 fertilizer?

> Sulphate of ammonia, 20.5% nitrogen. Superphosphate, 18% phosphoric acid. Muriate of potash, 50% potash.

14 15 8 4. If 16% superphosphate is selling for \$20.00 per ton, what is the value of a ton of 18% superphosphate?

- F. I. D.
 17 17 14 5. An irrigation ditch is 3 ft. wide at the bottom, 3¹/₂ ft. wide at the surface of the water which is 24" deep. The water is flowing at the rate of 8 ft. per minute. Allowing 7¹/₂ gallons per cubic foot determine the flow of water per hour through the ditch.
- 17 16 7 6. How many pounds of threshed barley are in a bin 10 ft. x 18 ft. two and one-half feet deep? (A bushel of barley contains 1.244 cubic feet and weighs 48 lbs.)
- 15 17 9 7. How many tons of settled alfalfa hay are in a mow 30 ft. x 50 ft. x 15 ft. deep? (485 cubic feet = one ton.)
- 21 23 12 8. How many tons in a settled stack of alfalfa hay 15 ft. wide, 50 ft. long and 48 ft. over top? A ton of hay in this case occupies 485 cubic feet.

Volume
$$= \frac{0 W^2}{4} x L$$

0 = Distance over top of stack
L = Length
W = Width

F. I. D.
12 14 7. 9. How many bushels of corn on the cob will a crib 10 ft. x 35 ft. x 8 ft. hold? (2¹/₂ cubic feet of ear corn equals a bushel of shelled corn.)

9 9 14 10. Find the crop index of the following farm. Average yield per Average of crops Yield per acre in produced acre the region

50 acres	wheet	28 bu.	22
00 A0105	Miloau N 7		20
45 acres	partey	33 bu.	28
60 acres	alfalfa	3.10 tons	2.25
25 acres	cotton	780 lbs.	540
Number of acres needed to produce crops at average Crop index <u>- yields</u>			
	Actual	number of a	cres used

13 11 9 11. The protein in cottonseed meal is about 17% nitrogen. What is the fertilizer value of a ton of cottonseed meal that contains 37% protein, 2.6% phosphoric acid, and 1.8% potash when these plant foods are valued as follows:

> Nitrogen - $12\frac{1}{2}$ per lb. Phosphoric acid - 5¢ per lb. Potash - 5¢ per lb.
- F. I. D.
- 9 10 12 12. The water from the roof of a barn 60 ft. x 160 ft. drains into a cistern. If the rainfall is 16" per year how many gallons of water will it supply? (1 cubic foot of water = 7½ gallons)
- 16 17 12 13. A hammer mill with a pulley 5" in diameter has a rated speed of 2020 R. P. M. What size pulley should be used on the electric motor of 1750 R. P. M. for driving the grinder?

D = diameter of driver D = diameter of driven D x RPM of driver = d x RPM of driven

- 17 18 15 14. What length belt is needed for connecting two pulleys, eight feet apart, one 10" in diameter and the other 24"? How much belting would be needed if the belt is to be crossed?
- 12 9 11 15. How many gallons of water does a well contain if the pipe is 16" in diameter and the water 20 ft. deep? (The area of a circle is ¹/₂ the radius x circumference. A gallon contains 231 cubic inches)

- F. I. D.
- 7 7 14 16. A farmer wishes to put a conical roof on a silo. The diameter of the cone is 16 ft. at the eaves and 8 ft. high from base to the peak of the roof. Allowing 15% for waste, how many squares of roofing should be purchased for the job?
- 21 22 10 17. What should be the capacity of a silo to feed a herd of 30 cows 38 lbs. of silage per day for 9 months?
- 17 19 10 18. What should be the diameter of the silo (above) to allow the removal of a layer of silage at least 4" deep per day? (A ton of average silage occupies 50 cubic feet.)
- 13 17 14 19. How long should the rafters for a building be cut when the width of the building is 30 ft., the height of the gable is 10 ft. and tail of the rafter is 18" long.

- F. I. D.
 13 16 15 20. In plumbing a farmstead, 24 outlets from pipe one inch in diameter are to be used. If the main line leading from the well is to equal half the capacity of the inch pipes, what should be the diameter in inches to the nearest 1/4 inch of the main line?
- 17 16 14 21. What is the capacity of a watering trough with flat bottom and sloping sides 32" long, 24" deep, 20" wide at the top and 16" wide at the bottom? (Allow 7.5 gallons per cubic foot.)
- 16 15 12 22. A triangular pasture has the following side dimensions 21, 38, and 42 rods. How many acres does it contain?
- 17 17 10 23. A farmer purchased a grain drill at \$180.00. It will last 15 years and has a scrap value of \$12.00. Fixed charges other than the first year are:

 Interest on investment \$90.00
 at 6%
 Housing per year
 5.85

If the machine is used 85 days (ten hours per day) during this period, what is the rate per hour for fixed charges alone?

17 17 11 24. What is the average depreciated investment in a manure spreader during the first five years? Machine cost \$156.00, life, 10 years, scrap value \$15.00.

Formula: $d = \frac{Vo - Vn}{N}$ Vk = Vo-Kd $D = \frac{1}{2} (Vo - Vk)$

D = Average depreciated investment Vo = Original value Vn = Scrap value d = Annual depreciation N = Years of life of machine K = Years machine has been in use Vk = Value at end of k years

13 14 12 25. What will be the cost of paint for the outside of a barn 40 ft. x 80 ft. 18 ft. to eaves and a round roof in the form of a half circle? There are 8 windows on each side 30" x 36". Paint cost \$2.75 per gallon that will cover 250 square feet with two coats.

10

10 15 26. A man weighing 170 lbs. wishes to lift the front end of a tractor weighing 800 lbs. with a piece of timber. The fulcrum is placed 14" from the base of the tractor, what should be the total length of the timber?

W - Weight
P - Power
d" - Distance from fulcrum to point
 of application of force
d' - Distance from fulcrum to where
 weight is attached

W : P :: d" : d'

- 15 14 15 27. Irrigation water is delivered to a 20 acre field through an 8" pipe with a velocity of one foot per second, how long will it take to supply $\frac{1}{4}$ acre foot of water to the entire field?
- 16 15 13 28. A team of horses weigh 1400 and 1600 lbs. respectively. How would you divide 48" doubletree to use with this team?
- 10 10 15 29. How many board feet does a log contain that is 20" in diameter at one end, 16" in diameter at the other and 16 ft. in length?

Volume in cubic feet = $B \frac{1}{8} x$ length. B = Area of middle cross section in square feet.

9 8 13 30. How many bushels of wheat are contained in a conical pile 30 ft. around the base and 5 ft. high? (A bushel = about 1¹/₄ cubic feet.)

15 16 12 31. The excavation for a building 30 ft. x 55 ft. located with the long side across the slope, is 7 ft. deep at the top and $4\frac{1}{2}$ ft. deep at the bottom of the slope. How many cubic yards of dirt were removed?

