AGRICULTURAL ARITHMETIC

A Practical Arithmetic

FOR ESTATE AGENTS, FARMERS, AGRICULTURAL, HORTICULTURAL, AND DAIRY STUDENTS, AND FOR USE IN RURAL SCHOOLS

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PREFACE

I HAVE been honoured by the Authors of this Agricultural Arithmetic with the request that I should write a preface, an undertaking which I accept with pleasure.

It might have been thought, having regard to the almost excessive activity in the production of books on arithmetic and other subjects to meet the various demands of special industries, that there was no room for another entirely concerned with the needs of those who are likely to follow a practical career on the land, but I am convinced that a really suitable arithmetic written with this object in view will not only find a ready public but supply a long felt want.

Many School Arithmetics dealing in part with agricultural questions have not had behind them writers with a special and practical knowledge of the type of problem the farmer has to solve. Some have tried to present questions that at first glance appear entirely agricultural and practical, but a closer examination of, say, the amount of ploughing per day a man can do with a single plough and pair of horses, must make every farmer envious of the fortunate possessor of the extraordinary ploughman.

On the contrary, the present book deals with actual agricultural problems which have been met in the conduct of a Farm School for the last fifteen years. The pupils of the School are practically all lads who come from the land and intend to return to it to earn their living; each would readily detect any exaggerated statement or inaccuracy in the matter of current prices, either for work or material, and look with doubt upon questions based on an imaginary condition of English farming.

I believe, therefore, a book like the present is greatly needed wherever rural education is involved, and I trust it will bring to the Authors a ready response from the public for whom it has been prepared.

DAVID T. COWAN,
Director of Education.

THE CASTLE,
WINCHESTER, *January* 1913.

INTRODUCTION

ALL who are engaged in rural pursuits continually encounter mathematical problems, the solution of which would be more easily attained if greater consideration were given to the exercise of simple rules in arithmetic, the use of simple formulæ and data, and to the practice of mental calculation.

Many years ago Mr D. T. Cowan, M.A., the Director of Education for Hampshire, intimated the difficulty that teachers in rural schools experienced in obtaining reliable data from which to formulate suitable arithmetical problems for the guidance of their pupils. Later the subject of Agricultural or Rural Arithmetic was introduced into the time-table of Teachers' Holiday Courses, and the interest manifested in the subject induced me to secure the help of my friend, Mr T. V. Philpott, M.A., in the production of what might prove a useful text-book on agricultural arithmetic for general use.

It is scarcely necessary to point out that a boy who intends to take up agricultural pursuits in after years will gain some advantage in having simple agricultural questions brought to his notice during school life. We have known boys who have been through the ordinary

school course of mensuration and yet have been completely "floored" when asked to estimate the contents of a haystack—mainly, of course, because it was a haystack and they were unaccustomed to it as an object for mensuration. One of the objects of the present book is to bring such boys into closer contact with the many agricultural problems which the farmer daily encounters.

J. C. NEWSHAM.

OLD BASING,
January 1913.

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AGRICULTURAL ARITHMETIC

CHAPTER I

ELEMENTARY

ARITHMETIC deals with Numbers and Calculations.

Numbers are expressed by means of :—

(1) Figures—1, 2, 3, 4, 5, 6, 7, 8, 9, which we call digits.

(2) Letters—I, V, X, L, C, D, M.

The first method is the Arabic system and came from the Hindoos through the Arabs and Moors in Spain to the Europeans. "The invention of letters and of nine figures and a cipher with the device of place is ascribed to the beneficent Creator of the Universe." Figures have two values—the one for which they actually stand, and another due to the place they occupy. A figure in the first place of a number on the right stands for units, the same figure in the second place denotes so many tens, in the third place so many hundreds, and so on; so that the value of a figure increases tenfold each time it is moved a place to the left. In any number, 4444, the first 4 on the right is 4 units, the second 4 tens, the third 4 hundreds, the fourth 4 thousands. Of course if we move in the opposite way, *i.e.*, towards the right, the figures decrease tenfold for each place, and if we place a figure to the right of the unit's place it will have a place value ten times less than unity value, and so denotes tenths. The next place to the right denotes a value ten times less than a tenth, *i.e.*, a hundredth, and so on. We must have some method of marking which figure is the units figure in a number, and this is done by placing a dot after it.

The invention of the cipher, naught or zero symbol has been described as the greatest step ever taken in the history of Arithmetic, and it has given its name to the Science. We still speak of ciphering. The use of a cipher is to fill up a place in which there is no digit, and the cipher is simply a place keeper, just like the article we place on our seat in a railway carriage, when we are absent for a short time. If we wish to write any number, four thousand and twenty-three say, there are no hundreds mentioned, the hundreds place is filled up with a cipher, and we get 4,023. Again 34,206 means 3 tens, 4 units, 2 tenths, 0 hundredths, 6 thousandths.

The second method of expressing numbers is the Roman system and does not lend itself to calculation.

I, V, X, have place values; for instance IV means 4, VI means 6. The method is useful for recording numbers, and we still use it in date and chapter numbers.

Addition

Addition is the process of finding a single number, which is as large as two or more numbers put together. The result of addition is called the sum, and the operation is shown by the sign + (plus); thus $7 + 8$ means 8 added to 7, and we write $7 + 8 = 15$. The sign = (equals) denotes the result of an operation.

When adding numbers we must take care to set them down so that unit figures come under unit figures, tens under tens, and so on, thus—

Add 246, 2,037, 7,462.

$$\begin{array}{r} 246 \\ 2037 \\ 7462 \\ \hline 9745 \end{array}$$

The sum of the units column is 15, and this is one ten and five units. Place the 5 in the units' place and add 1 to the tens. The sum of the digits in the tens column is 14; this

is 1 hundred and 4 tens. Place 4 in the tens' place and add 1 to the hundreds. The hundreds will be 7. Place 7 in the hundreds' place. The sum of the thousands column is 9.

Subtraction

Subtraction is the process of finding the difference between two numbers, or finding what quantity must be added to the smaller of two numbers to make the greater, and is only another way of looking at addition.

The symbol denoting the operation is – (minus).

Ex. 1.—Find the difference between 4,287 and 3,143.

4287
3143
1144

Mental work—3 and **4** make 7, put down 4.
4 and **4** make 8, put down 4.
1 and **1** make 2, put down 1.
3 and **1** make 4, put down 1.

After some time this is shortened to :—

3 and **4**, 7 ; 4 and **4**, 8 ; and so on.

Ex. 2.—Find the difference between 56 and 39.

Here is a difficulty, because we cannot say 9 and how many make 6. We get out of it in this way.

The difference between two numbers is unaltered if we add the same number to each.

So add 10 to the 6 and one ten to the 3 tens.

Then we have :—

9 and 7 make 16, put down 7.
4 and 1 make 5, put down 1.

Another example.—Find the difference between 984,205 and 780,496.

984205
780496
203709

Work—6 and **9**, 15; 10 and **0**, 10; 5 and **7**, 12;
1 and **3**, 4; 8 and **0**, 8; 7 and **2**, 9.

You may have been in the habit of working in an ancient way in which the following jargon is used: "6 from 5, can't, borrow 1, 6 from 15, 9, and so on."

If you wish to do rapid calculation the sooner you abandon this method the better.

Multiplication

Multiplication is the process of finding the sum of a given number of repetitions of the same number. It is a short way of doing addition.

You must be quite familiar with the multiplication tables.

The sign of multiplication is $\times$.

Suppose we wish to multiply 246 by 8.

246 = multiplicand.
8 = multiplier.

1968 = product.

This is—

48 units = 4 tens and 8 units.
32 tens = 3 hundreds and 2 tens.
16 hundreds = 1 thousand and 6 hundreds.

$\therefore$ the total is 1 thousand + 9 hundreds + 6 tens + 8 units.

The mental work is—8 sixes 48, write down 8, carry 4 to the tens. 8 fours 32, and 4, 36, write down 6 and carry 3 to the hundreds. 8 twos 16, and 3, 19, write down 19.

When two or more numbers are multiplied together to form a product, each of the numbers is called a factor of the product. Thus, $3 \times 5 = 15$. 3 and 5 are factors of 15.

Suppose we wish to multiply 4 by 15; the product is 60, and we get this result if we multiply 4 by 3, and then the product by 5. Generally, if we wish to multiply a number by another which can be split into factors, we obtain the result by multiplying the number by one of the factors, then the product so obtained by the next factor, and so on.