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11 12 11 32. A farmer wishes to build a concrete
water tank as an extension on the top
of his concrete silo. The silo is 12 ft.
in diameter, inside dimension. He needs
a maximum supply of 15000 gallons of
water, how tall should the tank be con-
structed?
```

F. I. D.
10 12 17 33. If a heating unit of 660 watts is to be constructed and 110 volt current to be used, how much resistance wire of 1 ohm per foot should be used in the heating element?

12 19 21 34. A farmer wishes to install a chain hoist in his work shop to lift a maximum load of 2 tons. It is to be suspended from a beam of yellow pine 10" wide and l6 ft. long, resting on the plates of the building at each end. What should be the thickness of the beam?

Formula: $S = \frac{K b d^2}{L}$

(See problem No. 37)

11 15 17 35. A loading platform 6 ft.wide of yellow pine is made by 2" x 10" beams 12" apart projecting from a sill of the building. The floor is made of 2" yellow pine. What maximum uniform load will it support?

$$\mathbf{S} = \frac{\mathbf{K} \mathbf{b} \mathbf{d}^2}{2\mathbf{L}}$$

(See problem No. 37)

- 16 14 8 36. A farmer paid \$1.60 per bushel for $28\frac{1}{4}$ bushels of seed potatoes, 1/20 of which were discarded because of disease. What was the cost per bushel for the good seed?
- 11 13 18 37. A barn loft 40 ft. long is supported by 2" x 10" yellow pine timber 12 ft. long placed edgewise 2 ft. apart between centers. Allowing 12 lbs. per square foot for the weight of the floor, find the number of tons of grain distributed uniformly, that can be safely stored on the floor.

The strength coefficient of yellow pine is 100.

Formula: $S = \frac{a K b d^2}{L}$

b = breadth of beam in thickness
d = depth of beam in inches
K = coefficient of strength
L = length of full span in feet
S = safe load in pounds

- F. I. D.
- 19 20 15 38. How much cement, sand and gravel are required for a concrete floor five inches thick for a room 23 ft. x 38 ft. inside dimensions. The base 4" thick to be l:3:5 micture and a 1" wearing surface to be made of l:2 cement mortar.

Fuller's Formula for figuring materials needed in concrete

 $C = \frac{11}{C \ S \ 9} \qquad S = \frac{3.8 \ Cs}{27} \qquad G = \frac{3.8 \ CG}{27}$ C = Cement in barrels (one barrel 4 sacks) S = Sand (cubic yards) G = Gravel

22 21 9 39. What is the cost of fencing materials for a square 60 acre field using woven wire 30" high and one barbed wire. Post set 16 ft. apart.

rrice	01	woven wire	20g	per	roa
Price	of	barbed wire	4 글 순	per	rod
Price	of	posts	15¢	eacl	1

24 21 8 40. The total cost of baling 3582 bales of alfalfa hay with power baler was \$460.28. The bales averaged 81.2 lbs. per bale. What was the cost per ton for this work?

- F. I. D.
 8 9 10 41. The inside dimension of a silo made of 3" x 3" staves is 12 ft. Allowing one foot for lap, what should be the length of the binding rods for the silo?
- 10 11 16 42. A dairyman wishes to set the safety valve on a steam boiler for 120 lbs. pressure. The valve is 2" in diameter, the short lever 2" long and the long lever 10". What weight should be attached to the lever?
- 12 11 10 43. How many bricks would be required to wall a cellar 12 ft. x 16 ft. seven feet high with 4 windows 12" x 30" (Seven common bricks 2" x 4" x 8" will occupy one square foot of space in a wall one brick thick.)
- 13 16 11 44. What size manila rope should be used to elevate 850 lbs of hay: Diameter of rope in inches, squared x 7200 = Breaking strength. A safety factor of 1/7 should be used. (Diam. in inches)² x 7200 = safe load.

- F. I. D.
 16 15 13 45. A strip 180 feet wide was mowed around a field of alfalfa 112 rods square. If the alfalfa yields 1.5 tons of hay per acre, how many pounds of hay were cut?
- 21 19 8 46. This month's electric meter reading is 8206, last month's reading was 8076 kilowatt-hours.

The rate is $3\frac{1}{2}\phi$ per kilowatt-hour and there is a fixed charge of \$1.50 per month, what would be the total bill for the month?

- 11 11 16 47. An emery grinder with a grinding wheel 8" in diameter runs at a surface speed of 3600 ft. per minute. When the stone wears down to 6" in diameter how many revolutions per minute should the wheel be increased to maintain the original surface speed?
- 23 19 12 48. How many hours would be required to plow a 60 acre field with a two 14" bottom plow and a tractor traveling $4\frac{1}{2}$ miles per hour?

19 21 16 49. What is the nutritive ratio of the

following ration for a yearling steer?

		Percent	
		total	
		digest-	Percent
	Amount	ible	digest-
	in	nutri-	ible
Feed	pounds	ents	protein
Alfalfa hav	3	50.3	10.3
Ground Sorghun	n 13	74.3	5.6
Sorghum	15	17.8	1.1
Cottonseed mea	al 1	75.5	35.

		Percent	of	total	diges	stib le
Nutritive		nutrient	ts_			
ratio	*****	Percent	of	digest	tible	pro-
		tein				

20 22 14 50. Determine the cost of producing a pound

of butterfat when the expenses and returns were as follows:

1.	Feed and pasture	\$107.92
2.	Bedding	<u> </u>
3.	Man labor	43.36
4.	Bull service	7.71
5.	Rent on buildings	5.36
6.	Use of e quipment	8.92
7.	Interest on investment	5.67
8. !	Taxes and insurance	1.57
9.	Overhead	13.56
10.1	Depreciation on stock	9.96
11. '	Value of manure	9.05
12. 1	Value of skim milk	6.83
13. 1	Value of calf	22.10
14.	Production 7386 lbs. milk,	
	3.5% butterfat	

21 22 13 51. From the following data determine the

cost per dozen of eggs produced by

this flock of 100 hens.

Feed

Sorghum grain	\$29.83
Oats	9.35
Wheat	5.34
Tankage	2.62
Bran & Middlings	3.48
Mixed Feeds	5.79
Skim milk	2.96
Man labor	43.58
Buildings and equipment	10.68
Taxes and insurance	1.25
Miscellaneous and overhead	14.31
Interest	4.89
Depreciation in value of sto	ck 38.50
Value of manure	4.62
Number of eggs produced	
during year	18,220

18 19 9 52. What is the value of the plant food added to the soil by six tons of cow manure?

Percent of plant food in Value per lb. barnyard manure of plant food

Nitrogen		•42	12¢
Phosphoric	acid	•39	5¢
Potash		•32	5¢

13 16 12 53. If manure from a herd of 15 dairy cows is applied to the land as produced at the rate of ten tons per acre, how much superphosphate per day should be added to the gutter to make a 600 lb. per acre application along with the manure? (Cows produce on average of 75 lbs. of manure per day) F. I. D.
15 19 15 54. A farmer has a herd of 8 producing dairy cows for which he paid the following prices: \$70, \$85, \$95, \$100, \$135, \$150, \$150, \$300. Find the annual depreciation. Formula:

> Percent of depreciation per year = $\frac{I - S}{L \times I} \times 100$ I = Initial cost of animals S = Salvage value for beef L = Life expectancy in years

- 16 16 8 55. What would a steer weighing 1325 lbs. and purchased at 6½ per pound have to sell at per pound dressed to equal the purchase price if it dressed 62%?
- 17 15 8 56. A steer weighed on foot, 1165 lbs. and dressed out 65 lbs. for each 100 lbs. live weight. What was the dressed weight?
- 14 23 13 57. A farmer replaced 10 cows producing an average of 6000 lbs. of milk per year with 10 cows averaging 9000 lbs of milk per year. The cost of the change was \$1800.00. The high producing cows in-

creased the feed bill by \$14.40 per head per year. With milk selling for \$2.50 per hundred and interest rates at 5%, how many months will it take the cows to pay for the transaction?

18 18 8 58. Fifty young chickens were shipped to a commission merchant who sold them for 29¢ per pound. The express charges were \$1.20 and the selling charge 7%. What was the net price per pound received by the shipper?

13 17 7 59. If a farmer used 42 kilowatt-hours of electric power during one month to milk his herd of 20 cows, what would be the cost per year for milking one cow at a rate of 4¹/₂₀/per kilowatt-hour?

16 17 8 60. A farm cooperative consigned a carload of fat cattle weighing 28,860 to a commission firm who sold them at 8¹/₄¢ per pound. Their commission for selling the load was \$22.00 plus an extra charge for

grading of \$3.00 and a charge of \$2.50 for pro-rating the returns. What was the commission firm's gross charge per pound for selling the cattle?

- 18 18 13 61. What price per pound is a dairyman receiving for butterfat when he sells 25% cream for \$1.50 per gallon?
- 15 16 14 62. A farmer sells his milk to a plant for \$3.10 per hundred pounds for his basic allotment and 60¢ per pound for butterfat and 30¢ per hundred pounds for skimmilk in the portion designated as surplus. During August he delivered 13,200 lbs. of milk testing 3.8% butterfat, 12% of which was designated as surplus. What was his total payment for milk for the month?
- 19 18 11 63. In checking the efficiency of his cream separator, a farmer found the skim milk to contain .07% butterfat. His herd of 25 cows produced an average of 8,240 lbs.

of milk per year. At $60 \neq$ per lb. for butterfat, what was the annual value of his loss in butterfat?

- 12 18 11 64. A farmer wishes to secure an annual contract for the sale of whole milk to test a minimum of 4% butterfat. His present herd of 25 Holstein cows averages 8,250 lbs. per year of milk testing 3.1% butterfat. How man Jersey cows producing 6,330 lbs. each of milk testing 5% should be purchased so that the mixed milk will test 4% butterfat?
- 11 10 7 65. The food budget of a farm family shows that 300 lbs. of butter will be needed for the year. The family cow produces 4,800 lbs. of milk per year with an average butterfat content of 4.8%. Allowing 20% extra for overrun in making butter, how much butter will need to be purchased?
- 15 16 11 66. A high producing herd of 17 cows averaged 10,429 lbs. of milk per cow for

the year. Another herd of 15 cows in the same community averaged 5598 lbs. of milk per cow. How many of the low producing cows must be kept to equal the total production of the 17 cows in the high producing herd?

17 18 10 67. A farmer has 25 cows that produce an average of 6200 lbs. each per year for milk testing 5.2% butterfat. What will be the returns from selling the product by the following methods?

- 1. As whole at \$4.75 per hundred pounds.
- 2. As 25% cream at \$1.50 per gal. and skim milk at 30¢ per hundred pounds.
- 3. As butterfat in sour cream at 55¢ per 1b. and 30¢ per hundred pounds for skim milk.

21 20 11 68. A farmer delivered five lots of milk as follows: 500 lbs. testing 4.25%; 650 lbs. testing 5.85%; 1250 lbs. testing 4.38%; 400 lbs. testing 3.90%. What was the average percent butterfat for the entire lot? F. I. D.
16 17 11 69. If a steer weighing 1020 lbs. on foot dressed 63% and the dressed carcass sold for eleven cents per pound, what price per pound should the steer sell for on foot? Include \$3.00 charge for slaughtering and delivery.

19 22 12 70. A farmer shipped a car load of lambs weighing 15,820 lbs. at the farm, to market where they weighed 14,862 lbs. and sold for \$8.50 per hundred. His marketing costs were as follows:

Freight	\$16.50
Hay	5.20
Grain	3.18
Yard charge	7.50
Commission	11.50

What price per hundred pounds at the farm would be equivalent to the price received at the terminal market?

20 24 12 71. A feeder purchased steers weighing 950 lbs. each at 6½¢ per pound. During the feeding period they gained an average of 200 pounds each at a cost of \$18.00 per head. The finished steers

sold for $7\frac{1}{4}e'$ per pound. Did the feeder gain or lose and how much per head?

- 18 21 15 72. A farmer has an unpaid balance on his farm of \$1200.00 to be paid off in 15 equal payments annually. The interest rate is 5%. How much should be set aside each year for this payment?
- 20 20 14 73. A farmer paid a balance of \$600.00 on a tractor in 12 monthly payments of \$50.00 each. He paid 6% interest on the \$600.00 or \$36.00. What was the actual rate of interest paid?
- 21 23 12 74. A farmer borrowed the following amounts through his local Production Credit Association: \$250.00 for 90 days; \$300.00 for 6 months, and \$500.00 for nine months. The rate of interest was 5% per year. How much interest did he pay for the use of working capital?

22 22 9 75. The cash price per ton of fertilizer is \$42.00. The "time" price due in 6

months is \$46.50 per ton. What rate of interest does this represent?

14 14 14 76. What is the ratio of price received to price paid when the index of price received on corn is .92 and the index of price paid for a mower is 128? Ratio of prices $= \frac{\text{Index of prices}}{\frac{\text{received}}{\text{Index of prices}}} \times 100$ paid

15 21 11 77. A dairyman pays \$1400.00 per year for milking. If he could reduce this labor cost to \$400.00 by installing milking machines, how much could he afford to pay for the machines if money is worth 5% and depreciation and maintenance are 9% on the machines?

14 16 11 78. A farmer agrees to sell a lot of steers for \$300.00 or for alfalfa hay valued at \$350.00. What will he receive for the cattle if he is paid 50% in cash and the remainder in alfalfa hay?

- F. I. D. 16 15 8 79. If the commission charge on selling cattle at the stock yards is 50¢ per head, what percent of the selling price is this on a lot of 38 head weighing 1150 each and selling for \$8.00 per hundred pounds?
- 14 10 11 80. A combine leaved 1/2 tons of wheat straw per acre on the field which contains 1/2% nitrogen, 1/5% phosphoric acid and 3/5% potash. At a value of twelve, five and five cents per pound respectively, what is the plantfood value of the straw?
- 22 20 11 81. How many acres of sorghum producing 14 tons of silage per acre are needed to feed a herd of 25 cows 40 lbs. of silage each per day for nine months?
- 17 15 13 82. What is the price index for cotton selling at 9¢ per pound when the price during the base period averaged 12.5¢ per pound?

Price index = Price at any given time x100 Average price during base period

83. The average rate for farmer's mutual fire insurance companies is 25¢ per hundred dollars of property insured. What would be the fire insurance bill on the average farm in Maricopa County, Arizona?

(Buildings valued at \$2526.00 per farm)

- 16 15 13 84. A man accepted in payment for a tract of farm land, a note for \$4630.00 at $5\frac{1}{4}\%$ due in six months. The note was discounted at once by his bank at 6%, how much cash did he receive for the land?
- 20 20 13 85. A 120 acre farm is valued at \$160.00 per acre and buildings at \$3100.00. The owner has personal property valued at \$2800.00; \$1200.00 of which is exempt from taxes. The rate on personal property is $l\frac{1}{2}g'$ on the dollar. The real estate is listed at 4/5 its actual value. What is the annual tax bill of the farmer?

- F. I. D.
- 16 16 12 86. The average value per farm including buildings and equipment in Maricopa County, Arizona, in 1930 was \$22,819.00. Farm buildings were valued at \$2526.00 per farm and machinery and equipment \$1063.00 per farm. Determine the percent of total investment in buildings; in equipment.
- 18 18 13 87. The tax rate in this county was \$4.69 per acre in 1930. The farms averaged 125.8 acres in size. At 5% on the investment in land, what was the amount of fixed charges for this item and taxes per farm? per acre?
- 18 18 9 88. Determine the annual cost of buildings and equipment per year on the farm listed in Problem No. 86.

Depreciation	\mathbf{on}	machinery	10%
Depreciation	on	buildings	4%
Interest on :	inve	stment	6%

17 18 8 89. What is the total expense per farm for interest⁷⁷ capital in land, taxes, and charge for buildings and machinery on farm listed in Problem No. 86?

- F. I. D.
 14 15 10 90. A Farmers' Cooperative has \$40,000 in outstanding stock with a deficit of \$16,000.00. A farmer has five \$100.00 shares of the stock. What is the actual value of the stock?
- 14 18 14 91. Farm records show that 29% more man labor is required on fields less than 6 acres as compared with fields of 18 acres or more. What is the extra cost for 60 acres of alfalfa hay on the small fields if 12 man hours per acre at 30¢ per hour are required on the larger fields?
- 13 15 11 92. The average cash receipts of 10 high producing farms in 1937 were \$3435.00. The cash expenses were \$2403.00. Increase in farm inventory \$591.00. Interest on investment, \$427.00. What was the labor income?
- 14 17 10 93. The farm also furnished the family with foods worth \$110.00, fuel worth \$26.00,

and use of a house valued at \$320.00 for the year.

Considering these perquisites, what was the total labor income for the family?

- 15 19 14 94. A man made a payment of \$5000.00 on a farm at the time of purchase and agreed to pay \$1000.00 every year for 10 years. If money is worth 4% compounded annually, what is the cash value of the property?
- 18 21 11 95. When money is worth 5% what is the capitalized value of a farm which yields an annual income of \$1250.00?
- 19 20 15 96. The following items are average costs for operating a tractor on farms in the middle west for 255 hours of service per year.
 Evel 514-7 gal. @ 13.5d

Fuel	514.7	ga⊥.	@	13.5¢	
Oil	26	gal.	@	63¢	
Grease				-	\$1.66
Man lal	b or 51 1	nours	0	25¢	
Repairs	s and Me	schan	ics	pay	25.16
Other of	operatio	ng cos	st		.82
Depreci	iation	-			87.81
Housing	g				5.07
Intere	st				20.45
Taxes					4.72

- 1. What was the cost per hour for the year?
- 2. What percent of the total cost was depreciation?
- 3. What percent of the total cost is so-called fixed charges?

11 17 13 97. Ten high income farms in 1937 spent \$261.00 per farm more than did the average farm but received in cash return \$879.00 more per farm than the average. What percent interest did the better farms return on the extra expense?

12 17 14 98. Following is the average capital distribution on ten high income and ten low income farms in Ohio 1937. Determine the percent of capital invested in each class of property for the two groups of farms.

	Average of 10 high farm	Average of 10 slow farms
Land	\$4305.00	\$3796.00
fences	2208.00	2513.00
Livestock	1848.00	1106.00
supplies	1029.00	875.00
Machinery and tools	1292.00	439.00

11 14 15 99. The productive animals kept on the two groups of farms mentioned above were as follows:

	Average of 10 high farms	Average of 10 low farms
Cows	5.9	5
Hens	134.0	83
Ewes	45.0	21

Express the ratio between the amount of livestock kept by the two groups with the high group representing 100 per cent. Use animal units as a basis of the computation.

Animal unit = 100 hens, one cow, seven ewes.

14 16 10 100. A farm house which was insured for 80% of its value was damaged by fire to the extent of 45% of its value. If the house was valued at \$6500.00, how much insurance did the owner collect?

16 21 14 101. Determine the cost per acre for harvesting grain with a 10 ft. combine used on 200 acres per year when the cost items are as follows:

15

18

Cost of machine Life of machine - 8 years	\$1250.00
Interest on investment 6%	
Taxes \$1.35 per 100 Dollars	
on average value of the	
machine	
Man Labor	82,00
Tractor	120.00
Fuel	64.00
011	6.00
Grease	2.00
Repairs	20.00
Housing	7.50

12 102. A local chapter of Future Farmers of America purchased supplies as listed below during the fiscal year ending July 1, 1938. One percent of the savings were retained in the treasury, the remainder of the savings were paid to the members as patronage dividends. Determine the total amount paid to members.

Item purchased	Amount of Purchase	Percent saving
Seed	\$362.00	12
Feed	[°] 476₊00	9
Wire fencing	136.00	18
Chicks	1,237.24	14
Plants	319.40	22
Disinfectants	48.50	30
Vegetable containers	18.45	13
Poultry equipment	645.76	27
Spray materials	292.10	20
Dairy heifers	563.00	8
Swine, breeding stock	t 132.00	10

- F. I. D.
 15 19 12 103. A member of a farmers' cooperative purchased \$320.00 worth of supplies during the year at an estimated saving of \$8.00 under individual store prices. His patronage dividend check for the year was \$25.00. What was the total percentage of saving through cooperative buying?
- 10 14 11 104. A highway 68 feet wide crossed the corner of a farm for a distance of 1/4 mile. The farmer is to be paid 150% of the sale value of \$1.60 per acre for land used in the right-of-way. How much will the owner collect for the land?

APPENDIX B

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PRACTICE EXERCISES IN MATHEMATICS FOR STUDENTS OF VOCATIONAL AGRICULTURE IN ARIZONA

INTRODUCTION

The following list of examples and practice exercises was compiled for the purpose of developing the abilities in mathematics used in the operation of farms and ranches in Arizona.

The list is made up of type problems, selected by a group of competent workers familiar with the various types of agriculture conducted in the state.

Only two sections, namely, mensuration and general percentage are included in this bulletin. The other sections deal with cost of production, marketing, and finance.

The list of examples and exercises is rather short but the problems represent a wide range of abilities common to Arizona agriculture. Similar problems from local farms and the community may be used to supplement the list. Practice in solving these problems will improve your training in mathematics and afford definite preparation for the problems you are facing in agriculture.

Study the examples carefully before attempting to solve the practice exercises. You should be able to solve all the exercises correctly before the end of this school year. Your teacher of agriculture will give you a test on this work near the end of the year. Since you are a member of a group of students selected to make initial use of this material it is important that you do not let this bulletin get into the hands of other students. You will find the problems very interesting and the increased ability derived from this practice will have practical value in your field of work.

MENSURATION USED IN AGRICULTURE

Man's progress in the field of physical science is based upon the use of accurate methods of measuring. Since agriculture is rapidly becoming an exact science, many of the arithmetical problems in this field have to do with the computation of lengths, surfaces, and solids. The simplest of these is the measurement of length. The more common units of length used in agriculture are the inch, hand, foot, yard, rod, and mile. For the most accurate measurements on machines, fractional parts of the inch are used. The following are some of the more common units of distance and their equivalents.

> Four inches = one hand; 12 inches = one foot; 3 feet = one yard; $16\frac{1}{2}$ feet = one rod; 320 rods = one mile.

Area is the amount of surface contained in a plane or solid figure. The units of area are square feet, square inches, square rods, square yards, square miles, and acres. A square foot is the area that would be contained in a square surface that is one foot on each side. The student should note here that 12 square inches do <u>not</u> equal 1 square foot. Instead, a square foot may be considered as a square that is 12 inches on each side, and since the area of a square is equal to the square of one of its sides,

one square foot equals 144 square inches.

144	square	inches	=	1	square	foot
9	square	feet	=	l	square	yard
160	square	rods	=	1	acre	-
640	acres		=	l	square	mile

The area known as the rectangle finds the most common use in agriculture. The area of a rectangle is equal to the product of the length of the rectangle times its width. The circle is also widely used in agriculture. It is often necessary to determine the circumference and area of a circle. The circumference of a circle is equal to $\widetilde{\Pi}$ times its diameter, where γ equals 3.1416. The area of a circle is equal to $\tilde{\chi}$ times the radius of the circle, squared. The radius is the distance from the center to the edge. To compute the capacity of a water tank or the amount of hay in a stack, one must deal with volume. Volume is the amount of space contained between the surfaces of a solid figure. Volume or cubic content differs from area measurements in that a third dimension is involved. The more common units of volume are cubic inches, cubic feet, and cubic yards. A cubic foot may be considered equal to a cube that is one foot long, one foot high, and one foot wide. Again the student should note that 12 cubic inches do not equal 1 cubic foot. Instead 1 cubic foot= $12 \times 12 \times 12 = 1728$ cubic inches.

Most problems in mensuration resolve themselves into simple multiplication and division. The main decis-
ions to be made are; what is to be found, what facts are given, and what processes are necessary to solve the problem. The student should ask himself the following questions before beginning work on a problem.

- 1. What does the problem ask me to find?
- 2. What facts are given?
- 3. How can I arrange the facts to solve the problems?

One of the most important factors in solving problems in measurements is the unit. The units must be kept the same. For example: Find the volume of a right rectangular box which is 2 yards long, one foot wide, and 6 inches in height. The volume of a right rectangular box equals the product of the height times the length times the width. In this case the length is given in yards, the width in feet, and the height in inches. To calculate the volume we must change all of the dimensions to a common unit.

Changing them to feet we have

Length
$$3 \times 2 = 6$$
 ft.
Width $= 1$ ft.
Heighth $6 \times 1/12 = \frac{1}{2}$ ft.

We can now proceed to calculate the volume V = 1 wh = 6 x 1 x $\frac{1}{2} = 3$ cubic feet.

EXAMPLE I

What should be the capacity in tons of a silo to feed a herd of 30 cows, 38 lbs. of silage each per day for 9 months?

First, what does the problem ask us to find? The capacity in tons of a silo. Second, what facts are given? The number of cows (30), the amount of silage each eats for 1 day, (37 lbs.), the number of months (9) supply the silo must hold. Now the third question; how can we arrange these facts to solve the problem? Since we know the number of cows and the amount of silage each eats per day, we can find the amount of silage the herd eats in one day.

Amount of silage consumed by the herd per day = $30 \times 38 = 1140$ lbs.

To find the total weight of silage consumed in 9 months, multiply the total weight consumed per day by the number of days in 9 months. The number of days in 9 months = $9/12 \times 365 = 274$ days.

Weight of silage consumed in 9 months = $274 \times 1140 =$ 312,360 lbs.

As the capacity of the silo is given in tons, the weight of silage consumed in 9 months must be changed from pounds to tons.

Capacity of silo $= \frac{312,360}{2,000} = 156.18$ tons

Exercises

1. How many acres of sorghum producing 10 tons per acre are needed to feed the cows of the above problem for 9 months?

- 2. How many pounds of grain are required to feed 200 hens for a year if each hen consumes 75 lbs. of feed per year and the ration is 65% grain?
- 3. A dairyman has a contract to deliver a minimum of 10,000 lbs. of milk a week. If his herd averaged 65 lbs. of milk per day, per cow, how many cows must the dairyman keep?
- 4. The acreage of short staple cotton for Arizona in 1938 was 161,000. The average yield per acre was 520 lbs. of lint cotton. How many bales of 500 lbs. each were produced?
- 5. A 160 acre field of barley produced 2230 sacks of grain which averaged 108 lbs. each. What was the yield in pounds per acre?

EXAMPLE II

How many hours would be required to plow a 40 acre field with a plow having two 14 inch bottoms and a tractor traveling $4\frac{1}{2}$ miles per hour?

Applying the first two questions, we find:

Required: The number of hours to plow a given field.

Facts: A 40 acre field, to be plowed by two 14 inch bottom plows traveling at 42 miles per hour.

The first step is to reduce the data to a common unit, in this case feet.

40 acre field = 40 x 43,560 = 1,742,400 square feet. 14" plow = 14" x 1/12 = 7/6 feet. 4¹/₂ miles per hour = 4¹/₂ x 5280 = 23,760 ft. per hour.

Now to answer the third question; how can we arrange these facts to solve the problem? This is obviously a problem in area. We are given a certain area to be plowed and also a tractor which is plowing at a given rate per hour.

The area plowed by the tractor in one hour is equal to the span of the plow bottoms times the distance the tractor will travel in an hour.

> Area plowed per hour = 23,760 x (2 x 7/6) 55,440 square feet Time required to plow the 40 acre field = $\frac{1,742,400}{55,440}$ = 31.5 hours

Exercises

- 1. How many hours would be required to disk a 160 acre field using a 21 foot disk moving at the rate of 3 3/4 miles per hour?
- 2. How many hours would be required for a ten foot combine to harvest an 80 acre field of grain, if the combine is moving at the rate of 4 miles per hour?
- 3. How many acres of cotton could be cultivated in a 8 hour day, if the implement covers 4 rows each 42 inches wide and moves at the rate of 4 miles per hour?

EXAMPLE III

What is the cost of fencing materials for a 160 acre square field using woven wire and 1 strand of barbed wire. Posts are set 1 rod apart?

Price	of	woven wire	26¢	per	rod
Price	of	barbed wire	4불성	per	rod
Price	of	posts	15¢	each	ı

Required: To find the cost of materials for a fence of woven wire and barbed wire for a given field. Given: A 160 acre field, posts set 1 rod apart, price of woven wire 26¢ per rod, barbed wire $4\frac{1}{2}$ ¢ per rod, posts 15¢ each.

The chief operation in this problem is to find the length of the perimeter of the square field. Let us change the area of the field from acres to square rods.

A 160 acres = 160×160 square rods.

The side of a square equals the square root of the area of the square. Therefore one side = $\sqrt{160 \times 160}$ = 160 rods.

The perimeter of the field = $4 \times 160 = 640 \text{ rods}$.

Now that we know the distance around the field we can find the cost of fencing it.

Cost Cost Cost	for for for	woven barbed posts	wire wire	640 640 640	x x x	•26 = •045= •15 =	\$166.40 = 28.80 = 96.00
Тс	otal	cost o:	f fenci	ing ma	aterials	=	\$291.20

Exercises

- 1. What would it cost to fence a 40 acre square field using 4 strands of barbed wire? Posts set 1 rod apart. Price of posts -- 18¢ each, barbed wire 5¢ per rod of wire.
- 2. What would be the total cost of constructing an irrigation ditch along one side of a 80 acre square field if the unit cost is twenty-five cents per rod?
- 3. Machinery for harvesting silage was driven over a strip of the crop 8 feet wide along one side of a 40 acre square field. If the field yields 10 tons per acre and one-third of the forage in the strip was lost, what was the total loss?
- 4. How many square feet of roofing will be required for a barn 60 feet long with a gable roof with rafters 26 feet from comb to eaves?

EXAMPLE IV

What length of belt is needed to connect two pulleys, 8 feet apart, each 10 inches in diameter?

- Required: To find length of belt to connect two pulleys of equal size.
- Given: Diameter (10") of pulleys, distance (8') between centers of pulleys. Change the diameter of pulleys to feet, 10" = 5/6'

To solve this problem the student must be able to find the circumference of a circle.

Since the pulleys are of equal diameter, the belt will stretch from the top of one pulley to the top of the other pulley. It will extend halfway around the second pulley, then back to the first pulley and half way around it to reach the starting point.

The belt, therefore covers the distance between the centers of pulleys twice and goes halfway around each of the pulleys. Thus the length of belt equals twice the distance between pulley centers, plus the circumference of one of the pulleys.

circumference = π x diameter Length of belt = 2 x 8 + π x 5/6 = 18.618 feet.

Exercises

1. The pulleys on a stationary motor and a pump are both 8 inches in diameter. If the distance between pulley centers is 10 feet, what length of belt is needed?

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- 2. A stockman wishes to build a wooden stave water tank 10 feet in diameter. (Outside). Allowing one foot for lap, what length rods should be purchased for hoops for the outside of the tank?
- 3. A poultryman has 300 feet of poultry wire to be used in making a circular lot for temporary pasture for chicks. How many square feet of space can be enclosed with the wire?

EXAMPLE V

A hammer mill with a pulley 5 inches in diameter has a rated speed of 2020 R. P. M. What size pulley should be used on the electric motor of 1650 R. P. M. for driving the grinder?

- Required: To find the size of the pulley to be used on the electric driving motor.
- Given: Diameter of pulley (5") of hammer mill, speed (2020 R. P. M.) of hammer mill, speed (1650 R. P. M.) of electric motor.

This is a problem in finding the circumferences of circles. The speed of a point on the surface pulley of the mill will be equal to the speed of the belt and the speed of the belt is equal to the speed of a point on the surface of the motor pulley. Therefore the surface speed of the mill pulley equals the surface speed of the motor pulley. The speed of a point on the surface of a pulley is equal to the circumference of the pulley times the pulley speed in R. P. M. Therefore, if D = diameter of grinder pulley and d = diameter of motor pulley, $\pi \propto D \propto R$. P. M. of grinder = x d x R. P. M. of motor.

D x R. P. M. of grinder = d x R. P. M. of motor 5 x 2020 = d x 1650

diameter of motor pulley $= \frac{5 \times 2020}{1650} = 6.12"$

Exercises

- 1. A hammer mill with a pulley 6 inches in diameter has a rated speed of 2020 R. P. M. The pulley on the electric motor driving the grinder is 7 inches in diameter. What must be the speed of the electric motor?
- 2. A tool grinder with a grinding wheel 8 inches in diameter has a surface speed of 3200 ft. per minute. (a) What is the surface speed when the grinder is worn down to 6 inches in diameter? (b) What number of R. P. M. should the speed of the shaft be increased to bring the surface speed of the grinder back to 3200 feet per minute?
- 3. A combination burr mill and roughage cutter is to he driven at 650 R. P. M. by a motor at 1650 R. P. M. If the drive pulley on the motor is 4 inches in diameter, what should be the diameter of the pulley on the feed mill?

EXAMPLE VI

How many pounds of threshed barley in a bin 10' x 18' by two and one-half feet deep? (A cubic foot of barley weighs about 38.54 lbs.)

Required: To find the weight of threshed barley in a rectangular bin.

Given: Dimensions (10' x 18' x 2½') of the storage bin, weight of barley (38.54 lbs.) per cubic foot. This is a problem in finding volume. The volume of a rectangular right prism is equal to length times width times height.

Volume of barley in bin = 10 x 18 x $2\frac{1}{2}$ = 450 cubic feet Weight of threshed barley in bin equals volume of barley in bin times the weight of a cubic foot of barley. Weight of threshed barley = 38.54 x 450 = 17,343 lbs.

Exercises

- 1. The excavation for a building 35' x 55' is to be made 7 feet deep. How many cubic yards of dirt must be removed?
- 2. What is the capacity of a water trough with a flat bottom 10 feet long, 24 inches deep, and 4 feet wide? (Allow 7.5 gallons per cubic foot.)
- 3. How many tons of silage will a trench silo hold that is 8 feet deep, 8 feet wide at the bottom 12 feet wide at the top, 100 feet long. (1 cubic foot of silage weighs 35 lbs.)
- 4. The floor of a truck body is 6 feet by 10 feet. How high must the side walls extend to hold 3 tons of fresh silage? (Allow 32 lbs. per cubic foot for freshly cut silage.)

EXAMPLE VII

How many tons in a settled flat top stack of alfalfa hay 15 feet wide, 50 feet long, and 48 feet over the top? A ton of hay in this case occupies 485 cubic feet.

> O = distance over top of stack L = length W = width Volume = (.56 x O - (.55 x W) x WL

Required: To find the number of tons of hay in a given settled flat top stack of alfalfa hay. Given: The dimensions (15 feet wide, 50 feet long, 48 feet over) of the stack, volume (485 cubic feet) occupied by a ton of hay.

Before we can find the total weight of hay, we must find the total volume of hay. The total volume of hay is found by substituting the given stack measurements into the volume formula.

Volume of stack

Volume = $(.56 \times 0) - (.55 \times W) \times W L =$ $(.56 \times 48) - (.55 \times 15) = 26.88 - 825 \times 750 =$ Volume = 13,972.5 cubic feet

Since we know the number of cubic feet of hay in the stack, and the number of cubic feet of hay in ton is given, we can find the number of tons of hay in the stack.