Ex.—41728×35.

$$\begin{array}{r} 41728 \\ 7 \\ \hline 292096 \\ 5 \\ \hline 1460480 \end{array}$$

Again, suppose we want to multiply 41,728 by 342. We proceed thus:—

$$\begin{array}{r} 41728 \\ 342 \\ \hline 12518400 = 41728 \times 300 \\ 1669120 = 41728 \times 40 \\ 83456 = 41728 \times 2 \\ \hline 14270976 = 41728 \times 342 \end{array}$$

The three products obtained in the above work are called Partial Products.

The 0's in the partial products might be omitted. Always place units figures under units figures, tens figures under tens figures, and so on.

To multiply a number by 10, we simply add a zero at the right, because this changes units into tens, tens into hundreds, and so on. Thus $484 \times 10 = 4840$.

In like manner, to multiply by 30 we multiply by 3, and add a zero at the right.

To multiply by 100 add two zeros at the right.

If you have been accustomed to start a multiplication by using the units figure of the multiplier first of all, and the highest figure of the multiplier last of all, **give it up**. *It is plain common sense to obtain the most important partial products before those of less value. Moreover, if a mistake is made in multiplication, it is more likely to occur towards the end, and a mistake in the less important products is of less importance than if it occurred in those of higher value. You may want to do contracted work in multiplication later on, and, if you have not adopted the method here recommended, the*

work will be awkward. **Teachers should insist on this method being followed.**

Division

Division is the process of finding how many times one number is contained in another larger number.

The sign of division is ÷ or /; thus 42 divided by 7 is written $42 \div 7$, or 42/7. We can also write $\frac{42}{7}$—all three mean the same thing.

The number by which we divide is called the divisor, the number which we divide is called the dividend, and the result of division is called the quotient.

Ex.—$9792 \div 8$.

8 is contained in 9,792 one thousand times and 1,792 remains.

8 is contained in 1,792 two hundred times and 192 remains.

8 is contained in 192 two tens (twenty) times and 32 remains.

8 is contained in 32 four times.

Shortly we work thus—

$$8\overline{)9792}$$
$$1224$$

Mental work—8 into 9, 1 and 1 over. This is 1,000 over, *i.e.*, 10 hundreds, so we have now 17 hundreds.

8 into 17, 2 and 1 over. This is 100 over, *i.e.*, 10 tens, so now we have 19 tens.

8 into 19, 2 and 3 over. 3 tens over, *i.e.*, 30, so we now have 32 units.

8 into 32, 4.

This method is called Short Division.

Ex.—$8991 \div 37$.

$$\begin{array}{r} 243 \\ 37\overline{)8991} \\ \underline{} \\ 159 \end{array}$$

The work is thus—It is plain that there can be no thousands in the answer, since we have only 8 thousands to deal with.

37 into 89, 2. Multiply 37 by 2 and subtract as you go, thus—

$2 \times 7 = 14$ and 5 make 19, set down 5 and carry 1; $2 \times 3 = 6$ and 1, 7 and 1 make 8, set down 1.

Bring down the 9. 37 into 159, 4. $4 \times 7 = 28$ and 1, 29. Set down 1 and carry 2; $4 \times 3 = 12$ and 2; 14 and 1, 15; set down 1. Bring down 1.

37 into 111, 3. $3 \times 7 = 21$ and 0 make 21, carry 2. $3 \times 3 = 9$ and $2 = 11$ and 0 make 11.

This form of division is called Long Division.

In short division the quotient is placed under the dividend, but in long division there is no room in that place and so we write the answer above the dividend, each figure in its proper place. Never write the answer on the right of the dividend.

Division by 10 is done by moving all the digits of the dividend one place to the right. Thus $7465 \div 10 = 746$ and 5 over. The 7, which in the dividend stands in the thousands' place, stands in the hundreds, place in the quotient, and so on.

In the same way division by 100 is done by moving the digits of the dividend two places. $7465 \div 100$ gives 74 and 65 over.

Hence, to divide any number by 10 cut off the last digit, the remaining digits form the quotient and the digit cut off is the remainder.

To divide by 100 cut off the last two digits.

Brackets

Brackets in use are ( ), { }, [ ], and —.

Brackets show that the quantities within them are to be taken as a whole.

Ex.—

$$(10 - 4) \div 3 = 6 \div 3 = 2.$$

When the operations of addition, subtraction, multiplica-

tion, and division are indicated in an expression, multiplication and division must be done before addition and subtraction.

Ex.—

$$5 \times 4 - 6 + 8 \div 2 = 20 - 6 + 4 = 18.$$

When several brackets one within another occur in an expression first remove the innermost bracket.

Ex.—

$$\begin{aligned} & 24 \times 2 \div \{(9 - 8) + 7\} \\ &= 48 \div \{1 + 7\} \\ &= 48 \div 8 \\ &= 56. \end{aligned}$$

Weights and Measures

Weights and measures as applied to farm and garden produce are very variable. Thus many of the tables must be regarded as approximate only, and teachers in rural schools should lose no opportunity of affording pupils practice in measuring and weighing.

A standardisation of weights and measures is badly needed, and it is hoped that in the near future legislation will remedy some of the defects in our present system.

The variations in the weights and measures of corn, fruit, and vegetables are altogether absurd, while something might also be done to simplify the live weights and carcass weights of animals. For example, instead of quoting pigs, say, at so much per stone of 8 or 14 lbs. to the stone, or per score of 20 lbs., why not estimate a live pig at so many lbs. live or dead weight; and the same with all other animals? At present beef is quoted at per cwt. actual live weight, per stone of 14 lbs. dressed carcass weight, and frequently at per stone of 8 lbs. dressed carcass weight.

Before it is possible to quote corn sold on the different markets throughout England and Wales by weight or weighed measures, it must necessarily be converted into the equivalent price per quarter, as required by the Corn Returns Act, at the rate of 60 lbs. of wheat, 50 lbs. of barley, and 39 lbs. of oats per bushel.

If the principal London and provincial markets would only adopt the same standard of weights and measures, much confusion would be avoided. Why a pot of beet is 70 lbs. at Birmingham, and only 56 lbs. at Evesham is a point difficult of explanation, as are many others relative to the sale of fruit and vegetables.

TABLES

Money

4 farthings	= 1 penny (d).
12 pence	= 1 shilling (s).
20 shillings	= 1 sovereign or 1 pound (£).

d, the symbol for pence, is the first letter of the Latin denarius.
s, the shillings symbol, is the first letter of the Latin solidus.
£, the pounds symbol, is the first letter of the Latin libra.

Weight (Avoirdupois)

16 drams	= 1 ounce (oz.).
16 ounces	= 1 pound (lb.).
14 pounds	= 1 stone (st.).
28 pounds	= 1 quarter (qr.).
4 quarters	= 1 hundredweight (cwt.).
20 hundredweights	= 1 ton (t.).

Length

12 inches	= 1 foot (ft.).
3 feet	= 1 yard (yd.).
220 yards	= 1 furlong (fur.).
22 yards	= 1 chain, used in surveying (ch.).
1 chain	= 100 links.
5½ yards	= 1 rod, pole, or perch.
40 poles	= 1 furlong.
8 furlongs	= 1 mile.
1760 yards	= 1 mile.

Area (Square Measure)

144 square inches (sq. in.)	= 1 square foot (sq. ft.).
9 square feet	= 1 square yard (sq. yd.).
4840 square yards	= 1 acre (ac.).
640 acres	= 1 square mile (sq. ml.).
30¼ square yards	= 1 square pole (sq. po.).
40 square poles	= 1 rood (r.).
4 roods	= 1 acre.

Note that if we square the different numbers given in long measure we get the corresponding numbers in square measure, *e.g.* :—

12 inches = 1 foot.
144 square inches = 1 square foot.

Square (Surface or Land) Measure

The square foot contains 144 square inches.

Yard = 9 feet = 1,296 inches.

Rod, pole, or perch = 30¼ yards = 272¼ feet.

Chain = 16 rods = 484 yards = 4,356 feet.

Rood = 40 rods = 1,210 yards = 10,890 feet.

Acre = 4 roods = 160 rods = 4,840 yards.

Yard of land = 30 acres = 120 roods.

Hide = 100 acres = 400 roods.

Mile = 640 acres = 2,560 roods = 6,400 chains = 102,400 rods, poles, or perches, or 3,097,600 square yards.

A square containing an acre, roughly stated, has four equal sides of 69½ yards; more accurate measurement gives each side 208·71 feet.

The sides of a square half-acre would be 147·581 feet, and of a square quarter-acre 104·355 feet.

The above imperial measure is now employed in the United Kingdom, in Canada, Australia, and the Colonies generally, also in the United States; but occasionally some older measurements are referred to; of these :—

The Lancashire acre of 160 perches, each containing 49 square yards = 7,840 square yards.

The Cheshire acre of 160 perches, each containing 64 square yards = 10,240 square yards.