Number of tons $= \frac{13,972.5}{485} = 28.81$ tons

Exercises

1. A farmer has a high round topped stack of hay that measures 20 feet wide, 60 feet long, and 40 feet over the top. How many tons of hay are there in the stack? (A ton of hay occupies 485 cubic feet.)

> 0 = distance over top of stack L = length of stack W = width Volume = $(.52 \times 0) - (.46 \times W) \times W L$

2. A farmer has two low round topped stacks of alfalfa that are 45 feet long, 20 feet wide, and 38 feet over the top. If a ton of hay occupies 485 cubic feet, how many tons of hay does the farmer have?

> O = distance over top of stack L = length of stack W = widthVolume = (.52 x O)-(.44 x W) x W L

EXAMPLE VIII

How much cement, sand, and gravel are required for a concrete hog feeding floor that is 5 inches thick x 40 feet x 30 feet inside dimensions.

Concrete mixture to be (1: 2 : 3)

- Formula: $C = \frac{42}{c \ s \ g}$ C = required number of
bags of packed cement
per cubic yard of con-
crete. $S = \frac{C \ x \ s}{27}$ S = required number of cubic
yards of loose sand per
cubic foot of concrete. $G = \frac{C \ x \ g}{27}$ G = required number of cubic
yards of loose gravel
per cubic yard of con-
- C = Number of parts by volume of cement in the mixture s = Number of parts of sand g = Number of parts of gravel

crete.

- Required: To find the necessary amounts of cement, sand, and gravel to make a concrete floor of given mixture and given dimensions.
- Given: Dimensions of floor (5" x 40' x 30') proportions of cement, sand, and gravel in mixture respectively (1:2:3)

Before finding the amounts required of each constituent of the floor, we must first find the volume of the floor.

Changing all the dimensions of the floor to yards we have: Width $= \frac{30}{3} = 10$ yards, length $= \frac{40}{3}$ yds., depth $= \frac{5}{12 \times 3} = 5$ yds.

Volume of the floor = $10 \times 40/3 \times 5/36 = 18.52$ cubic yards.

By use of the formulas we obtain the quantities of the constituents required per cubic yard of floor. The total amount required of each constituent equals the quantity needed per cubic yard, times the total volume of the floor.

Cement

Bags required per cubic yard of concrete

$$\frac{42}{c + s + g} = \frac{42}{1 + 2 + 3} = 7$$
Bags
Total amount of cement required for floor
= 7 x 18.52 = 129.64 bags

Sand

Cubic yards required per cubic yard of concrete $\frac{C \times s}{27} = \frac{7 \times 2}{27} = \frac{14}{27} = .518 \text{ cubic yard}$ Total amount of sand required = 18.52 x .518= 9.6 cubic yards

Gravel

Cubic yards required per cubic yard of concrete $\frac{C \times g}{27} = \frac{7 \times 3}{27} = .778$ cubic yard Total amount of gravel required 18.52 x .778 = 14.41 cubic yards.

Exercises

- 1. Find the cement, sand, and gravel necessary to make 50 corner fence posts that measure 10" x 10" x 8'. Use a (1 : 2 : 3) mixture.
- 2. A farmer wishes to build 100 feet of concrete walk that is 42 inches wide and 4 inches thick. If he uses a (1 : 2^{1/2} : 5) mixture, how much cement, sand, and gravel will he need?
- 3. A poultryman wishes to build a foundation for a poultry house that is to be 20' x 30'. (outside dimensions)

The contract sills are to be 6 inches wide at the top, 10 inches at the bottom, and 14 inches deep. How much cement, sand, and gravel will be used in a (1:3:5) mixture? (Note: In finding the volume of the sills, it will be accurate enough to consider the length of the two longer sills equal to the given outside dimensions and the length of the shorter sills equal to the outside width of the foundation minus twice the average thickness of the sills.

4. A water trough is to be 3 feet wide, 2 feet deep, and 8 feet long (outside dimensions). The bottom is to be 6 inches thick; the side walls are to be 7 inches thick at the bottom and 4 inches thick at the top. The ends are to be 5 inches thick. If a (1:2:3) mixture is used, how much cement, sand, and gravel will be needed to build the trough?

ANSWERS TO EXERCISES ON MENSURATION

I 1)	15.62 acres
2)	9750 pounds
3)	22 cows
4)	167,440 bales
5)	1505.25 pounds per acre
II 1)	16.76 hours
2)	16.5 hours
3)	54.2 acres
III 1)	\$121.60
2)	28.28
3)	.808 tons
4)	3120 square feet
IV 1)	22.094 feet
2)	32.416 feet
3)	7162 square feet
V 1)	1731 RPM
2)	a. 2400 feet per minute b. 509.3 RPM in-
3)	10.15 inches crease
VI 1)	499.075 cubic yards
2)	600 gallons
3)	140 tons
4)	3.125 feet
VII 1)	28.7 tons
2)	40.7 tons
VIII 1)	cement - 72.1 bags sand - 5.3 cubic yards gravel - 8.0 cubic yards
2)	cement - 21.2 bags sand - 1.97 cubic yards gravel - 3.93 cubic yards

- 3) cement 13.1 bags
 sand 1.45 cubic yards
 gravel 2.42 cubic yards
- 4) cement 6.64 bags sand - .492 cubic yards gravel - .737 cubic yards

GENERAL PERCENTAGE USED IN AGRICULTURE

The student of agriculture will find that many of the problems in every branch of this vocation can be solved by use of percentage. The amount of butterfat in milk is given in percentage, and feed rations are figured in percentage of nutrients. Marketing, insurance, and tax problems are also largely a matter of percentage.

A "percent" is a fraction whose denominator is 100. In other words, "percent" is an expression for the common fractions and decimals which the student has already learned. For example, 32 percent may also be written 32/100 or .32. The commercial sign % signifies percent. Any number with the term "percent" or the sign of percent, %, following it can be written as a decimal by moving the decimal point two places to the left.

There are three important terms involved in a percentage problem which represents the three cases of percentage. These terms are; the <u>base</u>, the <u>rate</u>, and the <u>percentage</u>.

The <u>base</u> is that quantity which you are considering as the whole amount of something. It is the amount of which the percentage is a part.

The rate is a certain number of hundreth parts of

150

the whole amount. The whole amount or base is thought of as being divided into a hundred parts. The <u>rate</u> is a certain number of these parts. The <u>rate</u> shows the number of hundredths that the <u>percentage</u> is of the base.

The <u>percentage</u> is a certain part of the whole amount. For example: \$.75 (the percentage) is 75% (the rate) of \$1.00 (the base).

The relation between <u>base</u>, <u>rate</u>, and <u>percentage</u> can be shown by the formula:

base x rate percentage

There are three types of percentage problems. These may be shown by the following examples: Case I: Finding the percentage: given base and rate

Ex. What is 50% of \$1.00?
Fifty percent of \$1.00 means fifty hundredths or
.50 times \$1.00.
.50 x \$1.00 = \$.50
rate x base = percentage

(Notice that the rate must always be expressed as a decimal in the computation)

Case II: Find the rate given base and percentage.

Ex. 25 cents is what percent of \$1.00?

rate =
$$\underline{percentage}_{base}$$
 x 100 = $\underbrace{.25}_{1.00}$ x 100 = 25%

Case III: Find the base when given rate and percentage. Ex. 75 cents is 75% of how much money?

$$base = \frac{percentage}{rate} = \frac{\$.75}{.75} \times 1.00 = \$1.00$$

The student will find that he can solve almost any percentage problem by finding which two of the three factors, base, percentage, and rate, are given and then applying the simple relation

rate x base = percentage

EXAMPLE I

A steer weighed on foot 820 lbs. and dressed out 65 lbs. for each 100 lbs. live weight. What was the dressed weight?

Required: To find the dressed weight of a given steer.

Given: The base, live weight of steer (820 lbs.), the rate, dressing percentage (65 lbs. of dressed meat for 100 lbs. live weight).

820 lbs. is the <u>base</u>, for that is what we start with. The <u>rate</u> will be 65%; for, out of every 100 one pound parts of live steer, we will get 65 one pound parts of dressed meat. The weight of dressed meat will then be the percentage.

percentage = base x rate

Weight of dressed meat = 820 x .65 = 533 pounds

Exercises

- 1. A stockman delivered to market 40 hogs that averaged 208 lbs. each. If the hogs dressed out 78 lbs. of dressed meat per 100 lbs of live weight, what was the total weight of dressed pork?
- 2. A poultryman selected seventy-eight fryers to be dressed for market. They averaged 2.9 pound each alive and lost

39% of their live weight in dressing. What was the total weight of dressed fryers?

EXAMPLE II

What would a steer weighing 800 lbs. and purchased at 6 1/2 cents per pound have to sell at per pound dressed to equal the purchase price if it dressed 62%.

This is, of course, a problem in percentage. Let us ask the same questions used in the first section. What does the problem ask us to find? The selling price per pound of a dressed steer. What facts are given? Weight of the steer (800 lbs.) purchase price 6 1/2 cents per pound, dressing percentage (62%). How can we arrange these facts to solve the problem? The weight of the steer will be the base, for that is what we shall take the rate 62% of to find the weight of the dressed meat (the percentage).

percentage = base x rate

Weight of dressed meat = 800 x .62 = 496.00 pounds
Total purchase price for steer equals total weight
times cost per pound.
Total purchase price = 800 x \$.065 = \$52.00

The total selling price equals the total purchase price. Therefore, the selling price per pound of dressed meat equals the total purchase price divided by the total weight of dressed meat.

Selling price per pound $= \frac{\$52.00}{496.00} = 10.48$ cents.

Exercises

- 1. Live poultry is selling for 18 cents per pound at the farm. If the cost of shipping to the market is 1 1/4 cents per pound and the shrinkage in shipment is 10%, what price per pound at the market should the birds sell for to equal the farm price?
- 2. A grower has 160 acres of cotton which averaged 1 1/2 bales (500 lbs. each) per acre. The local gin gave a turnout of 38% lint while a gin 15 miles away gave 40% lint. At a price of 9 cents per pound for cotton, what would be the additional income from hauling the cotton to the gin giving the higher percentage of lint?

EXAMPLE III

What is the value of plant food (nitrogen and phosphoric acid) added to the soil by six tons of cow manure?

Percent of	plantfood	Value per pound
in manure	_	of plant food

Nitrogen		•43%	\$.12
Phosphoric	acid	•39%	•05

- Required: To find the value of the plant food added to the soil by a given amount of cow manure.
- Given: The base, 6 tons of cow manure, rate of each constituent of the plantfood in the manure (nitrogen, .43%), phosphoric acid, .39%), value as plant food per pound of each constituent.

The 6 tons of manure is the <u>base</u> for it is the whole amount which we are starting with. As the <u>rate</u> of each constituent of the plantfood in the manure is given, we can solve for the percentage or amount of plantfood in the manure.

percentage = rate x base

Weight of nitrogen $= 6 \times 2000 \times .0043 = 51.6$ pounds. Weight of phosphoric acid $= 6 \times 200 \times .0039 = 46.8$ pounds.

Value of each constituent

Nitrogen = $51.6 \times $.12 = 6.19 Phosphoric acid = $46.8 \times $.05 = \frac{2.34}{$8.53}$ Total Value of plantfood = \$8.53

Exercises

- 1. What is the cost per pound of protein in tankage when the tankage sells for \$28.00 per ton and contains 52% protein?
- 2. A vegetable grower wishes to mix 10 tons of a 8-40-0 fertilizer (8% nitrogen40% phosphoric acid (no potash) using sulphate of ammonia containing 20% nitrogen and treble superphosphate containing 46% phosphoric acid. How many pounds of each of the above materials will he need?

EXAMPLE IV

A dairyman delivered four lots of milk as follows: Five hundred pounds testing 4.25%; 650 pounds testing 5.85%; 1250 pounds testing 4.38%; 400 pounds testing 3.90%. What was the average percentage of butterfat for the entire lot?

- Required: To find the average percentage of butterfat for the entire supply of four lots of milk.
- Given: The weight of each of four lots of milk and the percent of butterfat in each.

The weight of each lot is the <u>base</u> for that lot. The percent of butterfat for each lot is the <u>rate</u> for each lot. To find the total weight of <u>percentage</u> of butterfat in each lot

percentage = base x rate

Lot 1. 500 pounds of milk-butterfat= $500 \times .0425 = 21.25$ pounds 2. 650 pounds of milk-butterfat= $650 \times .0585 = 38.025$ pounds 3. 1250 pounds of milk-butterfat= $1250 \times .0438 = 54.75$ pounds 4. 400 pounds of milk-butterfat= $400 \times .039 = 15.60$ pounds

Total milk = 2800 pounds. Total butterfat = 129.63 pounds We now have the resultant base, the total weight of milk, and the resultant percentage, the weight of butterfat in the four lots. We wish to find the rate, average percentage of butterfat in the four lots.

$rate = \frac{percentage}{base} \times 100$

Average percentage of butterfat $= \frac{129.63}{2800} \times 100 = 4.63\%$

Exercises

1. A local chapter of Future Farmers of America purchased supplies as listed below during the fiscal year ending July 1, 1938. One percent of the savings were retained in the treasury. The remainder of the savings were paid to the members as patronage dividends. Determine the total amount paid to members.

Item purchased	Amount	Percentage	saved	
Seed	\$ 362.00	12		
Feed	476.00	9		
Wire fencing	136.00	18		
Chicks	1,237.24	14		
Plants	319.40	22		
Disinfectants	38.50	30		
Vegetable containers	18.45	13		
Poultry equipment	645.76	27		
Spray materials	292.10	20		
Dairy heifers	563.00	8		
Swine, breeding stock	132.00	10		

2. A farmer wishes to mix rations for his livestock as follows: 1000 lbs. of growing mash for poultry, containing 5% barley; 3000 lbs. of laying mash containing 10% barley; 2500 lbs. for feeder steers containing 17% barley; 4000 lbs. for dairy cows containing 30% barley. How many pounds of barley will he need for the four lots of feed?

3. A ration for feeder steers contains the following feeds.

Feed	Amount in pounds	Percent protein		
Hegari silage	22	0.9		
Alfalfa hay	4	10		
Rolled oats	6	8		
Cottonseed meal	2	35		

What percent protein does the ration contain?

4. During the month of November a lot of 300 pullets produced 7200 eggs; 120 hens produced 2400 eggs. What was the average percentage of production for the entire lot of birds for the month?

EXAMPLE V

In checking the efficiency of his cream separator, a dairyman found the skim milk to contain .07% butterfat. His herd of 25 cows produced an average of 7,240 pounds of milk per cow for the year. At 60 cents per pound for butterfat, what was the annual value of his loss in butterfat due to poor adjustment of the separator?

- Required: To find the loss in butterfat for a given amount of milk.
- Given: <u>Base</u>, amount of milk produced by 25 cows averaging 7,240 lbs. a year, <u>rate</u>, percent of butterfat left in milk by separator, cost per pound of butterfat.

Total amount of milk produced is the base. Total weight of milk = $25 \times 7,240 = 181,000$ pounds. Percent of butterfat left in the milk is the rate. We wish to find the percentage of butterfat left in the

skim milk.

percentage = rate x base

Weight of butterfat lost $=.0007 \times 181,000 = 126.7$ pounds Value of loss in butterfat $= 126.7 \times $.60 = 76.02

Exercises

- 1. The inventory value of machinery on an Arizona farm at the beginning of the year was \$1285.00. If it depreciated 9% during the year, what was the value at the end of the year?
- 2. If interest, depreciation and maintenance on farm buildings is 12% per year of their value, what is the annual cost on farm buildings on Maricopa County, Arizona, farms where buildings are valued at \$2526?
- 3. A poultryman wishes to make 10 gallons of disinfecting solution containing 3% of the disinfecting chemical. How many ounces of the chemical should be used? (A pint of water weighs about 16 ounces).

EXAMPLE VI

The average value per farm, including buildings and equipment, in Maricopa County, Arizona for 1930 was \$22,819.00. Farm buildings were valued at \$2526 per farm. Determine the percentage of total investment in buildings.

- Required: To find what percentage of the total investment is represented by farm buildings.
- Given: The base, average value (\$22,819.) per farm, the percentage value (\$2526.) of farm buildings.

In this problem we are given the base and percentage and wish to find the rate. Percentage of total investment represented by farm build-

ings

 $Percent = \frac{\$2526}{22.819} \quad x \ 100 = 4.66\%$

Exercises

1. If it cost \$43.50 to maintain a brood sow for a year, find the percentage of total cost represented by the following items.

Labor - \$7.50, Feed - \$29.15, Buildings and equipment - \$1.25.

EXAMPLE VII

A member of a farmers' cooperative purchased \$320.00 worth of supplies during the year at an estimated saving of \$8.00 under individual store prices. His patronage dividend check for the year was \$25.00. What was the total percentage of saving through cooperative buying?

Required: To find the percentage of saving obtained from cooperative buying.

Given: The base-cost (\$320.) of supplies, base, and the total saving, percentage.

We wish to find what percent, the <u>rate</u>, the savings is of the cost,

Percent of savings = $8 + \frac{25 \times 100}{320} = 10\%$

Exercises

- 1. The retail price of a four rwo tractor planter was \$300. When purchased through a farmers' cooperative the cost was \$252.50. What percentage of the retail price did the buyer save?
- 2. A class of students in farm mechanics purchased a used grain drill for \$85.00. Labor and repairs cost \$18.00. The repaired drill was sold for \$120.00. What percentage of the cost of the machine was realized as profit from the project.

EXAMPLE VIII

What is the nutritive ration of the following ra-

tion for a yearling steer?

Feed	Amount in pounds	Percent total digestible nutrients	Percent digestible protein
Alfalfa	3	50.3	10.3
Ground Sorghum	13	74.3	-5.6
Sorghum silage	15	17.8	1.1
Cottonseed meal	1	75.5	35.

Nutritive ratio = percentage of total digestible nutrients percentage of digestible protein

Required: To find the nutritive ratio of a given ration:

Given: The base, weight of each constituent of the ration, rates, percentage of total digestible nutrients and percentage of digestible protein in each constituent of the ration.