The Irish acre = 1·619835 statute; or 1 statute = 0·617347 Irish.

The Cunningham acre = 1·291322 statute; or 1 statute = 0·7744 Cunningham.

The Scottish acre = ·261183 statute (nearly 6,104 square yards).

Volume (Cubic Measure)

1728 cubic inches (c. in.) = 1 cubic foot (c. ft.).
27 cubic feet = 1 cubic yard (c. yd.).

Note that cubic measure can be got from long measure by cubing the corresponding numbers in long measure, *e.g.* :—

3 feet = 1 yard.
3 × 3 × 3 = 27 cubic feet = 1 cubic yard.

Angles

60 seconds (″) = 1 minute (′).
60 minutes = 1 degree (°)
90 degrees = 1 right angle (**rt. ang.**).

Time

60 seconds (sec.) = 1 minute (min.).
60 minutes = 1 hour (hr.).
24 hours = 1 day.
7 days = 1 week (wk.)
365 days = 1 year.
366 days = 1 leap year.

A year is a leap year if the last two digits of its number are divisible by 4, *e.g.*, 1912 is a leap year.

A year ending a century is not a leap year unless the number of the century is divisible by four, *e.g.*, 1900 was not a leap year, 2000 will be a leap year.

The Astronomical Day commences at noon, and is computed from 1 to 24 hours.

Imperial Measures of Capacity

5 ounces of water	= 1 gill.
4 gills	= 1 pint (pt.).
2 pints	= 1 quart (qt.).
4 quarts	= 1 gallon (gal.).
2 gallons	= 1 peck (pk.).
4 pecks	= 1 bushel (bus.).
8 bushels	= 1 quarter (qr.).

Imperial Corn Measure

2 quarts	= 1 pottle (pot.).
2 pottles	= 1 gallon (gal.).
2 gallons	= 1 peck (pk.).
4 pecks	= 1 bushel (bus.).
2 bushels	= 1 strike (str.).
4 bushels	= 1 coomb (coomb).
4 bushels	= 1 sack.
2 coombs or 8 bushels	= 1 quarter (qr.).
4 quarters	= 1 chaldron.
5 quarters	= 1 load (load).
2 loads or 10 quarters	= 1 last (last).

Solid Measure

A barrel bulk	= 5 cubic feet.
A load of rough timber	= 40 ,, ,,
A load of squared timber	= 50 ,, ,,
A ton of timber, shipping	= 42 ,, ,,
A ton of freight	= 40 ,, ,,
A stack of wood	= 108 ,, ,,
A cord	= 128 ,, ,,

Bread and Flour Weight

4 lbs. 5½ oz. imperial	= 1 quarter loaf.
8 lbs. 11 oz. ,,	= 1 half-peck loaf.
17 lbs. 6 oz. ,,	= 1 peck loaf.

A peck or stone of flour is 14 lbs. ; a bushel of flour is 56 lbs. ; a boll is 140 lbs. ; and a sack of 5 bushels is 280 lbs., or 2½ cwt.

Hay and Straw Weight

36 lbs. imperial of straw	= 1 truss.
56 lbs. of old hay	= 1 ,,
60 lbs. of new hay	= 1 ,,
36 trusses	= 1 load.
A load of straw	= 11 cwt. 64 lbs.
A load of old hay	= 18 cwt.
A load of new hay	= 19 cwt. 32 lbs.

Hay sold between 1st June and 31st August is reckoned new hay, and must weigh 60 lbs. per truss. Hay sold between 31st August and the succeeding 1st June is reckoned old, and must weigh 56 lbs. per truss.

Wool Weight

7 lbs. avoirdupois	= 1 clove.
14 ,, or 2 cloves	= 1 stone.
28 ,, or 2 stones	= 1 tod.
182 ,, or 6½ tods	= 1 wey.
364 ,, or 2 weys	= 1 sack.
4368 ,, or 12 sacks	= 1 last.

20 lbs. = 1 score, and 240 lbs. or 12 score = 1 pack.

Wool is frequently sold in Scotland by the stone of 24 lbs. Imperial. In practice wool buyers frequently reckon 30 lbs. to the tod. English wool (washed or unwashed) is sold annually at auction sales at per lb., the auctioneer charging 1½ per cent. commission.

The Quarterly Terms

In England and Ireland

Lady Day	25th March.
Midsummer	24th June.
Michaelmas	29th September.
Christmas	25th December.

In Scotland

Candlemas	2nd February.	Old style	13th February.
Whitsunday	15th May.	,,	26th May.
Lammas	1st August.	,,	12th August.
Martinmas	11th November.	,,	22nd November.

Seasons

Spring commences 21st March.
Summer ,, (longest day) 21st June.
Autumn ,, 23rd September.
Winter ,, (shortest day) 21st December.

Thirty days hath September,
April, June, and November;
February hath twenty-eight alone,
All the rest have thirty-one.
But leap year coming once in four,
February then has one day more.

Foreign Liquid Measures

	Name of Measure.	Contents in Gallons.
Britain	Gallon	1·0
America	Do.	0·833
Austria	Eimer	12·449
Denmark	Anker	8·493
France	Litre	0·22
Holland	Anker	8·406
Portugal	Almude	3·750
Prussia	Eimer	15·147
Russia	Veddras	2·712
Spain	Arroba	3·527
Sweden	Eimer	17·289

Miscellaneous Weights and Measures

Asparagus	Bundle	100 to 150
Bricks	Load	500
Broccoli	Bundle	6 to 20
Butter	Firkin	56 lbs.
Carrots	Bunch	36 to 40
Cheese	Clove	8 lbs.
Cider	Pipe	100 to 118 imp. gals.
Clover seed	Cask	7 to 9 cwt.
,, ,,	Sack	2 to 3½ cwt.
Coal	Barge	21 tons
,,	Chaldron (London)	36 bus.
,,	Load (Scottish)	1 cwt.
,,	Sack	224 lbs.
,,	Ton	10 sacks

Miscellaneous Weights and Measures (continued)—

Cucumbers	Pad	24 to 36
Currants	Sieve	20 qts.
Faggots	"Hundred"	120
,,	Load	50 to 60
Feathers	Bale	1 cwt.
Flax	Last	17 cwt.
Flooring and thatching	Square	100 sq. ft.
Flour	Gallon	7 lbs.
Fruit	Bushel or Sieve	48 lbs.
,,	Pot	2 bus.
,,	Punnet	½ to 4 lbs.
Glass	Seam	120 lbs.
,,	Stone	5 lbs.
Gravel or earth	Ton	20 c. ft.
Guano	Bag	1½ cwt.
,,	Bushel	60 to 70 lbs.
Hay	Bale	2 cwt.
,,	Load	36 trusses
,, (Old)	Load	18 cwt.
Honey	Gallon	12 lbs.
Kainit	Bag	2 cwt.
,,	Bushel	75 to 80 lbs.
Molasses	Barrel (36 gals.)	5 to 6 cwt.
,,	Puncheon	10 to 12 cwt.
Nitrate of soda	Bag	2⅛ cwt.
Oil (train)	Gallon	7½ lbs.
Paper	Quire	24 sheets
Potatoes	Barrel	200 lbs.
,,	Sack (London)	168 lbs.
,,	Ton	45 bus.
Radishes	Hand	12 to 30
Rhubarb	Bungle	20 to 30
Salt	Bushel	56 lbs.
Straw	Truss	36 lbs.
,,	Load (36 trusses)	11 cwt. 64 lbs.
Strawberries	Pottle	½ gal.
Tar	Barrel	25 gals.
Tiles, pipe, 1 in.	Load	1,000
Timber (Rough)	Load	40 c. ft.
,, (Squared)	Load	50 c. ft.
,, (Inch-planking)	Load	600 sup. ft.
Turnips	Bunch	20 to 25
Vegetables	Sieve	7 imp. gals.

Miscellaneous Weights and Measures (continued)—

Wheat	(Bushel) standard	62 lbs.
,,	(Load) *imperial*	5 qrs.
Wood	Cord	128 c. ft.
,,	Stack	108 c. ft.
Wool	Pack	240 lbs.
,,	Stapler's tod	30 lbs.

Covent Garden Weights and Measures

A bundle of asparagus contains from 100 to 150 heads; celery and broccoli, according to size, from 6 to 20 heads; rhubarb, from 20 to 30 stems, according to size and season; carrots, from 36 to 40; turnips, from 20 to 25; greens, as many as can be tied together by the roots.

A tally of cabbage is 5 doz.

A pottle of mushrooms is expected to hold as many as will weigh 1 lb. A pottle of strawberries is supposed to hold $\frac{1}{2}$ gal., but seldom holds more than $1\frac{1}{2}$ pts. A hand of radishes should be from 12 to 30 in number, according to the season. A score of lettuce is 22 heads.

A sieve of peas is equal to 1 bus., contains $10\frac{1}{2}$ imp. gals., and is $17\frac{3}{4}$ in. in diameter at top and $11\frac{1}{4}$ in. deep. A sieve of currants, about 20 qts.; half-sieve, about 10 or 11 qts. A sieve or basket of cherries, 48 lbs.

Grapes are put in 2-lb. and 4-lb. baskets. Peaches, nectarines, and apricots into half-dozen or dozen baskets. New potatoes are generally put up into 2-lb. punnet baskets. Apples and pears are put up in baskets, sieves, or half-sieves, the sieve being equal to a bushel. Chip baskets holding from 4 to 6 lbs. are now almost exclusively used in marketing soft fruits as raspberries, strawberries, currants, etc.

Measures Used in the Sale of Wheat

Quarter of 8 imp. bus., at London and throughout the country.

Coomb of 4 bus., at Beccles.

Load of 3 bus., at Sheffield, Doncaster.

Load of 5 qrs., at Oxford, Cirencester.

Load of 144 qts., at Ulverston.

Load of 5 imp. bus., at Bedford.

Boll of 3 imp. bus., at Newcastle, Carlisle, Darlington.

Boll of 6 imp. bus., at Berwick, Duns, Kelso.

Boll of 4 imp. bus., throughout Scotland.

Bushel of 62 lbs., at Birmingham, Gloucester.

Bushel of 70 lbs., at Liverpool, Manchester.

Bushel of 75 lbs., at Chester, Shrewsbury, Nantwich, Market Drayton.

Bushel of 80 lbs., at Monmouth, Abergavenny.

Bushel of 65 lbs., at Aberystwith.

Boll of 264 lbs., at Glasgow.

Boll of 240 lbs., at Hamilton.

Barrel of 280 lbs., at Dublin, Cork.

Cwt. of 112 lbs., at Bedford, Newry.

Cental of 100 lbs., at Liverpool.

Windle of 220 lbs., at Preston.

Hobbet of 168 lbs., at Denbigh.

1 boll of oats = 8 bus.; 1 boll of oatmeal = 140 lbs. = ½ sackful; in Galloway, 280 lbs. = 1 boll of oatmeal; 1 boll of rye-grass seed = 4 bus. of 24 lbs. = 96 lbs.

Weight of Produce per Bushel

	Lbs.		Lbs.
Barley (ground)	42	Salt	65
Brewers' Grains (wet)	40	Lentils	63
Carrots	40	Maize	60
Beans and Oats (ground)—		*Dari*	60
equal parts	33	Millet	60
Middlings	32	Potatoes	56
Rye Meal	32	Linseed	52
Oats (ground)	30	Cottonseed Meal	51
Brewers' Grains (desiccated)	20	Bean Meal	50
Bran	17	Maize Meal	47
Malt Combs	14½	Mangolds	45
Hay (chaffed)	8	Swedes	45
Oat Straw (chaffed)	5	Turnips	45
Oat Chaff	2½		

Where, as in many isolated country districts, no measuring glass is available for measuring liquids for use as medicine

for stock, etc., the following table of the approximate contents of the various domestic appliances, although of course not strictly accurate for all the different kinds of spoons, cups, etc., may prove useful :—

1 teaspoonful	= about	1 to 2 drachms.
1 dessertspoonful	= ,,	3 to 4 drachms.
1 eggcupful	= ,,	½ to 1 ounce.
1 cupful (small)	= ,,	5 to 7 ounces.
1 cupful (large)	= ,,	8 to 11 ounces.
1 tumblerful (average)	= ,,	½ pint (imperial).

Poisonous drugs should, however, always be measured by means of a properly graduated measuring glass.

With regard to the dilution of the various antiseptics used in the form of washes, etc., for stock, the following should be borne in mind :—

½ per cent.	= 1 fluid ounce in 10 pints (imp.).
1 per ,,	= 1 fluid ounce in 5 pints (imp.).
5 per ,,	= 1 fluid ounce in 1 pint (imp.).
10 per ,,	= 2 fluid ounces in 1 pint (imp.).

If it is required to make a percentage solution of solids in liquid, the following may be taken as a rough guide :—

To make a 1 per cent. solution of a solid in a liquid, take 4½ grs. of the solid to 1 oz. of liquid. For a 2 per cent. solution take 9 grs. to the oz. ; 5 per cent. 20 grs. ; 10 per cent. 40 grs. ; and so on.

Railway Parcel Rates at Company's Risk per Passenger Train

Not exceeding 30 miles :—

2 lbs. 4d. ; 3 lbs. 5d. ; 4 lbs. and upwards to 24 lbs. 6d.

Not exceeding 50 miles :—

2 lbs. 4d. ; 3 lbs. 5d. ; 6 lbs. 6d. : 12 lbs. 8d. ; 15 lbs. 9d. ; 18 lbs. 10d. ; 21 lbs. 11d. ; 24 lbs. 1s.

Not exceeding 100 miles :—

2 lbs. 4d. ; 3 lbs. 5d. ; 4 lbs. 7d. ; 5 lbs. 7d. ; 6 lbs. 8d. ; 7 lbs. 9d. ; 8 lbs. 10d. ; 9 lbs. 11d. ; 12 lbs. 1s. ; 14 lbs. 1s. 1d. ; 16 lbs. 1s. 2d. ; 18 lbs. 1s. 3d. ; 20 lbs. 1s. 4d. ; 22 lbs. 1s. 5d. ; 24 lbs. 1s. 6d.

Over 100 miles:—

2 lbs. 4d.; 3 lbs. 5d.; 4 lbs. 6d.; 5 lbs. 7d.; 6 lbs. 8d.; 7 lbs. 9d.; 8 lbs. 10d.; 9 lbs. 11d.; 11 lbs. 1s.; 12 lbs. 1s. 1d.; increasing 1d. per lb. up to 23 lbs. and 24 lbs. which are both charged 2s.

Over 24 lbs. is charged $\frac{1}{4}$d. per lb. under 30 miles, $\frac{1}{2}$d. per lb. under 50 miles, $\frac{3}{4}$d. per lb. under 100 miles, and 1d. per lb. over 100 miles.

Parcel Post

For long distances it is sometimes advisable to send firm fruit in small boxes by post, the rate being as follows:—

Not exceeding 1 lb. 3d.; 1d. per lb. over 1 lb. up to 9 lb. and 1d. the next 2 lb.

Maximum length $3\frac{1}{2}$ ft., length and girth combined 6 ft.

„ weight 11 lbs.

Reduction

Every concrete quantity consists of two parts called the unit and the measure respectively—£6 = £1 × 6.

£1 is the unit and 6 is the measure.

Reduction is the leading back from one unit or set of units to others of the same kind.

Reduce £6 to half-crowns.

We want to change from the £1 unit to half-crown unit.

£1 = 8 half-crowns.

∴ £6 = 48 half-crowns.

A longer example—How many farthings in £63. 15s. $8\frac{1}{2}$d.?

£	s.	d.
63	15	$8\frac{1}{2}$
20		
1275s.		
12		
15308d.		
4		
61234f.		

The pounds are reduced to shillings and the 15 shillings added, the shillings are brought to pence and the 8 pence added, the pence are brought to farthings and the 2 farthings added.

After practice you may leave out the multipliers and work thus :—

£	s.	d.
63	15	8½
1275s.		
15308d.		
61234f.		

If we wish to lead back from smaller units to larger units we must use division instead of multiplication.

Ex.—How many tons cwts. qrs. lbs. are there in 42,865 lbs.?

28	7 42865		
	4 6123	4 remainder	Final remainder $= 3 \times 7 + 4 = 25$ lbs.
	4 1530	3 remainder	
	20 382	2 qrs.	
	19	2 cwt.	

Answer.—19 tons 2 cwt. 2 qrs. 25 lbs.

NOTE.—After division by 7, 6,123 stands for so many 7's, so that the 3 left when dividing by 4 is not 3 lbs. but 3×7 lbs., and the final remainder is $3 \times 7 + 4 = 25$ lbs.

Compound Rules

Addition, subtraction, multiplication, and division, when applied to concrete quantities, are worked just as in the case of pure numbers, but the results have to be modified.

Ex.—Add together £14. 16s. 8½d.; £234. 10s. 11d.; £9. 18s. 9¼d.; 15s. 8¾d.

£	s.	d.
14	16	8½
234	10	11
9	18	9¼
0	15	8¾
260	2	1½

The farthings column amounts to 6 farthings = 1½d.
Write down ½d. and carry 1d. to the pence column.
The pence column amounts to 37 pence = 3s. 1d.
Write 1d. and carry 3s. to the shillings column.
The shillings column amounts to 62 shillings = £3. 2s.
Write 2s. and carry £3 to the pounds column.
The pounds are added in the ordinary way.