We are given the weight of each constituent and the percentages of total digestible nutrients and the percentages of digestible protein in each constituent. The first step is to find the weights of digestible nutrients and digestible protein in the ration.

percentage = rate x base

Feed	Amount i: pounds	n		Weigh diges nutri	t d til ent	of ole cs			Weigh diges prote	ıt ₃ti ∋ir	of ble ns
Alfalfa hav	3	3	x	•503	н	1.509	3	x	.103	=	.309
Ground sorghum	13	13	x	•743	=	9.659	13	x	.056	=	.728
Sorghum silage	15	15	x	.178	=	2.67	15	x	.011		.165
Cottonseed meal	1	l	x	•755	2	•755	l	х	•35	H	•35
	32					14,593				Ĵ	.552

We now have the total weight of the ration, <u>base</u>, and the total weight of digestible nutrients and the total weight of digestible proteins, the percentages.

We now wish to find the percentage of digestible nutrients and the percentage of digestible proteins, the rate, in the ration.

 $rate = \frac{percentage}{base} \times 100$

Percentage of digestible nutrients

$$\% \quad \frac{14.593 \times 100}{32} = 45.6\%$$

Percentage of digestible proteins

$$\% \quad \frac{1.552}{32} \ge 100 = 4.85\%$$

Now we can obtain the nutritive ratio.

Nutritive ratio = percentage of total digestible nutrients = percentage of digestible protein

 $\frac{45.6}{48.5} = 9.41$ or 1:9.41. For each pound of protein the ration

contains 9.41 pounds of total digestible nutrients.

Exercises

1. Find the nutritive ratio for the following ration for feeder pigs.

Feed	Amount in pounds	Percentage of T.D.N.	Percentage of digestible protein
Sorghum grain	800	79	7.4
Tankage	80	65.8	56.7
Alfalfa ha y	40	50	10.4

2. Find the nutritive ratio for the following ration for fattening lambs.

Feed		Pound s	Percentage of T.D.N.	Percentage of digestible protein
Cracked he	egari	450	79	7.4
Alfalfa ha	ay	950	50	10.4

I	1) 2)	6490 pounds 138 pounds
II	1) 2)	21.4¢ \$216.00
III	1) 2)	2.69¢ per pound Sulphate of ammonia, 8000 pounds Treble superphosphate, 17391 pounds
IV	1) 2) 3) 4)	\$652.75 1975 pounds of barley 5.23% 76.2%
V	1) 2) 3)	\$1169.35 \$303.12 38.4 ounces
VI	1)	Labor, 17.24% Feed, 67% Buildings and equipment, 2.87%
VII	1) 2)	15.8% 16.5%
VIII	1) 2)	1:6.48 1:6.29

APPENDIX C

Individual Student Information Form For second, third, and fourth year students of Vocational Agriculture

1.	School	Date			
2.	Name of student				
3.	Year in high school				
4.	Number of years completed in Vocational Agriculture				
5.	Number of years completed in mathematics (Include all mathematics work in the elementary, junior, and senior high school)				
6.	Average grade in all mathematics courses				
7.	Average grade in all high school subjects, to date				
8.	Score on intelligence test if available				
9.	Score on reading test if available (Name of test if available	<u> </u>			
10.	Teachers estimate of student as to resp	onsibility, inter-			
	est, and general attitude toward school	work. (Use in-			
	formation from as many reliable sources	s as possible in ar-			
	riving at your estimate.)				
	Rank the student as follows				
	Ea	cellent			
	Go	bod			
	Av	orago			
	Be	low Average			
	- Pc	oor			

APPENDIX D

AGRICULTURAL MATHEMATICS TEST

Name	 _Age	 Grade	

School

Date

Directions

Please show all of your work on the space provided below each exercise or in the margin. Use the back of the sheet if necessary.
 Write the answers on the blank line at the end of each problem.
 You will be allowed as much time as you need for the test.

Problems

The annual production of a cow was 8230 lbs of milk that averaged
 5.45% butterfat. At a price of 45.6¢ per pound for butterfat, what
 was the value of her production of butterfat for the year?

Answer

2. At a price of \$55.00 per thousand board feet, what would be the cost of 90 pieces of lumber 2"x10"x16'?

Answer

3. A creamery received the following lots of milk in a shipment.

500 lbs. of milk testing 4.5% butterfat 600 lbs. of milk testing 5.25% " 520 lbs. of milk testing 3.9% " 805 lbs. of milk testing 3.4% "

What was the average percentage of butterfat for the entire lot?

Answer

4. A farmer has a trench silo 8 ft. wide at the bottom, 12 ft. wide at the top, 8 ft. deep and 90 ft. long. How many tons of silage will it hold? (cubic of silage weighs 35 lbs.)

Answer

5. What is the cost of fencing a square field containing 160 acres with woven wire and one strand of barbed wire, posts set one rod apart?

Woven wire--26¢ per rod Barbed wire--42¢ per rod Posts-----20¢ each (640 acres = one sq. mile or section. 320 rods = 1 mile)

Answer

6. What would a steer weighing 1450 lbs. and purchased at $6\frac{1}{2}\phi$ per pound have to sell at per pound dressed to equal the purchase price if the dressing percentage was 62?

Answer

7. The cost of baling 3450 bales of hay was \$282.50. The bales averaged 80.5 lbs. each. What was the cost per ton for the work?

Answer

8. The cash price on a ton of feed is \$42. The price on credit, due in 6 months is \$45.40 per ton. What rate of interest does this represent?

Answer

9. How long should the rafters for a building be cut when the width of the building is 30 ft., the height at the gable is 10 ft., and the tail of the rafter is one ft. long?

(In a right triangle, the side opposite the right angle is called the hypotenuse. The square of the hypotenuse is equal to the sum of the squares of the other two sides).

Answer____

10. A farmer paid \$1.15 per bushel for $3l\frac{1}{4}$ bushels of seed wheat, 1/20 of which was discarded in cleaning. What did the cleaned seed cost per bushel?

Answer_____

11. What length belt would be required to connect two pulleys 24" in diameter, ten feet apart (from center of shafts) (Circumference of a circle = 3.1416 x diameter)

Answer_____

How many fruit trees are needed to plant an acre when each tree
occupies a space 25 x 25 feet? (43560 sq. ft. in an acre)

Answer	J

13. If superphosphate containing 16% plantfood is selling for \$20 per ton, what is the value of a ton of double superphosphate containing 42% plantfood?

Answer

14. If an acre of barley produces 2750 lbs. of grain containing 1.38% nitrogen, how much sulphate of ammonia containing 20.8% nitrogen will be needed to supply the nitrogen removed by the barley crop?

Answer

15. How many gallons of water does a well contain if the pipe is 16" in diameter and 20 ft. long? (the area of a circle is $\frac{1}{2}$ the radius x circumference. A gallon contains 231 cubic inches.)

Answer
APPENDIX E

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DIVISION OF THE PRE-TEST AND FINAL TEST IN MATHEMATICS FOR DETERMINING RELIABILITY

Possible Score: Part A., 46; Part B., 47; Total test, 93.

Part Points

Problems

A. 5. 1. The annual production of a cowwas 8230 lbs. of milk that averaged 5.45% butterfat. At a price of 45.6¢ per pound for butterfat, what was the value of her production of butterfat for the year?

Answer

B. 5. 2. At a price of \$55.00 per thousand board feet, what would be the cost of 90 pieces of lumber 2"x10"x16'?

Answer

B. 9. 3. A creamery received the following lots of milk in a shipment.

> 500 lbs. of milk testing 4.5% butterfat 600 lbs. of milk testing 3.25% butterfat 520 lbs. of milk testing 3.9% butterfat 905 lbs. of milk testing 3.4% butterfat

What was the average percentage of butterfat for the entire lot?

Answer_____

A. 10. 4. A farmer has a trench silo 8 ft. wide at the bottom, 12 ft. wide at the top, 8 ft. deep and 90 ft. long. How many tons of silage will it hold? (A cubit foot of silage weighs 35 lbs.)

Answer

B. 7. 5. What is the cost of fencing a square field containing 160 acres with woven wire and one strand of barbed wire, posts set one rod apart?

> Woven wire - 25¢ per rod Barbed wire - 4½¢ per rod Posts - 20¢ each (640 acres = one sq. mile or section. 320 rods = one mile)

> > Answer

B. 7. 6. What would a steer weighing 1450 lbs. and purchased at 6½¢ per pound have to sell at per pound dressed to equal the purchase price if the dressing percentage was 62?

Answer _____

A. 6. 7. The cost of baling 3450 bales of hay was \$282.50. The bales averaged 80.5 pounds each. What was the cost per ton for the work?

Answer

 A. 6. 8. The cash price on a ton of feed is \$42.00. The price on credit, due in 6 months is \$45.50 per ton. What rate of interest does this represent?

Answer

B. 6. 9. How long should the rafters for a building be cut when the width of the building is
30 ft., the height at the gable is 10 ft., and the tail of the rafter is one ft. long?

(In a right triangle, the side opposite the right angle is called the hypotenuse. The square of the hypotenuse is equal to the sum of the squares of the other two sides).

Answer

A. 7. 10. A farmer paid \$1.15 per bushel for 31¹/₄ bushels of seed wheat, 1/20 of which was discarded in cleaning. What did the cleaned seed cost per bushel?

Answer

B. 6. 11. What length belt would be required to connect two pulleys 24" in diameter, ten feet apart (from center of shafts) (Circumference of a circle = 3.1416 x diameter)

Answer

B. 4. 12. How many fruit trees are needed to plant an acre when each tree occupies a space 25 ft. x 25 ft.? (43560 square feet in an acre)

Answer _____

B. 5. 13. If superphosphate containing 16% plantfood is selling for \$20.00 per ton, what is the value of a ton of double superphosphate containing 42% plantfood?

Answer

A. 6. 14. If an acre of barley produces 2750 lbs. of grain containing 1.38% nitrogen, how much sulphate of ammonia containing 20.8% nitrogen will be needed to supply the nitrogen removed by the barley crop?

Answer

B. 5. 15. How many gallons of water does a well contain if the pipe is 16" in diameter and 20 ft. long? (The area of a circle is ¹/₂ the radius x circumference. A gallon contains 231 cubic inches.)

Answer

APPENDIX F

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REVISED PRACTICE EXERCISES IN MATHEMATICS FOR STUDENTS OF VOCATIONAL AGRICULTURE IN ARIZONA 173

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 Yields on cotton

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- 2. Harvesting with a combine
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- 1. Taxes and interest on investment in farm land
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MENSURATION USED IN AGRICULTURE

Man's progress in the field of physical science is based upon the use of accurate methods of measuring. Since agriculture is rapidly becoming an exact science, many of the arithmetical problems in this field have to do with the computation of lengths, surfaces, and solids. The simplest of these is the measurement of length. The more common units of length used in agriculture are the inch, hand, foot, yard, rod, and mile. For the most accurate measurements on machines, fractional parts of the inch are used. The following are some of the more common units of distance and their equivalents.

> Four inches = one hand; 12 inches = one foot; 3 feet = one yard; $\cdot 16\frac{1}{2}$ feet = one rod; 320 rods = one mile.

Area is the amount of surface contained in a plane or solid figure. The units of area are square feet, square inches, square rods, square yards, square miles, and acres. A square foot is the area that would be contained in a square surface that is one foot on each side. The student should note here that 12 square inches do <u>not</u> equal 1 square foot. Instead, a square foot may be considered as a square that is 12 inches on each side, and, since the area of a square is equal to the square of one of its sides, one square foot equals 144 square inches.

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144 square inches = 1 square foot 9 square feet = 1 square yard 160 square rods = 1 acre 640 acres = 1 square mile

The area known as the rectangle finds the most common use in agriculture. The area of a rectangle is equal to the product of the length of the rectangle times its The circle is also widely used in agriculture. width. It is often necessary to determine the circumference and area of a circle. The circumference of a circle is equal to π times its diameter, where π equals 3.1416. The area of a circle is equal to T times the square of the radius. The radius is the distance from the center to the edge. To compute the capacity of a water tank or the amount of hay in a stack, one must deal with volume. Volume is the amount of space contained between the surfaces of a solid figure. Volume or cubic content differs from area measurements in that a third dimension is involved. The more common units of volume are cubic inches, cubic feet, and cubic yards. A cubic foot may be considered equal to a cube that is one foot long, one foot high, and one foot wide. Again the student should note that 12 cubic inches do not equal 1 cubic foot. Instead 1 cubic foot = 12×12 x 12 = 1728 cubic inches.

Most problems in mensuration resolve themselves into stimple multiplication and division. The main decisions to be made are; what is to be found, what facts are

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given, and what processes are necessary to solve the problem. The student should ask himself the following questions before beginning work on a problem.

- 1. What does the problem ask me to find?
- 2. What facts are given?
- 3. How can I arrange the facts to solve the problem?

One of the most important factors in solving problems in measurements is the unit. The unit must be kept the same. For example: Find the volume of a right rectangular box which is 2 yards long, one foot wide, and 6 inches in height. The volume of a right rectangular box equals the product of the height times the length times the width. In this case the length is given in yards, the width in feet, and the height in inches. To calculate the volume we must change all of the dimensions to a common unit.

Changing them to feet we have

Length = 3 x 2 = 6 feet Width = 1 foot Height = 6 x k/12 = $\frac{1}{2}$ foot We can now proceed to calculate the volume V = 1 wh = 6 x 1 x $\frac{1}{2}$ = 3 cubic feet.

GENERAL PERCENTAGE USED IN AGRICULTURE

The student of agriculture will find that many of the problems in every branch of this vocation can be solved by use of percentage. The amount of butterfat in milk is given in percentage, and feed rations are figured in percentage of nutrients. Marketing, insurance, and tax problems are also largely a matter of percentage.

A "percent" is a fraction whose denominator is 100. In other words, "percent" is an expression for the common fractions and decimals which the student has already learned. For example, 32 percent may also be written 32/100 or .32. The commercial sign % signifies percent. Any number with the term "percent" or the sign of percent, %, following it can be written as a decimal by moving the decimal point two places to the left.

There are three important terms involved in a percentage problem which represents the three cases of percentage. These terms are; the <u>base</u>, the <u>rate</u>, and the <u>per-</u> centage.

The <u>base</u> is that quantity which you are considering as the whole amount of something. It is the amount of which the percentage is a part.

The <u>rate</u> is a certain number of hundredth parts of the whole amount. The whole amount is the unit of material or quantity with which a problem deals. The <u>rate</u> shows the number of hundredths that the <u>percentage</u> is of the base.

The <u>percentage</u> is a certain part of the whole amount. For example: \$.75 (the percentage) is 75% (the rate) of \$1.00 (the base).

The relation between <u>base</u>, <u>rate</u>, and <u>percentage</u> can be shown by the formula:

base x rate = percentage

There are three types of percentage problems. These may be shown by the following examples:

Case I: Finding the percentage: given base and rate.

Ex. What is 50% of \$1.00? Fifty percent of \$1.00 means fifty hundredths or .50 times \$1.00 .50 x \$1.00 = \$.50 rate x base percentage

(Notice that the rate must always be expressed as a decimal in the computation)

Case II: Find the rate given base and percentage.

Ex. 25 cents is what percent of \$1.00?

Case III: Find the base when given rate and percentage. Ex. 75 cents is 75% of how much money?

$$\frac{base}{rate} = \frac{percentage}{rate} = \frac{\$.75}{.75} \times 1.00 = \$1.00$$

The student will find that he can solve almost any percentage problem by finding which two of the three factors, base, percentage, and rate, are given and then applying the simple relation,

rate x base = percentage

PART ONE

GENERAL FARM PROBLEMS

I. CROP AND ANIMAL YIELDS

EXAMPLE

What should be the capacity in tons of a silo to feed a herd of 30 cows, 38 lbs. of silage each per day for 9 months?

First, what does the problem ask us to find? The capacity in tons of a silo. Second, what facts are given? The number of cows (30), the amount of silage each eats for 1 day, (38 lbs.), the number of months (9) supply the silo must hold. Now the third question; how can we arrange these facts to solve the problem? Since we know the number of cows and the amount of silage each eats per day, we can find the amount of silage the herd eats in one day. Amount of silage consumed by the herd per day = $30 \times 38 = 1140$ lbs.

To find the total weight of silage consumed in 9 months, multiply the total weight consumed per day by the number of days in 9 months. The number of days in 9 months $= 9/12 \times 365 = 274$ days.

Weight of silage consumed in 9 months = $274 \times 1140 = 312,360$ lbs.

As the capacity of the silo is given in tons, the weight of silage consumed in 9 months must be changed from pounds to tons.

Capacity of silo $= \frac{312,360}{2,000} = 156.18$ tons

Exercises

- 1. How many acres of sorghum producing 10 tons per acre are needed to feed the cows of the above problem for 9 months?
- 2. A dairyman has a contract to deliver a minimum of 10,000 pounds of milk a week. If his herd averaged 65 pounds of milk per day, per cow, how many cows must the dairyman keep?
- 3. The acreage of short staple cotton for Arizona in 1938 was 161,000. The average yield per acre was 520 lbs. of lint cotton. How many bales of 500 lbs. each were produced?
- 4. A 160 acre field of barley produced 2230 sacks of grain which averaged 108 lbs. each. What was the yield in pounds per acre?

II. DUTY OF FIELD MACHINERY

EXAMPLE

How many hours would be required to plow a 40 acre field with a plow having two 14 inch bottoms and a tractor traveling $4\frac{1}{2}$ miles per hour?

Applying the first two questions, we find: Required: The number of hours to plow a given field.

Facts: A 40 acre field, to be plowed by two 14 inch bottom plows traveling at $4\frac{1}{2}$ miles per hour.

The first step is to reduce the data to a common unit, in this case feet.

40 acre field = 40 x 43.560 = 1,742,400 square feet 14" plow = 14" x 1/12 = 7/6 feet $4\frac{1}{2}$ miles per hour = $4\frac{1}{2}$ x 5280 = 23,760 feet per hour

Now to answer the third question; how can we arrange these facts to solve the problem?

This is obviously a problem in area. We are given a certain area to be plowed and also a tractor which is plowing at a given rate per hour.

The area plowed by the tractor in one hour is equal to the span of the plow bottom times the distance the tractor will travel in an hour.

> Area plowed per hour = 23,760 x $(2 \times 7/6)$ = 55,440 square feet Time required to plow the 40 acre field $=\frac{1,742,400}{55,440} = 31\frac{1}{2}$ hours

Exercises

- 1. How many hours would be required to disk a 160 acre field using a 21 foot disk moving at the rate of 3-3/4 miles per hour?
- 2. How many hours would be required for a ten foot combine to harvest an 80 acre field of grain, if the combine is moving at the rate of 4 miles per hour?
- 3. How many acres of cotton could be cultivated in a 8 hour day, if the implement covers 4 rows each 42 inches wide and moves at the rate of 4 miles per hour?

III. VOLUME CAPACITY OF FARM STRUCTURES

EXAMPLE

How many pounds of threshed barley are in a bin 10 feet x 18 feet by two and one-half feet deep? (A cubic foot of barley weighs about 38.54 lbs.)

- Required: To find the weight of threshed barley in a rectangular bin.
- Given: Dimensions (10' x 18' x 2½') of the storage bin, weight of barley (38.54 lbs.) per cubic foot.

This is a problem in finding volume. The volume of a rectangular right prisim is equal to length times width times height.

Volume of barley in bin = 10 x 18 x $2\frac{1}{2} = 450$ cubic feet Weight of threshed barley in bin equals volume of barley in bin times the weight of a cubic foot of barley Weight of threshed barley = $38.54 \times 450 = 17,343$ lbs.

Exercises

- 1. The excavation for a building 35 feet x 55 feet is to be made 7 feet deep. How many cubic yards of dirt must be removed?
- 2. What is the capacity of a water trough with a flat bottom 10 feet long, 24 inches deep, and 4 feet wide. (Allow 7.5 gallons per cubic foot.)
- 3. How many tons of silage will a trench silo hold that is 8 feet deep, 8 feet wide at the bottom, 12 feet wide at the top, 100 feet long. (A cubic foot of silage weighs 35 lbs.)
- 4. The floor of a truck body is 6 feet by 10 feet. How high must the side walls extend to hold 3 tons of fresh silage? (Allow 32 lbs. per cubic foot for freshly cut silage)

5. A house of four rooms is to be cooled with a window type evaporative cooler. Three rooms are 12' x 14', one 10' x 12' and the ceiling is 10 feet high. What should be the free air capacity per minute of the fan to cool the house? (A fan delivers two-thirds of its free air rating when placed in a cooler)

IV. TONS OF HAY IN STACKS

EXAMPLE

How many tons in a settled flatt top stack of alfalfa hay 15 feet wide, 50 feet long, and 48 feet over the top? A ton of hay in this case occupies 485 cubic feet.

> 0 = distance over top of stack L = length W = width $Volume = (.56 \times 0) - (.55 \times W) \times WL$

- Required: To find the number of tons of hay in a given settled flat top stack of alfalfa hay.
- Given: The dimensions (15 feet wide, 50 feet long, 48 feet over) of the stack, volume (485 cubic feet) occupied by a ton of hay.

Before we can find the total weight of hay, we must find the total volume of hay. The total volume of hay is found by substituting the given stack measurements into the volume formula.

Volume of stack

Volume = $(.56 \times 0) - (.55 \times W) \times W L$ $(.56 \times 48) - (.55 \times 15) =$ $26.88 - 8.25 \times 750$ Volume = 13,972.5 cubic feet

Since we know the number of cubic feet of hay in the stack, and the number of cubic feet of hay in a ton is given, we can find the number of tons of hay in the stack.

Number of tons
$$= \frac{13,972.5}{485} = 28.81$$
 tons

Exercises

1. A farmer has a high round topped stack of hay that measures 20 feet wide, 60 feet long, and 40 feet over the top. How many tons of hay are there in the stack? (A ton of hay occupies 485 cubic feet)

0 = distance over top of stack
L = length of stack
W = width
Volume = (.52 x 0) - (.46 x W) x W L

2. A farmer has two low round topped stacks of alfalfa that are 45 feet long, 20 feet wide, and 38 feet over the top. If a ton of hay occupies 485 cubic feet, how many tons of the hay does the farmer have?

> 0 = distance over top of stack L = length of stack W = width Volume = (.52 x 0) - (.44 x W) x W L

> > V. CONCRETE CONSTRUCTION

EXAMPLE

How much cement, sand, and gravel are required for a concrete hog feeding floor that is 5 inches thick x 40 feet x 30 feet, outside measurements. Use a 1:2:3 mixture. Given: Floor is 5 inches thick, 30 feet wide and 40 feet long. 1:2:3 mixture. It takes approximately 42 cubic feet of dry material, (sand, cement, and gravel) to make 27 cubic feet or 1 cubic yard of set concrete. One sack of cement holds approximately 1 cubic feet of cement.

Example of a 1:2:3 mixture. (1 part cement, 2 parts sand, 3 parts gravel).

In a 1:2:3 mixture there would be 1+2+3=6 total units of material in the mixture.

There would be $\frac{42}{6}$ =7 cubic feet of dry material in each unit of mixture in a cubic yard.

Cement: (1 unit of cement). 7x1=7 cubic feet of cement, or 7 sacks of cement in 27 cubic feet, or 1 cubic yard of set concrete.

Sand: (2 units of sand). 7x2=14 cubic feet of sand. Therefore $\frac{14}{27} = .519$ cubic yards of sand in each cubic yard of set concrete.

Gravel: (3 units of gravel). 7x3 = 21 cubic feet. So $\frac{21}{27} =$.778 cubic yards of gravel in each cubic yard of set concrete.

Example of a 1:3 mixture. (1 part cement, 3 parts sand). In a 1:3 mixture there are 1+3=4 total units of dry material in the mixture.

There would be $\frac{42}{4} = 10.5$ cubic feet of dry material in each unit of material in a cubic yard.

Cement: (1 unit of cement). $1 \times 10.5 = 10.5$ cubic feet or 10.5 sacks of cement in each cubic yard of set concrete. Sand: (3 units of sand). $3 \times 10.5 = 31.5$ cubic feet. Therefore 31.5 = 1.17 cubic yards of sand in each cubic yard of set concrete.

Solving the problem:

The volume of the floor = $\frac{5}{12} \times \frac{40}{1} \times \frac{30}{1} = 500$ cubic feet $\frac{500}{27}$ or 18.5 cubic yards.

From the 1:2:3 example listed above, we find that there are 7 sacks of cement, .518 cubic yards of sand and .788 cubic yards of gravel in each cubic yard of set concrete. Therefore, with 18.5 cubic yards of concrete in the floor, there would be 7 x 18.5 = 129.5 sacks of cement, .518 x 18.5 = 9.6 cubic yards of sand, and .788 x 18.5 = 14.6 cubic yards of gravel in the feeding floor.

Exercises

- 1. Find the cement, sand, and gravel necessary to make 50 corner fence posts that measure 10" x 10" x 8'. Use a (1:2:3) mixture.
- 2. A farmer wishes to build 100 feet of concrete walk that is 42 inches wide and 4 inches tick. If he uses a (1:22:5) mixture, how much cement, sand, and gravel will he need?
- 3. A poultryman wishes to build a foundation for a poultry house that is to be 20' x 30'. (Outside dimensions) The concrete sills are to be 6 inches wide at the top, 10 inches at the bottom, and 14 inches deep. How much cement, sand, and gravel will be used in a (1:3:5) mixture? (Note: In finding the volume of the sills, it will be accurate enough to consider the length of the two longer sills equal to the given outside dimensions and the length of the shorter sills equal to the outside width of the foundation minus twice the average thickness of the sills.)

4. A water trough is to be 3 feet wide, 2 feet deep, and 8 feet long (outside dimensions). The bottom is to be 6 inches thick; the side walls are to be 7 inches thick at the bottom and 4 inches thick at the top. The ends are to be 5 inches thick. If a (1:2:3) mixture is used, how much cement, sand, and gravel will be needed to build the trough?

VI. SPEEDS OF COMMON FARM MACHINES

EXAMPLE

A hammer mill with a pulley 5 inches in diameter has a rated speed of 2020 R. P. M. What size pulley should be used on the electric motor of 1650 R. P. M. for driving the grinder?

- Required: To find the size of the pulley to be used on the electric driving motor.
- Given: Diameter of pulley (5") of hammer mill, speed (2020 R. P. M.) of hammer mill, speed (1650 R. P. M.) of electric motor.

This is a problem in finding the circumferences of circles. The speed of a point on the surface pulley of the mill will be equal to the speed of the belt and the speed of the belt is equal to the speed of a point on the surface of the motor pulley. Therefore the surface speed of the mill pulley equals the surface speed of the motor pulley. The speed of a point on the surface of a pulley is equal to the circumference of the pulley times the pulley speed in R. P. M. Therefore, if D = diameter of grinder pulley and d = diameter of motor pulley, $\gamma \propto D \propto R$. P. M. of grinder $= \pi \mathbf{x} \mathbf{d} \mathbf{x} \mathbf{R} \cdot \mathbf{P} \cdot \mathbf{M} \cdot \mathbf{of}$ motor.

D x R. P. M. of grinder = d x R. P. M. of motor 5 x 2020 = d x 1650

diameter of motor pulley = $\frac{5 \times 2020}{1650} = 6.12"$

Exercises

- 1. A combination burr mill and roughage cutter is to be driven at 650 R. P. M. by a motor at 1650 R. P. M. If the drive pulley on the motor is 4 inches in diameter, what should be the diameter of the pulley on the feed mill?
- 2. A blower for an evaporative cooler is to be driven at a speed of approximately 550 R. P. M. by a motor with a speed of 1750 R. P. M. If the motor pulley is 2 inches in diameter, what size pulley should be used on the blower?
- 3. A tool grinder with a grinding wheel 8 inches in diameter has a surface speed of 3200 feet per minute. (a) What is the surface speed when the grinder is worn down to 6 inches in diameter? (b) What number of R. P. M. should the speed of the shaft be increased to bring the surface speed of the grinder back to 3200 feet per minute?

VII. CIRCUMFERENCE OF PULLEYS AND OTHER CIRCULAR FORMS

EXAMPLE

What length of belt is needed to connect two pul-

leys, 8 feet apart, each 10 inches in diameter?

Required: To find length of belt to connect two pulleys of equal size.

Given: Diameter (10") of pulleys, distance (8') between centers of pulleys. Change the diameter of pulleys to feet, 10 inches 5/6 feet. To solve this problem the student must be able to find the circumference of a circle.

Since the pulleys are of equal diameter, the belt will stretch from the top of one pulley to the top of the other pulley. It will extend half way around the second pulley, then back to the first pulley and half way around it to reach the starting point.

The belt, therefore covers the distance between the centers of pulleys twice and goes half way around each of the pulleys. Thus the length of belt equals twice the distance between pulley centers, plus the circumference of one of the pulleys.

circumference = $\pi \times \text{diameter}$ Length of belt = 2 x 8 + $\pi \times 5/6$ = 18.618 feet.

Exercises

- 1. The pulleys on a stationary motor and a pump are both 8 inches in diameter. If the distance between pulley centers is 10 feet, what length of belt is needed?
- 2. A stockman wishes to build a wooden stave water tank 10 feet in diameter. (Outside). Allowing one foot for lap, what length rods should be purchased for hoops for the outside of the tank?
- 3. A poultryman has 300 feet of poultry wire to be used in making a circular lot for temporary pasture for chicks. How many square feet of space can he enclose with the wire?

VIII. NUTRIENTS FOR PLANTS AND ANIMALS

EXAMPLE

What is the value of plant food (nitrogen and phosphoric acid) added to the soil by six tons of cow manure?

Percent of plant-	Value per pound		
food in manure	of plant food		
Nitrogen .43%	\$.12		
Phosphoric acid .39%	.05		

Required: To find the value of the plant food added to the soil by a given amount of cow manure.

Given: The case - 6 tons of cow manure, rate of each constituent of the plantfood in the manure (nitrogen, .43%), phosphoric acid, .39%), value as plant food per pound of each constituent.

The 6 tons of manure is the <u>base</u> for it is the whole amount which we are starting with. As the <u>rate</u> of each constituent of the plantfood in the manure is given, we can solve for the <u>percentage</u> or amount of plantfood in the manure.

percentage = rate x base

Weight of nitrogen = $6 \times 2000 \times .0043 = 51.6$ pounds Weight of phosphoric acid = $6 \times 200 \times .0039 = 46.8$ pounds

Value of each constituent

Nitrogen = 51.6 x \$.12 = \$6.19 Phosphoric acid = 46.8 x \$.05 = 2.34 Total Value of plantfood \$8.53

Exercises

1. A vegetable grower wishes to mix 10 tons of a 8-40-0 fertilizer (8% nitrogen, 40% phosphoric acid (no potash) using sulphate of ammonia containing 20% nitrogen and treble superphosphate containing 46% phosphoric acid.) How many pounds of each of the above materials will be needed?

2. What is the cost per pound of protein in tankage when the tankage sells for \$28.00 per ton and contains 52% protein?

IX. NUTRITIVE RATIO OF LIVESTOCK RATIONS

EXAMPLE

What is the nutritive ratio of the following ra-

tion for a yearling steer?

Feed	Amount in pounds	Percent total n digestible nutrients	Percent digestible protein
Alfalfa	3	50.3	10.3
Ground Sorghum	13	74.3	5 .6
Sorghum silage	15	17.8	1.1
Cottonseed meal	1	75.5	35

Nutritive ratio <u>total digestible nutrients</u> total digestible protein

Required: To find the nutritive ratio of a given ration:

Given: The base, weight of each constituent of the ration, rates, percentage of total digestible protein in each constituent of the ration.

We are given the weight of each constituent and the percentages of total digestible nutrients and the percentages of digestible protein in each constituent. The first step is to find the weights of digestible nutrient and digestible protein in the ration.

Feed	Amoun in pound	t s		We d: ni	ei ige iti	ght of estible rients	€	We di pi	eight Lgest: rotein	of Lbl ns	.e
Alfalfa Hay	3	_3	x	•503	4	1.509	lbs. 3	x	.103	=	.309
Ground sorghum	13	13	х	•743		9.659	13	х	•056	=	•728
Sorghum silage	15	15	x	.178	=	2.67	15	x	.011	=	.165
Cottonseed meal	L <u>1</u>	1	x	•755	-	.755	l	X	•35	=	•35
	32					14.593				כ	. 552

We now have the total weight of the ration, <u>base</u>, and the total weight of digestible nutrients and the total weight of digestible proteins.

Now we can obtain the nutritive ratio.

Nutritive ratio = total digestible nutrients = total digestible protein =

 $\frac{45.6}{4.85}$ = 9.40 or 1:9.40. For each pound of protein the

ration contains 9.40 pounds of total digestible nutrients.

Exercises

1. Find the nutritive ratio for the following ration for feeder pigs.

Feed	Amount in pounds	Percentage of T.D.N.	Percentage digestible protein	of
Sorghum grain	800	79	7.4	
Tankage	80	65.8	56.7	
Alfalfa hay	40	50	10.4	

2. Find the nutritive ration for the following ration for fattening lambs.

Feed	Pounds	Percentage of T.D.N.	Percentage digestible protein	of
Cracked hegari	4 50	79	7•4	
Alfalfa hay	950	50	10•4	

X. ANALYSIS OF SOME FARM MATERIALS

EXAMPLES

In checking the efficiency of his cream separator, a dairyman found the skim milk to contain .07% butterfat. His herd of 25 cows produced an average of 7,240 pounds of milk per cow for the year. At 60 cents per pound for butterfat, what was the annual value of his loss in butterfat due to poor adjustment of the separator?

- Required: To find the loss in butterfat for a given amount of milk.
- Given: Base, amount of milk produced by 25 cows averaging 7,240 pounds a year, <u>rate</u>, percent of butterfat left in milk by separator, cost per pound of butterfat.

Total amount of milk produced is the base Total weight of milk = $25 \times 7,240 = 181,000$ pounds Percent of butterfat left in the milk is the rate

We wish to find the percentage of butterfat left in the skim milk.

percentage = rate x base

Weight of butterfat lost = .0007 x 181,000 = 126.7 pounds Value of loss in butterfat = $126.7 \times $.60 = 76.02

Exercises

- 1. A poultryman wishes to make 10 gallons of disinfecting solution containing 3% of the disinfecting chemical. How many ounces of the chemical should be used? (A pint of water weighs about 16 ounces).
- 2. A vegetable grower wishes to mix 220 lbs. of poison bran mash containing 1.5 percent arsenic. How much arsenic will he need?

XI. FENCES AND DITCHES

EXAMPLE

What is the cost of fencing materials for a 160 acre square field using woven wire and 1 strand of barbed

wire. Posts are set 1 rod apart?

Price	of	woven wire	26¢	per rod
Price	of	barbed wire	4호¢	per rod
Price	of	posts	15¢	each

- Required: To find the cost of materials for a fence of woven wire and barbed wire for a given field.
- Given: A 160 acre field, posts set 1 rod apart, price of woven wire, 26¢ per rod, barbed wire 4½¢ per rod, posts 15¢ each.

The chief operation in this problem is to find the length of the perimeter of the square field. Let us change the area of the field from acres to square rods.

A 160 acres = 160 x 160 square rods.

The side of a square equals the square root of the area of the square. Therefore, one side of the field =

 $\sqrt{160 \times 160} = 160 \text{ rods}$.

The perimeter of the field = $4 \times 160 = 640 \text{ rods}$.

Now that we know the distance around the field we can find the cost of fencing it.

Cost for woven wire
Cost for barbed wire $640 \times .26 = \$166.40$ Cost for barbed wire
Cost for posts $640 \times .045 = 28.80$ $640 \times .15 = 96.00$

Total cost of fencing materials=\$291.20

Exercises

- What would it cost to fence a 40 acre square field using 4 strands of barbed wire? Posts set 1 rod apart. Price of posts, 18 cents each, barbed wire 5 cent per rod of wire.