Subtract 2 tons 15 cwt. 2 qrs. 8 lbs. 9 oz. from 18 tons 17 cwt. 3 qr. 4 oz.

Tons.	Cwt.	Qrs.	Lbs.	Oz.
18	17	3	0	4
2	15	2	8	9
16	2	0	19	11

We have to find what quantity must be added to the smaller to make it equal to the larger. When the lower line is greater than the top we use the method of Equal Additions (see Ex. 2 in Simple Subtraction).

We cannot say 9 and how many make 4, so add 16 oz. *to the top and* 1 lb. *to the lower line. Then* 9 *and how many* make 20, answer 11.

We cannot say 9 and how many make 0, so add 28 lbs. to the top line and 1 qr. to the bottom line.

Then, 9 and how many make 28, answer 19.
3 and how many make 3, answer 0.
15 and how many make 17, answer 2.
2 and how many make 18, answer 16.

Multiply 2 qrs. 3 bus. 1 pk. 1 gal. by 9.

Qrs.	Bus.	Pk.	Gal.
2	3	1	1
			9
21	6	1	1

1 gal. × 9 = 9 gals. = 4 pks. 1 gal.
Write 1 gal. and add 4 pks. to the next product.
1 pk. × 9 = 9 pks. and 4 pks. = 13 pks. = 3 bus. 1 pk.
Write 1 pk. and add 3 bus. to the next product.
3 bus. × 9 = 27 bus. and 3 bus. = 30 bus. = 3 qrs. 6 bus.

Write 6 bus. and add 3 *qrs.* to the next product.

2 qrs. × 9 = 18 qrs. and 3 qrs. = 21 qrs.

When the multiplier is a large number the following arrangement of work is recommended:—

Multiply £241. 7s. 8¾d. by 453.

453		
3		
4)1359 f.	= ¾d. × 453	
339¾d.		
3624	= 8d. × 453	
12)3963 d.		
330s. 3d.		
3171	= 7s. × 453	
20)3501s.		
175 pounds 1s.		
906	=	200 × 453
1812	=	40 × 453
453	=	1 × 453
£109348	1s.	3¾d.

Division

Ex.—Divide 427 tons 8 cwt. 2 qrs. 14 lbs. by 8.

Tons	Cwt.	Qrs.	Lbs.	Oz.
8)427	8	2	14	0
53	8	2	8	12

Explanation—427 tons divided by 8 gives 53 tons with 3 tons over.

This 3 tons is 60 cwt. which with the 8 cwt. in the dividend makes 68 cwt.

68 cwt. divided by 8 gives 8 cwt. with 4 cwt. over.

This 4 cwt. is 16 qrs. which with the 2 qrs. in the dividend makes 18 qrs.

18 qrs. divided by 8 gives 2 qrs. with 2 qrs. over.

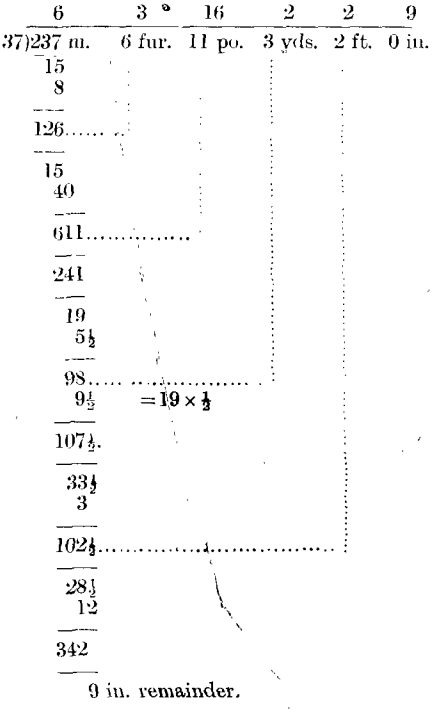
This 2 qrs. is 56 lbs. which with the 14 lbs. in the dividend makes 70 lbs.

70 lbs. divided by 8 gives 8 lbs. and 6 lbs. over.

This 6 lbs. is 96 oz.

96 oz. divided by 8 gives 12 oz.

Ex.—Divide 237 m. 6 fur. 11 po. 3 yds. 2 ft. by 37.



EXAMPLES I

Addition and Subtraction

1. A good temperature in which to cure bacon is 42° F. Should the thermometer in the curing-room register 72° F, how many degrees too warm is the curing-room?

2. The temperature of a greenhouse is 65·7° F. while the

outside temperature of the air is 43·3° F. What is the difference in temperature?

3. A farmer pays his ploughman 17s. 6d. per week, his cowman £1, his shepherd £1. 1s., his farm labourer 18s., and a boy 7s. 6d. What is the amount of his weekly wages bill?

4. If a dealer purchased 250 ewes and lambs for £593, and spent £17. 2s. 6d. on expenses before finally selling them for £623, how much did he gain?

5. A farmer bought 37 sixteen weeks' old store pigs for £53. 15s. and, when averaging 100 lbs. each in weight, sold them for £95. 17s. If from the time of purchase to the time of selling they cost him £35. 10s., what profit does he make?

6. A cesspool is 15 yds. 1 ft. deep, and the distance to the top of the liquid is 11 yds. 2 ft. 3 in. How deep is the liquid in the cesspool?

7. A man buys a piece of land 2 ac. 1 r. 25 sq. po. 15 sq. yds. in area, and on it builds a house and outhouses which occupy 2 r. 30 sq. po. 72 sq. yds. What area remains not built upon?

8. If in a garden, the total area of which is 750 sq. yds., 82 sq. yds. are taken up by paths, what area of ground remains for cultivation?

9. In a woodland farm of 470 ac. 92 ac. of woods are included, and 213 ac. are laid down to permanent pasture. How much land remains for arable purposes?

10. In the Midlothian district of Scotland a crop of Up-to-Date potatoes yielded 19 tons 2 qrs. 17 lbs., whereas in the Isle of Wight the same variety of potato yielded only 7 tons 3 qrs. 15 lbs. What was the difference in the two yields?

11. In fitting up a dairy for cheesemaking the following cheese moulds were purchased: 1 doz. Camembert moulds, 6s. 6d.; 1 doz. Skim Milk moulds, 7s. 6d.; 1 doz. Stilton moulds, £1. 3s. 6d; 1 doz. Cheddar moulds (15 × 16 in.), £1. 1s. 6d.; 3 Wensleydale moulds, 16s. 6d.; 6 Port du Salut moulds, 7s. 6d.; 1 doz. Caerphilly moulds, 9s. 6d.; ½ doz. Coulommier moulds, 3s. 9d.; 1 doz. Cambridge moulds, £1. 5s. 6d.; 3

Gorgonzola moulds, 9s. 9d.; 1 doz. Gervais moulds, 3s. 6d.; 1 doz. round Cream Cheese moulds, 8s. What was the total amount spent in purchasing moulds?

12. A field is bounded by 5 hedges, which are 231 yds. 1 ft.; 72 yds. 2 ft.; 330 yds. $1\frac{1}{2}$ ft.; 47 yds. 2 ft.; and 130 yds. $2\frac{1}{2}$ ft. in length respectively. Find the total length of hedge surrounding the field.

13. Find the total area of 3 fields of the following dimensions:—

(1) 15 ac. 3 r. 2 sq. ch. 3 sq. rods.
(2) 7 ac. 0 r. 1 sq. ch. 13 sq. rods 30 sq. yds.
(3) 32 ac. 2 r. $1\frac{1}{2}$ sq. ch. 9 sq. rods 9 sq. yds.

EXAMPLES II

Multiplication

1. If 36 bus. per acre of Square Head Master wheat were obtained from a bare fallow sown in October, how much wheat, at this rate, would be obtained from a field of 25 ac.?

2. If, in a good year, 1 ac. of Royal Sovereign strawberries yields $3\frac{1}{4}$ tons of fruit, what will be the yield under similar conditions from $12\frac{1}{2}$ ac.?

3. If Rough Chaff Wheat is purchased at 34s. 6d. per quarter, what will be the cost of 730 qrs.?

4. Find the area required to accommodate 250 Bush apple trees, each tree requiring 36 sq. yds.

5. If a horse requires 1,500 c. ft. of air space, a cow 800 c. ft., and a full-grown pig 300 c. ft., what will be the total amount of air space required in constructing a stable to hold 5 horses, a cow-house to contain 23 cows, and a piggery to accommodate 30 pigs?

6. If a farm labourer is paid at the rate of 4d. per hour for hoeing turnips, how much does he earn in 3 days 5 hours if he does 10 hrs. work per day?