- 2. What would be the total cost of constructing an irrigation ditch along one side of a 80 acre square field if the unit cost is twenty-five cents per rod?
- 3. Machinery for harvesting silage was driven over a strip of the crop 8 feet wide along one side of a 40 acre square field. If the field yields 10 tons per acre and one-third of the forage in the strip was lost, what was the total loss.

XII. IRRIGATION PART A

EXAMPLE

A farmer has a pumping plant with a capacity of 1800 gal./ min. He has 80 acres of alfalfa requiring 5 acre feet per year. The total cost for pumping (fixed charges and operating charges) is \$1.25 per hour.

(a) What is his water cost per year?

(b) What is his water cost per acre foot?

Some comparisons to keep in mind in solving the problems. 450 gallons per minute 1 cubic foot per second or one second foot. 40 miners inches (M. I.) = 1 cubic foot/ sec. or one second foot. One second foot for 1 hour = 1 acre inch or 1 acre covered 1 inch deep. One second foot for 24 hours = 2 acre feet or one acre covered 2 feet deep. 43560 square feet = One acre.

For solving problems always change M. I. or gal./min. to second foot.

- Given: Pump capacity 1800 gal./min., acres of alfalfa (80 acres), acre feet per acre (5 acre feet), cost per hour (\$1.25).
 - (a) Since 450 gal./min. = 1 second foot, 1800 gallons per minute = $\frac{1800}{450}$ = 4 second feet capacity of pump. 80 x 5 = 400 acre feet needed per year for the alfalfa. Since 1 second foot for 1 hour = 1 acre inch, 4 second foot for 1 hour =
4 acre inches or 1/3 acre foot.

4 second feet for 3 hours = 1 acre foot $400 \ge 3 = 1200$ hours to pump the water needed for alfalfa. 1200 $\ge 1.25 = 1500.00 or total water cost per year for alfalfa.

 (b) Since it takes 3 hours to pump 1 acre foot of water and it costs \$1.25 per hour, 3 x \$1.25 = \$3.75 or cost per acre foot of water.

Exercises

- 1. A farmer has 100 acres of cotton and applies a 200 M. I. (Miners inch) head for 80 hours.
 - (a) How many acre inches did he put on per acre?
 - (b) If each acre inch saturates the soil for 1 1/4 foot, (Sandy soil) how many feet deep was the soil saturated?
- 2. A farmer has a pump with a capacity of 2700 gal./min. If in July he puts 6 acre inches on 100 acres of cotton and 1 acre foot on 50 acres of alfalfa,
 - (a) How many hours does he need to pump in July?
 - (b) If it costs him \$1.00 per hour to pump, (operating and fixed charges) what is the cost per acre foot of water?
- 3. A farmer has 80 acres of alfalfa and uses 5 acre feet per acre per year. He irrigates with a head of 200 M.I. He puts on 6 acre inches per irrigation.
 - (a) How long would he run his head of water per irrigation?
 - (b) If he pays \$1.00 per hour for his head, how much would it cost per year to irrigate the 80 acres?
- 4. A farmer has 40 borders, each 33 feet by 440 yards. He wishes to put on 4 acre inches, using a head of 200 M.I.
 - (a) How many hours should the head be used?
 - (b) How many acres does he have?

PART B

EXAMPLE

The college farm at the University of Arizona has a pumping plant, direct-connected, which delivers .979 second foot as measured in a weir. The static water level is 28 feet deep from the height of the water discharge. The drawdown after pumping for 15 minutes is 21 feet. The average revolutions of the meter is 10 revolutions in 28.2 seconds. The meter KW = 6 2/3 watts.

- (a) What is the theoretical horsepower needed to lift the water?
- (b) How many KW of electricity are used per hour?
- (c) What is the overall efficiency of the pumping plant?
- (d) With electricity at one cent per KW hour, other operating costs, labor, oil, etc.) at fifty cents per hour, what is the cost per acre foot of water (disregard the fixed costs).

Some comparisons to keep in mind in solving the problems. H. P. or Horsepower power necessary to lift 33,00 lbs. one foot in one minute.

gal./min. x wt. per gal. x lift _ gal.min. x 8 1/3 x lift 33,000 33,000

 $\frac{\text{gal./min. x lift}}{3960} = \text{HP}$

One HP = .746 kilowatts or 1 KW = 1 1/3 HP.

KW of a meter is the number of watts used each time the disk rotates once.

The KW for each meter is marked on the face of the meter.

Kw x no. of rotations x 3.6 = KW of current used. sec. of time Efficiency $= \frac{\text{output}}{\text{input}}$ The % efficiency $= \frac{\text{output}}{\text{input}} \times 100$ The average efficiency of a direct-connected motor is about 88%. The average efficiency of a turbine pump is about 60-70%.

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(a) Given: Well capacity = .979 second feet, static water
lift = 28 feet, drawdown = 21 feet.
l second foot = 450 gal./min. (given in General
Irrigation Problems). .979 x 450 = 440.6 gal./
min. capacity of pump. Total lift = static
level+ drawdown = 28 feet + 21 feet = 49 feet
lift. Using the HP formula,
$$gal./min. x lift = 3960$$

HP. Therefore, $440.6 x 49 = 5.5$ HP for theo-
3960
retical horsepower needed.

(b) Given: KW 6 2/3 watts, rotations of meter disk
10, seconds of time. Using the KW for-
mula, KW x rotations x 3.6 _ kilowatts
sec. of time
Therefore
$$\frac{6 2/3 \times 10}{28.2}$$
 x 3.6 = 8.5 KW used per

hour of pumping.

(c) Since one KW = 1 1/3 Horsepower, therefore 8.5 KW = 8.5
x 1 1/3 = 11.3 HP input to the motor.
Since percent efficiency =
$$\frac{\text{output}}{\text{input}}$$
 x 100, therefore
 $\frac{5.5 \times 100}{11.3} = 48.7\%$ efficiency of pump and motor.

(d) Given: Electricity cost = 1 cent per KWH, other costs =
50 cent per hour. .979 second foot = approximately 1 second foot. One second foot for 1
hour = 1 acre inch (given in General Irrigation Problems).
Therefore 1 acre foot takes 12 x 1 = 12 hours to

pump one acre foot $12 \ge 8.5 = 102$ KW hours of electricity per acre foot at 1 cent = 102 cents or \$1.02 electricity cost per acre foot. $12 \ge .50 = 6.00 per acre foot for other operating costs. \$1.02 + \$6.00 = \$7.02 per acre foot total operating cost per acre foot

Exercises

- 1. A farmer has a direct-connected motor driven deep-well turbine pump with a total lift of 56 feet, pumping 1800 gal./min. The motor efficiency is 88% and the average pump efficiency is 67%.
 - (a) If his power cost is one cent per KW hour, how much is his power cost perhour?
 - (b) What is his power cost per acre foot of water?
- 2. On a certain plant the meter has a KW = 13 1/3 watts, and in 48 seconds the disk makes 60 revolutions. Electricity costs 1 1/2 cent per KWH.
 - (a) What is the power cost per hour?
 - (b) What is the horsepower output of the motor if the motor efficiency is 87%?
- 3. A pumping plant delivers 1150 gal./min. with a total lift of 132 feet. The pump is direct-connected to the motor. He finds that the disk on the meter makes 20 revolutions in 43 seconds and the meter KW is 26 2/3 watts.

- (a) Compute the theoretical or water horsepower necessary (b) Compute power input to motor in HP and K Watts.(c) What is the overall efficiency of the pump and motor?

COST OF PRODUCTION

One of the most important factors in determining the efficiency of a farm business is cost of production. The prices of farm products are determined largely by demand which is established through markets that are world wide in scope. The individual producer has little control over the forces that determine price. He does, however, have considerable control over the factors or cost items that enter into production. The efficiency with which he uses the factors of production depends upon his understanding of the whole field of technical agriculture in which he is engaged. However, skill in the use of mathematical operations aids him in predicting outcomes and measuring the efficiency of his work after the product has been sold or used.

Some common errors with this group of problems are caused by failure to include all items in cost of production and using wrong assumptions as to the items to be included in determining such cost. The true cost of producing a pound of beef, pork, or cotton, a ton of hay or grain, a dozen of eggs, or a box of citrus, cantaloupes, or lettuce is the basis for reorganizing the farm business. Such problems involve mainly, simple multiplication, division, and percentage.

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FINANCING THE FARM BUSINESS

Capital or finance, along with land and labor make up the basic elements of agricultural production. The specialized and highly competitive system of agriculture we have today requires more capital than ever before. With increased efficiency in production have come expensive machines and materials of production, processing and marketing. The raw materials of the farm change owners many times before reaching the ultimate consumer, and is paid for each time a change is made.

While many processing and marketing services are carried on by agencies off the farm, the need for production capital is constantly increasing. The average farm of 125 acres in Maricopa County, Arizona, was valued at \$11,620 for land and building alone, in 1935. If we add to this the sum needed for operating capital the amount becomes prohibitive for the majority of farm operators, if credit were not available.

Farm credit should be suited to the needs of the business and available at a reasonable rate. It is not uncommon to find interest rates as high as 20 percent on installment buying or store credit, while the legal rate on personal loans in some states is three percent per month or 36 percent a year. The Farm Credit Administra209

tion has done much in recent years to make suitable credit facilities available to agriculture. Land bank loans for the purchase of farms may be made at a rate of 4 percent interest.

In addition to obtaining and using credit, the farmer has problems of investing funds and handling finances in general. The degree of efficiency with which he buys, sells, and handles finances is often the determining factor on profit or loss on the farming enterprise. Capital, or credit is power, and must be wisely used.

The abilities in mathematics that have to do with financial problems in agriculture are not very difficult although the problems themselves often involve a large number of variable factors and are very complex. In general, they deal with the purchase and sale of goods and services. The term interest is widely used in dealing with money.

Interest is the amount charged for the use of money. The money received for the use of the <u>principal</u> is <u>interest</u>. The <u>rate of interest</u> is the amount that is charged for the use of one dollar for a period of time, usually one year. Since interest is calculated on the basis of use of 100 cents or hundredth parts of a dollar, the calculations of interest are governed by the rules of percentage and decimals. There is nothing new in the study of interest except that there is a time factor involved. When interest is computed on the original principal for the entire life of the transaction, we have what is known as <u>simple interest</u>. For example: If \$300, the <u>principal</u>, is loaned for 2 years, the time, at 6%, the <u>rate</u> of interest, per year, the <u>interest</u> will be \$36.00. The following are the fundamental formulas for simple interest. (Note they are like those for percentage except for the time factor).

Where: I = P i t P = principal A = P+P i t = P (l+i t) I = the interest i = the rate of interest usually taken for a year A = the final amount of P I t = time of loan

By use of these formulas, any problem in simple interest can be solved.

A principal is said to be earning <u>compound interest</u>, when the interest on the principal is added to the principal at regular intervals, and the interest is then computed on the new principal for the next interval. The sum of the principal and interest at the end of a stated time is called the <u>compound amount</u>. Compound interest formula: $S = P (1+i)^n$ S = compound amount

P = original principal

i = rate of interest per period

n = number of periods

- Example: Find how much \$500.00 will be at the end of 2 years at 6% per year, compounded semiannually.
 - P = \$500.00
 - S = final amount
 - n = then will be 4 periods of compounding
 - i = as the principal is compounded twice a year, the interest rate per period on the principal is 3%. Substituting in the formula for com-pound interest.
 - $S = P (l+i)^n$
 - $s = $500.00 (1+.03)^4 = 500 (1.03)^4 = 562.75

PART TWO

PRODUCTION, MARKETING, AND FARM FINANCE

I. LABOR COSTS

EXAMPLE

The total cost of baling 3582 bales of alfalfa hay with a power baler was \$460.28. The bales averaged 81.2 lbs. per bale. What was the cost per ton for this work? Required: To find the cost per ton of bailing a given number of bales of hay. Given: Number of bales of hay (3582), total cost of bailing the hay (\$460.28), weight (81.2) lbs. per bale. This is a problem of finding the cost per unit of

product, in this case a ton of hay.

Total tons of hay baled = number of bales x the weight in tons per bale.

Tons of baled hay $= \frac{3582 \times 81.2}{2000} = 145.43$

Cost per ton for bailing hay equals total cost of baling divided by the number of tons of hay baled.

Cost per ton $= \frac{\$460.28}{145.43} = \3.16

Exercises

1. The picking cost on 200 acres of cotton was \$2320. The average yield per acre was 1360 pounds of seed cotton. What was the cost per hundred pounds for picking?

2. The labor cost for 20 dairy cows for a year was \$624.00. The average production of the board was 10,200 lbs. per cow per year. What was the cost of labor per 100 lbs. of milk?

II. FARM MACHINERY COSTS

EXAMPLE

A farmer has a grain drill five years old that is valued at \$150.00.

Fixed charges for the year are as follows:

1.	Interest on investments	6	per cent
2.	Housing charges		- \$5 . 00
3.	Taxes		[°] 5₊85
4.	Depreciation		11.50

If the machine is used 12 days (10 hours per day) during the year what is the cost per hour for the use of the machine?

> Interest on investment = \$150 x .06 = \$9.00 Housing 5.00 Taxes 5.85 Depreciation 11.50 Total fixed charges for the year \$31.35 Total hours machine was used = 10 x 12 = 120 Cost per hour for use of machine = $\frac{$31.35}{120} = 26.14$

1. The following items are average costs for operating a tractor for 255 hours of service per year.

Fuel, 514.7 gallons at 13.5 cents per gallon Oil, 26 gallons at 63 cents per gallon Man labor, 41 hours at 25 cents per hour \$1.66 Grease 25.16 Repairs and Mechanics pay Other operating cost .82 87.81 Depreciation 5.07 Housing Interest 20.45 4.72 Taxes

What was the cost per hour for the year?

2. Determine the cost per acre for harvesting grain with a 10 foot combine used on 200 acres per year when the cost items are as follows:

Cost of machine, \$1250.00 Scrap value, \$50.00 Life of machine, 8 years Interest on investment, 6% Taxes, \$1.35 per 100 dollar on average value of machine Man labor \$82.00 Tractor 120.00 Fuel 64.00 011 6.00 Grease 2.00 20.00 Repairs 7.50 Housing

III. COST OF BUILDINGS AND EQUIPMENT

EXAMPLE

In Maricopa County, Arizona, the average value per farm of farm building was \$2526.00. Machinery and equipment was valued at \$1063.00 (1930 census), per farm. Determine the annual cost of buildings and equipment.

Depreciation	of	Machinery	10%
Depreciation	of	Buildings	4%
Interest on :	inve	stment	6%

Required: To find the annual cost of buildings and equipment.

Given: Value (\$2526.00) of the farm building; Value (\$1063.00) of equipment; rate (10%) of depreciation of machinery; rate (4%) of depreciation on buildings; rate (6%) of interest on investment.

This is a problem in percentage.

For the annual cost due to the depreciation on farm buildings, the value of the building will be the <u>base</u> and the percentage of depreciation will be the rate.

percentage = base x rate

Cost of depreciation on buildings = $$2526.00 \times .04$ = \$101.04

For the annual cost of depreciation on the machinery, the value of the machinery will be the <u>base</u>, and the percent of depreciation will be the rate.

> Cost of depreciation on machinery = $$1063.00 \times .10$ = \$106.30

For the annual cost of interest on investment, the investment will be the <u>base</u>, and the percent of interest will be the <u>rate</u>.

Cost of interest on investment = (\$2426.00 + \$1063.00) x .06 = \$215.34

Total cost will be the sum of the costs for depreciation and interest.

Total cost = \$101.04 + \$106.30 + \$215.34 = \$422.68

Exercises

- 1. If interest, depreciation and maintenance on farm buildings is 10% of their value per year, what is the total cost per year for buildings on the farm listed above?
- 2. What is the cost per bird per year for the use of land, buildings, and equipment on a poultry farm of 1500 birds when the cost items are as follows:
 - 1. Two acres of land at \$180.00 per acre
 - 2. Laying house and equipment \$1450.00
 - 3. Brooder house and equipment 500.00
 - 4. Room for feed, eggs, and supplies 250.00
 - 5. Water system
 - 6. Interest on investment at 6%
 - 7. Annual depreciation on buildings and equipment at 8%
 - 8. Taxes at \$2.30 per hundred dollars of assessed value of property. Property assessed at 40% of listed value.

IV. DEPRECIATION ON FARM MACHINERY

EXAMPLE

What is the average investment in a 7 foot tandem disk harrow during the first five years?

Machine cost \$165.00, life is 10 years, scrap

value \$10.00.

Required: To find the average depreciated investment in a disc harrow during the first five years.

700.00

The annual depreciation (d) equals the difference between total cost and scrap value divided by the life of the machine.

$$d = \frac{Vo - Vn}{N} = \frac{\$165.00 - \$10.00}{10} = \$15.50$$

The value of the machine at the end of five years, Vk, equals the original cost minus the annual depreciation times years of use.

 $Vk = Vo - Kd = $165.00 - $15.10 \times 5 = 89.50

The average depreciated investment equals one-half the difference between the original value and the value at the end of five years.

 $D = \frac{1}{2}(Vo - Vk)$ $\frac{1}{2}(\$165.00 - \$89.50) = \$37.75$

Average depreciated investment during first five years = \$37.75.

Exercises