7. If a Scotch cart holds 13 cwt. of dung, how many cwt. will there be in 15 loads?

8. If 30 school garden plots each contain 35 sq. yds., what is the total area?

9. How long is a nursery row which contains 1720 plants 15 in. apart, with a plant 7½ in. from each end?

10. The yearly rent of a farm is estimated at 25s. per acre. What rent is paid for 175 ac.?

11. Find the cost of 3 dozen wattle hurdles at 1s. 2d. each.

12. If lime trees are planted 15 yds. apart along an avenue, how long is an avenue which contains 130 trees on either side, a tree being placed at each end of the double row?

13. If 48 mins. are occupied in harrowing 1 ac. of cultivated ground, how much time will be required to complete the harrowing of a field containing 37 ac.?

14. What is the yield of yellow globe mangels from 130 ac., the average yield per acre being 32 tons?

15. A Jersey cow weighs 870 lbs.; what would be the weight of 13 such cows?

16. What is the weight of 33 qrs. of wheat weighing 480 lbs. per quarter?

17. What is the weight of 72 qrs. of barley weighing 400 lbs. per quarter?

18. What is the weight of 160 qrs. of oats weighing 312 lbs. per quarter?

19. 100 gals. of milk, containing 3·5 per cent. of fat, produced 114 lbs. of cheddar cheese; what amount would this realise at 60s. 8d. per cwt. wholesale?

20. What would be the cost of 4 cwt. of nitrate of soda at £10. 15s. per ton?

21. A pan tile is $13\frac{1}{2} \times 9\frac{1}{2} \times \frac{1}{2}$ in.; weight $5\frac{1}{4}$ lbs. What would be the weight of 1,000 such tiles?

22. What is the value of 14 Berkshire bacon hogs, averaging 10 score lbs. each, at 7s. 3d. per stone of 14 lbs.?

23. If 1 ac. of oats yielded $1\frac{1}{4}$ tons of straw, what weight of straw would 15 ac. of similar ground yield?

24. What would be the cost of 4 quarters of beef, the com

bined weight of which is 14 cwt. 16 lbs., when beef is selling at 55s. 6d. per cwt.?

25. Find the total cost of keeping a horse for one year, the price and quantity of foods being estimated as follows: 100 bus. of oats at 2s.; 18 cwt. of hay at 2s. 6d. per cwt.; 20 weeks' night grazing at 1s. 6d. per week; 20 weeks' supply of green fodder at 2s. per week; to which add £2. 10s. for chaff and roots.

26. If the work of a horse be estimated at 2s. 6d. per day for 150 days throughout the summer, and at 10d. per day for 150 days throughout the winter, what is the total charge for the work?

27. A bacon hog weighed 9 st. 7 lbs. (dressed carcass weight). What was its cost at 7s. 6d. per stone of 14 lbs.?

28. A porker weighed 5 score and 6 lbs. live weight and when killed lost 3 lbs. out of every 14 lbs. live weight. What was its cost at 12s. 6d. per score lbs.?

29. What is the cost of 25 tons of meadow hay at £4. 17s. 6d. per ton?

30. What is the cost of 30 tons of mangolds at 12s. 6d. per ton?

31. Find the cost of seeding a croquet ground per acre when the seed costs 32s. per bushel and $4\frac{1}{2}$ bus. are sown per acre.

32. It has been estimated that there are 120,000 small breathing pores or mouths in every square inch of a lilac leaf, if so, how many of such pores would occupy a leaf having an area of $2\frac{1}{2}$ sq. in.?

33. If veal is selling at $9\frac{3}{4}$d. per lb. what would be the value of a calf, the dead weight of which is 16 st. 5 lbs., if 8 lbs. = 1 st. dead weight?

34. A veal calf weighing 8 st. live weight is sold at 9d. per lb. dead weight. What was its cost if 8 lbs. = 1 st. dead weight?

35. A Hampshire Down in wool weighing 142 lbs. live weight makes $8\frac{1}{2}$d. per lb. dead weight. What price does it realise, the dead weight being 75 lbs.?

36. What is the cost of a fat steer weighing 13 cwt. 3 qrs. live weight at 52s. 6d. per cwt. dead weight, the dead weight being 7 cwt. 3 qrs. 12 lbs.?

37. If the floor of a pigsty is laid with 4-in. lime concrete, with 2-in. stones in the proportion of 1 to 6, costing 1s. 4d. per square yard super., and Staffordshire blue bricks set on edge in cement at 8s. 8d. per square yard super., what would be the cost of laying the floor of a sty having an area of 18 sq. yds.?

38. What would be the respective costs of cultivating 1 ac. of land at the following rates: (1) digging garden soil 1 spit deep at $2\frac{1}{2}$d. per square rod; (2) bastard trenching medium soil at 8d. per square rod; (3) trenching heavy soil at 11d. per square rod?

39. If it takes 560 lbs. of water to dissolve 1 lb. of quicklime, forming what is called lime water, how much water will be required to dissolve 1 cwt. of lime?

40. What is the cost of 28 lbs. Danish butter at £4. 15s. per cwt.?

41. What is the price of a shorthorn bullock weighing 66 st. (dead weight) at 8s. 1d. per stone of 14 lbs.?

42. 250 *tomato plants* (Laxton's Open Air) averaged $7\frac{1}{2}$ lbs. of fruit each. What was the total weight of fruit produced?

43. 150 ac. of Newmarket oats yielded an average of 67 bus. per acre; what was the total yield?

44. A Shorthorn cow weighs 1,112 lbs.; what would 7 cows of the same weight weigh?

45. A bacon hog weighs 200 lbs.; what would 45 bacon pigs of the same weight weigh?

46. A herd of 23 Guernseys gave an average of 655 gals. of milk per cow a year; what was the total quantity of milk given in the year?

47. When barley is selling at 28s. 6d. per quarter, what is the value of 120 qrs.?

48. If a fat ewe, weighing 180 lbs. alive, yields 92 lbs. of butchers' carcass, what is the value of same at $7\frac{3}{4}$d. per lb.?

49. If for every lb. of dry matter in a plant 300 lbs. of water are required, how much water would an average crop of wheat require from sowing to harvesting, the weight of the grain and straw being 2 tons?

50. If straw, used as litter, will absorb from 2 to 3 times its own weight of liquids, what quantity would be required to absorb 25 gals. of water (1 gal. water = 10 lbs.)?

51. If a mixture of grass seed for a permanent pasture consists of the following: perennial rye grass 10 lbs., Italian rye grass 5 lbs., cocksfoot 4 lbs., timothy 2 lbs., tall fescue 2 lbs., foxtail 1 lb., red clover 2 lbs., cowgrass (perennial) 2 lbs., white clover (Dutch) 2 lbs., alsike 2 lbs., and lucerne 8 lbs. per acre; what is the total quantity of seed sown per acre, and how much would be required to sow a field 4 ac. 2 r. 28 sq. po. in area?

52. A dealer said his drove of 17 of $2\frac{1}{2}$ year old North Devon steers was worth £15. 10s. a head. What sum would be required to buy the lot?

53. It is stated that worker cells for brood and honey are about $\frac{1}{5}$ in. across and number 28 to the square inch; while drone cells are $\frac{1}{4}$ in. across and number 18 to the square inch. How many of each class of cells would be contained in a square foot of comb?

54. Find the value of $5\frac{3}{4}$ cwt. of Caerphilly cheese at 73s. per cwt. wholesale.

55. Find the value of a Jersey cow weighing 800 lbs. at 7s. 9d. per stone (14 lbs.) live weight.

56. What is the value of a cow which weighs 88 st. dead weight, the carcass (3rd quality) being estimated at 4s. 2d. per stone?

57. A farmer employs 5 labourers at 2s. 6d. per day, and 3 boys at 1s. 6d. per day. Find how much he pays in wages in the year, excluding Sundays.

EXAMPLES III

Division

A farmer received £78. 15s. for porkers (Berkshires), the price of pork being estimated at 10s. 6d. per score lbs. The average weight of the pigs was 100 lbs. How many did he sell?

Weight of a pig = 100 lbs. = 5 score lbs.
Price of a pig = 10s. 6d. × 5 = 52s. 6d. = 21 half-crowns.
Price of all the pigs = £78. 15s. = 630 half-crowns.

$$\therefore \text{ number sold} = \frac{630}{21} = \underline{30.}$$

N.B.—As a rule when finding how many times one compound quantity is contained in another of the same kind reduce both to their *highest* common denomination. In the above sum we might have expressed the sums in half-guineas, but they are not so easily visible as half-crowns.

1. During the year a farmer received £157. 10s. for Factor potatoes, which he sold at £3. 10s. per ton. How many tons did he sell?

2. £1,568 was received for factory butter, which was sold at 98s. per cwt. How many cwts. were sold?

3. £100. 16s. was received for store pigs (3 months old) at 28s. each. How many were sold?

4. A farmer received £5. 13s. 3d. for a fat calf, veal being estimated at 9d. per lb. What was the weight of the calf?

5. If bacon hogs realise 11s. 3d. per score lbs., what is the equivalent price per lb., per stone of 8 lbs., and per stone of 14 lbs.?

6. If porkers realise 12s. 1d. per score lbs., what is the equivalent price per lb., per stone of 8 lbs., and per stone of 14 lbs.?

7. If prime quality beef realises 4s. 10d. per stone of 8 lbs., what is the equivalent price per lb., per stone of 14 lbs., and per cwt.?

8. The weight of a fat Hereford was 99 st. live weight,

and it realised £24. 15s. What was the price of this beef per stone?

9. 45 ac. of Mammoth Long Red mangels yielded 1,890 tons. What was the average yield per acre?

10. If our yearly imports of coniferous trees is estimated at $2\frac{1}{2}$ million loads, or, say, 93 million c. ft., and valued at £2,500,000, what is the price per cubic foot?

11. If a pair of ducklings, killed at 8 weeks old, weighed $4\frac{3}{4}$ lbs. each, and are sold in April for 7s. 6d. the pair, what was the price per lb.?

12. If eggs are 8 for a shilling, find out how much would be charged for 1, 2, 3, 5, and 6 respectively.

13. If a florist sells half-a-dozen dozens of arum lilies, and each purchaser buys four, how many customers were there?

14. If a farmer pays $\frac{1}{8}$th of his rent for rates, and his rent is £330, how much does he pay for rates per annum?

15. The quantity of Waterloo oats to sow a field of 33 ac. was 132 bus.; the yield from the field was 2,376 bus.

(*a*) What was the yield per acre?

(*b*) How many times was the crop greater than the seed?

16. It took 91 bus. of Up-to-Date potatoes to plant 7 ac. of ground; a yield of 2,520 bus. was procured.

(*a*) What was the yield per acre?

(*b*) The excess in quantity of seed procured over that planted?

17. If 430 ac. of ground produce 12,040 bus. of Red Standard wheat, what is the amount of wheat produced per acre?

18. If there are 570 ewes in a field and 6 rams, how many ewes are there to each ram on an average?

19. Green maize (Giant Caragua) yielded 23 tons per acre. The whole weight of maize cut and fed was 172 tons 10 cwt. How many acres were devoted to its cultivation?

20. At the end of the year the sale of milk from a herd of 50 Ayrshire cows was £1,135; what was the value of each cow's milk?

21. A nurseryman divides 18,000 Cox's orange apple trees into lots of 250; how many lots would there be?

22. A Devon steer was sold for £23. 10s. at 38s. per cwt.; what was its weight?

23. If 15 cwt. of hay represents the yearly allowance for a horse, and if the hay is only partaken of for 32 weeks, what would be the allowance per day?

24. It has been estimated that the cost of maintaining a farm horse is £25 per annum. What does this represent per working day throughout the year?

25. If it costs £8. 10s. per acre to stock a farm of between 300 and 600 ac., what number of acres can be stocked with a capital of £2,670?

26. A farmer pays £740. 12s. rent for a farm of 472 ac., including buildings; how much does he pay per acre?

27. £172. 10s. is received for the yield of oats from a 10-ac. field which yielded 17 sacks 1 bus. per acre. Find the price of the oats per bushel.

28. If a meadow of 35 ac. produced 42 tons 16 cwt. of hay, what was the yield per acre?

29. A gallon of water weighs 10 lb. How many gallons are there in a tank containing 2 tons 7 cwt.?

EXAMPLES IV

Weights and Measures

1. A field of 7 ac. 2 r. 18 sq. po. is divided into 30 allotments; find the size of each allotment, also the rent of each at £2. 15s. per acre.

2. If a bushel of oats weighed 39 lbs., how many bushels would be required to make 1 ton?

3. If it costs £9. 15s. per acre to stock a small mixed farm, what amount of capital will be required to stock a farm of 32 ac. 2 r.

4. Reduce 9 sq. ch. 4 sq. rods to square yards.

5. Express 1,750,142 sq. links as acres.

6. Into how many square rods, square yards, or square chains can 5 ac. of ground be divided?

7. How many square yards are there in $\frac{3}{4}$ of an acre?

8. How many square perches are there in 5 ac. 2 r. 3 sq. ch.?

9. What will be the cost of White Queen wheat seed to sow 22 ac., allowing $2\frac{1}{2}$ bus. per acre, the seed costing 32s. per quarter?

10. If wheat is quoted at 28s. 6d. per quarter, what is the price per bushel?

11. If 1 gal. of cream yields 6 lbs. of pure butter milk, how much will 14 gals. 1 qt. 1 pt. of cream yield?

12. 7 ac. of wheat produced $3\frac{1}{2}$ qrs. per acre.
15 ac. of oats ,, 8 qrs. 3 pks. per acre.
9 ac. of barley ,, 5 qrs. 3 bus. per acre.
What was the total quantity of grain from the 31 ac.?

13. A farmer threshed out $19\frac{1}{2}$ ac. of oats, which after winnowing yielded 285 sacks, the natural weight of each sack being 140 lbs. Finally the grain was weighed off at 40 lbs. to the bushel. How many sacks of grain remained?

14. In a herd of Dexter kerries 3 of the cows gave 2 gals. $1\frac{1}{2}$ qts. of milk per day over a period of 36 days.
(*a*) What did the total yield of milk amount to?
(*b*) What was its value when retailed at 4d. per quart?

15. When wheat is 39s. 6d. per quarter, what is the price of—(*a*) a coomb, (*b*) a bushel?

16. What is the live weight in cwts. quarters and stones of a fat bull weighing 1,342 lbs.?

17. The sides of an acre, laid out in the form of a square, measure $316\frac{1}{4}$ links nearly. What will this represent in feet and yards?

CHAPTER II

DECIMALS

Addition and Subtraction of Decimals

ADDITION and subtraction of decimals are just ordinary simple addition and subtraction.

You have to be careful to place figures denoting tenths under figures denoting tenths, figures denoting hundredths under figures denoting hundredths, and so on.

Ex.—Add 24·36, ·041, 240·478, 1·006.

$$\begin{array}{r} 24{\cdot}36 \\ {\cdot}041 \\ 240{\cdot}478 \\ 1{\cdot}006 \\ \hline 265{\cdot}885 \end{array}$$

Subtract 2·0047 from 98·4.

$$\begin{array}{r} 98{\cdot}4 \\ 2{\cdot}0047 \\ \hline 96{\cdot}3953 \end{array}$$

You can, if you like, fill in the vacant places in 98·4 with 0's thus :—

$$\begin{array}{r} 98{\cdot}4000 \\ 2{\cdot}0047 \\ \hline 96{\cdot}3953 \end{array}$$

But after a little practice this will not be necessary.

Multiplication of Decimals

Multiplication of decimals is done in the ordinary way. You have only to be careful to place the figures in the partial products in their proper places.

Ex.—**Multiply** 24·658 by 72.

24·658
72
1726·06
49·316
1775·376

The first partial product is the result of multiplying by 70, so we multiply by 7 and then by 10. The multiplication by 10 is simply done by moving the figures one place to the left. Of course the second partial product is the result of multiplying by 2 and there is no need to move the figures.

Another method.—24·658 × 72 is the same as multiplying 246·58 by 7·2.

246·58
7·2
1726·06
49·316
1775·376

By this method there is no change of places in the first partial product.

Ex. 2.—Multiply 317·481 by 23·602.

317·481	or	3174·81
23·602		2·3602
6349·62		6349·62
952·443		952·443
190·4886		190·4886
·634962		·634962
7493·186562		7493·186562

There was, in the old text-books, another method, a very bad method, in which the multiplication was done as though there were no decimal points at all. The decimal point was fixed in the product by the use of the rule that there are as many decimal places in the answer as there are in the multiplier and multiplicand together.

This method deprives all the partial products of their meaning and becomes a sort of conjuring trick.

Division of Decimals by Integers

We have seen that the division by 10 of any number is done by moving the digits one place to the right.

Thus $724{\cdot}631 \div 10 = 72{\cdot}4631$.

And division by 100 is done by moving the digits two places to the right.

$$724{\cdot}631 \div 100 = 7{\cdot}24631,$$

and so on for 1,000 and other powers of 10.