- 1. Using the formula given in the illustrated example, find the average investment in a 2 bottom tractor plow during the first 10 years. Machine cost \$175.00; life, 15 years; scrap value, \$12.00.
- 2. A two row tractor cultivator costs \$160.00, has a scrap value of \$8.00, and a life of 12 years. What is the average investment during the first 6 years?
- 3. A side delivery rake costs \$185.00, has a scrap value of \$12.00, and a life of 10 years. What is the average investment during the first 4 years?

V. DEPRECIATION ON LIVESTOCK

EXAMPLE

A dairyman has 18 young cows which cost on an average of \$90.00 each. The expected productive life of the cows is 5 years. The value for beef is about \$30.00 per head. What is the annual cost of depreciation on this herd? (This does not include loss by death)

Formula:

Percentage of depreciation per year = $\frac{I - S}{L \times I} \times 100$

I=Initial cost of animals S=Salvage value for beef L=Life expectancy in years

- Required: To find the annual depreciation on a herd of cows.
- Given: The number (18) of cows in the herd, expected producive life (5 years), average cost (\$90.00) per cow, salvage value (\$30.00) per head.

Our first step will be to find the percentage of depreciation per year. This is easily done by substituting the given values into the formula for percentage of depreciation.

> Percentage of depreciation per year = $\frac{I-S}{L \times I} \times 100$ = $\frac{\$90.00 - \$30.00}{5 \times \$90.00} \times 100 = 13.33\%$

The annual cost of depreciation (percentage) equals percentage of depreciation per year (rate) times the total original cost of the Cows (base) Total annual depreciation = .13333 x 18 x \$90.00 = \$216.00

Exercises

Using the Formula Above

- 1. What is the depreciation for the first year on the following herd of 25 cows? (Including death loss). Fifteen were purchased as matured cows at a total cost of \$1245.00. Life expectancy of this lot three additional years. Ten heifers at first calving were purchased for \$70.00 each. Life expectancy 5 years. The death loss for the year was 4% or one of the matured cows. (Beef value of cows, \$30.00.)
- What is the total depreciation on 1000 pullets the first year? Pullets valued at \$1.15 per bird. Depreciation 30% of original cost. Loss by death, 12% during first year.
- 3. What is the total depreciation on the flock for the second year? (Birds valued at 80 cents each at beginning of year) Depreciation 50% of value for second year. Loss by death 15% during second year.
- 4. What is the annual depreciation on 10 purebred Duroc brood sows? (Use formula) Value, \$60.00 each Life expectancy after maturity 3½ years Pork value \$30.00 per head

VI. COST OF PRODUCING ANIMAL PRODUCTS

EXAMPLE

Determine the cost of producing a pound of butterfat when the expenses and returns were as follows:

Feed and pasture	\$67.92
Bedding	4.42
Man Labor	43.36
Bull service	7.71
Rent on buildings	5.36

Use of equipment	\$8.92
Interest on investment	5.67
Taxes and insurance	1.57
Overhead	13.56
Depreciation on stock	9.96
Value of manure	9.05
Value of skim milk	6.83
Value of calf	22.10
Production 12320 lbs. milk contain-	
ing 3.5% butterfat.	

- Requred: To find the cost of producing a pound of butterfat when given the itemized expenses and returns.
- Given: Total milk production (12320 lbs.) percent (3.5%(of butterfat in the milk, itemized list of expenses and returns.

To find the net expense we will subtract the value of by-products from the total expenses.

By-Products	
Value of manure	\$9.05
Value of skim milk	6.83
Value of calf	22.10
Total returns for	, <u></u>
by-products	\$37.98

Expenses

1222	
Feed and pasture	\$67.92
Bedding	4.42
Man Labor	43.36
Bull Service	7.71
Rent on building	5.36
Use of equipment	8.92
Interest on investment	5.67
Taxes and insurance	1.57
Overhead	13.56
Depreciation on stock	9.96
Total expenses	\$168.45

Net expense \$\$\$168.45 - \$37.98 = \$130.47.

The total weight of butterfat (percentage) in the milk equals the weight of the milk (base) times the percent

of butterfat in the milk, (rate). Weight of butterfat, 12320 x .035 = 4312 pounds.

Cost of production per pound of butterfat equals the nex expense divided by the number of pounds of butterfat. Cost of production per pound of butterfat

 $\frac{\$130.47}{431.20} = 30.34$

Exercises

1. A stockman purchased 160 calves that averaged 400 lbs. each at 7[±]/₂ cents per pound. The following are the items of expense on the steers during the period from purchasing until marketing.

> Pasture 6 months @ \$1.00 per head per month Death loss, 5% Interest on purchase price at 5% per year

If the steers averaged 725 lbs. when delivered to the feeding pens, what was the cost of production per pound?

(Labor cost not included)

Number of eggs produced during

the year

2. From the following data determine the cost per dozen of eggs produced by this flock of 100 hens.

Feed			
Sorghum	\$34.25	Salt	\$1.08
Barley	[″] 4.₀60	Dried butter	
Wheat	37.80	milk	9.35
Bran	4.85	Bone meal	1.98
Meat scrap	24.75	Ground lime-	
Alfalfa leafmeal	6.05	stone	•94
Man labor		\$60.00	
Building and Ed	quipment	10.66	
Taxes and Insur	rance	1.25	
Miscellaneous a	and overhes	d 14.31	
Interest		4.89	
Depreciation in	n value of	stock 38.50	
Value of manure	•	4.62	

18,220

3. Find the cost of producing a pound of pork when the items of expense are as follows:

20 feeder pigs at \$4.00 each 1620 lbs. tankage at \$1.25 per hundred 800 lbs. alfalfa at \$8.00 per ton 200 lbs. mineral at \$1.50 per hundred 15,000 lbs. sorghum grain at \$1.25 per hundred Labor, 150 hours at 30 cents per hour Rent on equipment \$2.00 Interest on capital (purchase price of pigs) at 5% per year.

The pigs averaged 200 lbs. each at the end of the feeding period of 4 months.

VII. RETURNS FROM SELECTED FARM PRACTICES

EXAMPLE

A feeder purchased steers weighing 950 lbs. each at $6\frac{1}{2}$ cents per pound. During the feeding period they gained an average of 200 lbs. each at a cost of \$18.00 per head. The finished steers sold for $7\frac{1}{4}$ cents per pound. Did the feeder gain or lose and how much per head?

Required: To find the profit or loss a feeder would make per head of cattle.

Given: Average weight of steers (950 lbs.) when bought, cost per pound (6½¢) when purchased, cost of feeding (\$18.00 per head), weight gained (200 lbs.), selling price (7¼¢ per pound).

The first thing we must calculate is the total purchase price per head.

> Purchase price = $950 \times \$.065 = \61.75 per head. The purchase price plus the cost of feeding gives

the total cost of fattened steer = \$61.75 + \$18.00 = \$79.75.

The total selling price equals the weight of the fattened steer times the price per pound.

Total selling price = (950+200) x \$.0725 = \$83.38 per head.

Profit = total cost minus total selling price = \$83.38 - \$79.75 = \$3.63 per head.

Exercises

- 1. A cotton grower plans to use 200 pounds per acre ammonium phosphade on his crop. If this fertilizer costs \$69.00 per ton, how many additional pounds of lint cotton per acre should be produced to pay the cost of fertilizer when lint cotton sells for nine cents per pound? (Disregard extra labor cost incident to higher yields)
- 2. A grower has 160 acres of cotton which averaged 1 1/2 bales (500 lbs. each) per acre. The local gin gave a turnout of 38% lint while a gin 15 miles away gave 40% lint. At a price of 9 cents per pound for cotton, what would be the additional income from hauling the cotton to the gin giving the higher percentage of lint.

VIII. TAXES AND INSURANCE

EXAMPLE

A 120 acre farm is valued at \$160.00 per acre and buildings at \$3100.00. The owner has personal property valued at \$1500.00. The tax rate is 1.2 cent on the dollar. If the real estate is listed at 40% of its actual value, what is the farmer's annual tax bill?

Required: To find the total annual taxes on farmer and personal property.

Given: Size (120 acre) of farm, value (\$160.00 per acre), value (\$3100.00) of buildings, list (40% of actual) value of the real estate, value \$1500.00) of personal property, tax rate (1.22) on the dollar.

The total actual value of real estate \approx value of land + value of buildings. Total actual real estate \approx 120 x \$160.00 + \$3100.00 \approx \$22,300. The list of taxable value of the real estate is 40% of the actual value.

Taxable values of real estate $\approx .40 \times $22,300 = 8920.00 .

As the farmer owns \$1500.00 in personal property, his total taxable estate is \$8920.00 + \$1500.00 = \$10,420.

The tax rate is 1.2 cent on the dollar or 1.2%.

Total taxes equals taxable property times tax rate.

Annual tax bill = $$10,420 \times .012 = 125.04 .

Exercises

- 1. The tax rate in Maricopa County in 1930 was \$4.68 per acre. The farms averaged 125 acres in size and the average value of the land was \$19,230.00. If the rate of interest on the land was 5%, what was the total amount of fixed charges for interest on land and taxes per farm?
- 2. The average rate for farmer's mutual fire insurance companies is 26 cents per hundred dollars of property insured. What would be the fire insurance bill on the average farm in Maricopa County, Arizona? (Buildings valued at \$2526.00 per farm).

IX. BUYING FARM SUPPLIES COOPERATIVELY

EXAMPLE

A member of a farmer's cooperative purchased \$320.00

worth of supplies during the year at an estimated saving of \$8.00 under individual store prices. His patronage dividend check for the year was \$25.00. What was the total percentage of saving through cooperative buying?

- Required: To find the percentage of saving obtained from cooperative buying.
- Given: The base-cost (\$320.00) of supplies, the percentage-amount saved (\$8.00 + \$25.00).

We have the cost of supplies, <u>base</u>, and the total saving, <u>percentage</u>. We wish to find what percent, the <u>rate</u>, the savings is of the cost,

$rate = \frac{percentage}{base} \times 100$

Percent of saving = $\frac{8+25}{320}$ x 100 = 9.7%

Exercises

- 1. The retail price of a four row tractor planter was \$300.00. When purchased through a farmers' cooperative the cost was \$252.50. What percentage of the retail price did the buyer save?
- 2. A local chapter of Future Farmers of America purchased supplies as listed below during the fiscal year ending July 1, 1938. One percent of the savings were retained in the treasury. The remainder of the savings were paid to the members as patronage dividends. Determine the total amount paid to members.

Item purchased	Amount	Percentage saved
Seed	\$ 362.00	12
Feed	476.00	9
Wire fencing	136.00	18
Chicks	1,237.24	14
Plants	319.40	22

Disinfectants	\$ 38.50	30
Vegetable containers	19.45	13
Poultry equipment	645.76	27
Spray materials	292.10	20
Dairy heifers	563.00	8
Swine, breeding stock	132.00	10

X. BUYING FARM SUPPLIES ON INSTALIMENT PLAN

EXAMPLE

A farmer paid a balance of \$600.00 on a tractor in 12 monthly payments of \$50.00 each. He paid 6% interest on the \$600.00 or \$36.00. What was the actual rate of interest paid?

Required: To find the rate of interest on sum that was paid off in monthly payments for one year.

Given: Sum to be repaid (\$600.00), number (12) of monthly payments of \$50.00 each, interest paid (\$36.00).

As the farmer is paying for the tractor at the rate of \$50.00 a month, at the end of the sixth month, he will owe \$300.00 and at the end of the twelfth month, the full amount will have been paid. His average debt then is \$300.00.

The problem is now one of simple interest, for we have the principal (\$300.00), and the interest (\$36.00) and wish to find the rate of interest paid for 1 year.

I = Pit, $i = \frac{1}{Pt}$ Actual rate of interest paid = $\frac{$36}{$300} = 12\%$

Exercises

- 1. A farmer purchased \$540.00 worth of seed and feed to be paid for within 2 months. The store offered a 3% discount for cash. What would be the saving if the buyer borrowed the money from the Production Credit Association at 5% per year and paid cash?
- 2. The cash price per ton of fertilizer is \$42.00. The "Time" price due in 6 months is \$46.50 per ton. What rate of interest does this represent?
- 3. Lumber and building supplies were purchased for \$375.00. A sales note bearing 6% interest was made payable at the end of the 12 months. There was a finance charge of 5%. What was the total cost of the materials?

XI. FARM CAPITAL AND CREDIT

EXAMPLE

A farmer borrowed the following amounts through his local Production Credit Association: \$250.00 for 90 days; \$300.00 for 6 months; and \$500.00 for nine months. The rate of interest was 5% per year. How much interest did he pay for the use of working capital?

Required:	To find the total interest on three given sums, each borrowed for a given rate of
Given:	interest. Rate of interest 5%, three sums of money (principal) borrowed for different lengths of time.

This is a problem of simple interest. We are given the principal, the time, and the rate, and must find the interest. Let us take each sum separately and find the interest paid on same.

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Interest = principal x rate of interest x time.

 $\frac{\$250.00 \text{ loan:}}{\text{Interest} = \$250.00 \text{ x } .05 \frac{3}{12} = \$3.12}$ $\frac{\$300.00 \text{ loan:}}{\text{Interest} = \$300.00 \text{ x } .05 \text{ x } \frac{6}{12} = \7.50 $\frac{\$500.00 \text{ loan}}{\text{Interest} = \$500.00 \text{ x } .05 \text{ x } \frac{9}{12} = \18.75 Total interest paid = \$3.12 + \$7.50 + \$18.75 = \$29.37

Exercises

- 1. A farm of 160 acres was appraised at \$150.00 per acre. The buildings were valued at \$2400.00. The buyer obtained a federal land bank loan of 50% of the value of the land and 20% of the value of the buildings. He then secured an additional commissioner's loan which increased the sum to 75% of the total value of the land and buildings. He supplied the balance from his own finances.
 - (a) What was the amount of the commissioner's loan?
 - (b) What was the amount of funds supplied by the buyer from his own funds?
- 2. When money is worth 5%, what is the capitalized value of a farm which yields an annual income on investment of \$1250.00?
- 3. During a period of low prices, a farmer was unable to make payments on his farm loan of \$1800.00. He finally paid the loan in one payment at the end of the third year. With interest at 5% compounded annually, what was the total amount of the payment?

(See Formula and explanation of compound interest in introduction)

XII. MARKETING FARM PRODUCTS

EXAMPLE

What would a steer weighing 800 pounds and purchased

at $6\frac{1}{2}$ cents per pound have to sell at per pound dressed to equal the purchase price if it dressed 62%?

This is, of course, a problem in percentage. What does the problem ask us to find? The selling price per pound of a dressed steer. What facts are given? Weight of the steer (800 lbs.) purchase price 6 1/2 cents per pound, dressing percentage (62%). How can we arrange these facts to solve the problem? The weight of the steer will be the base, for that is what we shall take the rate 62% of to find the weight of the dressed meat (the percentage).

percentage = base x rate

Weight of dressed meat = 800 x .62 = 496.00 pounds
Total purchase price for steer equals total weight
times cost per pound.
Total purchase price = 800 x \$.065 = \$52.00

The total selling price equals the total purchase price. Therefore, the selling price per pound of dressed meat equals the total purchase price divided by the total weight of dressed meat.

Selling price per pound = $\frac{$52.00}{496.00}$ = 10.48 cents

Exercises

- 1. Live poultry is selling for 18 cents per pound at the farm. If the cost of shipping to the market is 1 1/4 cents per pound and the shrinkage in shipment is 10%, what price per pound at the market should the birds sell for to equal the farm price?
- 2. A poultryman selected seventy-eight fryers to be dressed for market. They averaged 2.9 pound each alive and lost

39% of their live weight in dressing. What was the total weight of dressed fryers?

- 3. A stockman delivered to market 40 hogs that averaged 208 pounds, each. If the hogs dressed out 78 pounds of dressed meat per 100 pounds of live weight, what was the total weight of dressed pork?
- 4. A dairyman delivered four lots of milk as follows: Five hundred pounds testing 4.25%; 650 pounds testing 5.85%; 1250 pounds testing 4.38%; 400 pounds testing 3.90%. What was the average percentage of butterfat for the entire lot?

ANSWERS TO PROBLEMS

PART ONE

Exercises	Example	Answer
I	1 2 3 4	15.62 Acres 22 Cows 167,440 Bales 1505.25 Pounds per acre
II	1 2 3	16.76 Hours 16.5 Hours 54.2 Acres
III	1 2 3 4 5	499,075 Cubic yards 600 Gallons 140 Tons 3.125 Feet 9360 Free air capacity of fan
IV	1 2	28.7 Tons 40.7 Tons
V	l	Cement 72.1 Bags Sand 5.3 Cubic yards Gravel 8 Cubic yards
	2	Cement 21.2 Bags Sand 1.97 Cubic yards Gravel 3.93 Cubic yards
	3	Cement 13.1 Bags Sand 1.45 Cubic yards Gravel 2.42 Cubic yards
•	4	Cement 6.64 Bags Sand .492 Cubic yards Gravel .737 Cubic yards
VI	1 2 3	 10.15 Inches in diameter 6.36 Inches in diameter a. 2400 Feet per minute b. 509.3 RPM increase
VII	1 2 3	22.094 Feet 32.416 Feet 7162.0 Square feet

Exercis	0 8	Example	Answer
VIII		l	a. 8000 Pounds Sulphate of Ammonia
			b. 173913 Pounds Treble super-
		2	2.69 Cents per pound
IX		1 2	l to 6.48 l to 6.29
x		1 2	38.4 Ounces 3.3 Pounds
XI		1 2 3	\$121.60 28.28 .808 Tons
XII	A	l	a. 4 Acre inches b. 5 Feet
		2	a. 196.36 Hours b. \$1.96 per Acre foot
		3	a. 96 Hours b. \$960.00 per Year
		4	a. 32 Hours b. 40 Acres
	В	1	a. 32.4 Cents per hour b. 97.2 Cents per acre foot
		2	a. 90 cents per hour b. 69.6 HP Output of Motor
		3	a. 38.3 HP b. 44.7 KW or 59.60 HP c. 64.3 Percent efficiency

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PART TWO

Exercises	Example	Answer
I	1 2	85.3 Cents 30.6 Cents
II	1 2	94.8 Cents \$2.48
III	1 2	\$252.60 30.5 Cents
IV	1 2 3	\$54.33 \$38.00 \$34.60
V	1 2 3 4	\$410.33 \$441.60 \$404.80 \$85.71
VI	1 2 3	3.83 Cents per pound 16.5 Cents per dozen 8.56 Cents per pound
VII	1 2	76.67 Pounds per Acre \$216.00
VIII	1 2	\$1546.50 6.57
IX	1 2	15.83 Percent \$652.75
X	1 2 3	\$11.83 21.4 Percent per year \$416.25
XI	1 2 3	a. \$7,320.00 b. \$6,600.00 \$25,000.00 \$2083.68
XII	1 2 3 4	21.4 Cents per pound 138 Pounds 6489.6 Pounds 4.63 Percent