Divide 724·631 by 20.

$$\begin{array}{r} 20)724{\cdot}631 \\ \hline 36{\cdot}23155 \end{array}$$

We divide by 2 and move the digits of the answer one place to the right for the division by 10.

Divide 43·624 by 128.

$$\begin{array}{r|l} 8 & 43{\cdot}624 \\ \hline 8 & 5{\cdot}453 \\ \hline 2 & {\cdot}681625 \\ \hline & {\cdot}3408125 \end{array}$$

or

$$\begin{array}{r} {\cdot}3408125 \\ \hline 128)43{\cdot}624 \\ 522 \\ \hline 1040 \\ 1024 \\ \hline 160 \\ 128 \\ \hline 320 \\ 256 \\ \hline 640 \end{array}$$

In short division the quotient is written below the dividend, but in long division there is no room, so in long division always place the quotient above the dividend because the

position of the decimal point fixes itself. Never write the answer, as is sometimes done, on the right of the dividend, unless the proper place is already occupied.

Division by a Decimal

Divide 705·6363 by ·096.

Division can be expressed thus: $\frac{705{\cdot}6363}{{\cdot}096}$ as we have seen before.

A fraction is unaltered if we multiply numerator and denominator by the same number (*v.* p. 47).

Multiply numerator and denominator of this fraction by 1,000 and we get:—

$$\frac{705636{\cdot}3}{96}$$

We now divide out by any common factor if possible other than powers of 10—

$$\frac{705636{\cdot}3}{96} = \frac{88204{\cdot}5375}{12} = 7350{\cdot}378125.$$

If there are no common factors we proceed to the division as in the case of integers.

Note that the divisor and dividend are multiplied by that power of 10 which makes the divisor a whole number. Do not make each of them whole numbers. If this be done many unnecessary ciphers are introduced.

All divisions in decimals do not "come out." Such quotients are called circulating decimals and these we shall not consider in this book. If you find that a division is not "out" when the quotient contains six decimal figures you may discontinue the work.

To turn Decimals into Vulgar Fractions

Ex.—Turn ·236 into a vulgar fraction.

$$\cdot 236 \text{ means } \frac{2}{10} + \frac{3}{100} + \frac{6}{1000} = \frac{200 + 30 + 6}{1000} = \frac{236}{1000} = \frac{59}{250}.$$

Again—

$$\cdot 0477 \text{ means } \frac{0}{10}+\frac{4}{100}+\frac{7}{1000}+\frac{7}{10000}=\frac{400+70+7}{10000}=\frac{477}{10000}.$$

Hence we write the figures to the right of the decimal point for the numerator, and for the denominator write 1 followed by as many 0's as there are figures to the right of the decimal point, and then reduce the fraction to its lowest terms.

To turn a Vulgar Fraction into a Decimal

Ex.—Turn $\frac{7}{8}$ into a decimal fraction.

We merely have to do the division—

$$\begin{array}{r} 8)7\cdot \\ \cdot 875 \end{array}$$

The Metric System

The Metric System of weights and measures is in general use on the Continent, and is so superior to our English system that it may be generally adopted in the future.

The unit of length is the metre which is nearly 39·37 in. The metre is subdivided into ten equal parts called decimetres, also into a hundred equal parts called centimetres, and lastly into a thousand equal parts called millimetres, and so the table runs :—

10 millimetres (mm.)	= 1 centimetre (cm.).
10 cm.	= 1 decimetre (dm.).
10 dm.	= 1 metre (m.).
10 m.	= 1 decameter (dm.).
10 dm.	= 1 hectometer (hm.).
10 hm.	= 1 kilometre (km.).

A kilometre is $\frac{5}{8}$ of a mile, nearly.

Of course a square metre = 10 × 10 sq. dm., and so on.

Land is generally measured in *ares*, 1 are = 100 sq. m.

Volume is usually measured in litres. A litre (l.) is a cubic decimetre and is about the same as $1\frac{3}{4}$ pts. The unit

of weight is the *gram* (g.), and it is the weight of a cubic centimetre of pure water at 4° C.

Multiples and parts of metre, litre, and gram are all expressed in the same way—1000 g. = 1 Kg., 100 cl. = 1 l.

LONG MEASURE COMPARED WITH ENGLISH UNITS

	Metres.	Inches.	Feet.	Yards.	Miles.
Millimetre	·001	·03937	·00328	·00109	...
Centimetre	·01	·3937	·0328	·0109	...
Decimetre	·1	3·937	·328	·1093	·00006
Metre	1·	39·37079	3·2809	1·0936	·00062
Decametre	10·	...	32·809	10·9363	·0062
Hectometre	100·	...	328·09	109·363	·06213
Kilometre	1000·	...	3280·9	1093·63	·62138
Myriametre	10000·	...	...	...	6·21382

SQUARE MEASURE COMPARED WITH ENGLISH UNITS

	Square Metres.	Square Inches.	Square Feet.	Square Yards.	Acres.
Milliare	·1	155	1·076	·119	...
Centiare	1·	1,550	10·764	1·19	·00025
Deciare	10·	15,501	107·64	11·96	·0025
Are	100·	...	1076·4	119·6	·0247
Decare	1000·	...	...	1196·	·2471
Hectare	10000·	...	...	11960·	2·4711

SOLID MEASURE COMPARED WITH ENGLISH UNITS

	Cubic Metres.	Cubic Inches.	Cubic Feet.	Cubic Yards.
Millistere	·001	61·028	...	...
Centistere	·01	610·28	·353	...
Decistere	·1	6102·8	3·531	·13
Stere, or cubic metre	1·	61028·	35·317	1·308
Decastere	10·	...	...	13·08
Hectostere	100·	...	...	130·802

Weights Compared with English Units

	Grammes.	Avoir. Oz.	Avoir. Lbs.	Cwt.	Tons.	Grains Troy.
Milligramme	·001	...	...	...	...	·015
Centigramme	·01	...	...	...	...	·154
Decigramme	·1	...	...	...	...	1·543
Gramme	1·	·035	·0022	·019	...	15·432
Decagramme	10·	·352	·022	·196	...	...
Hectogramme	100·	3·527	·2204	1·968	...	...
Kilogramme	1000·	35·274	2·2046	19·684	·00098	...
Myriagramme	10000·	...	22·046	...	·00984	...
Quintal	100000·	...	220·462	...	·0984	...
Millier or bar	1000000·	...	2204·62	...	·9842	..

Dry and Fluid Measure Compared with English Units

	Litres.	Inches.	Feet.	Gallons.	Bushels.
Millilitre	·001	·061	...	·00022	...
Centilitre	·01	·61	...	·0022	...
Decilitre	·1	6·1	...	·022	·0027
Litre	1·	61·02	·0353	·22	·0275
Decalitre	10·	610·28	·353	2·2	·275
Hectolitre	100·	...	3·53	22·	2·751
Kilolitre	1000·	...	35·317	220·09	27·512
Myrialitre	10000·	...	353·17	2200·9	275·121

EXAMPLES V

1. The average rainfall in Great Britain over a period of 72 years was Jan., 1·89 in.; Feb., 1·57 in.; March, 1·52 in.; April, 1·74 in.; May, 1·98 in.; June, 1·96 in.; July, 2·50 in.; Aug., 2·35 in.; Sept., 2·43 in.; Oct., 2·76 in.; Nov., 2·06 in.; Dec., 1·99 in. What was the average total rainfall per year?

2. If in 100 lbs. of milk there are 8·83 lbs. of solid matter

other than fat, and 3·7 lbs. of fat, how many lbs. of solid matter are there, and how many lbs. of water?

3. Five fields contain 27·29 ac., 32·16 ac., 17·7 ac., 45·09 ac., and 14·732 ac., respectively. What is the total area of the five fields?

4. What was the area of a field of red standard wheat, when the total quantity of seed sown was 72·8 bus., and 2·4 bus. of seed were used per acre?

5. A road is 172,439 links in length. How many times can a length of 334·6 links be marked off along it?

6. What number of drain pipes $1\frac{2}{5}$ ft. in length are required to drain a length of ground $47\frac{1}{2}$ ft. in length?

7. A farmer used 8 tons of dung on a plot of ground intended for cabbages at the rate of 15·25 tons per acre. What was the area of the plot manured?

8. If the average composition of 100 tons of farmyard manure is as follows: Water, 75 tons; organic matter, 22·7 tons; nitrogen, ·5 ton; lime, 1 ton; phosphoric acid, ·3 ton, and potash, ·5 ton; what quantity of each of these constituents would there be in 1 ton of such manure?

9. If in three hours rain fell to a depth of ·285 in., what was the rate of fall per hour?

N.B.—Cattle specially bred for feeding will increase in live weight at the rate of over 2 lbs. per day during the first year; about $1\frac{3}{4}$ lbs. the second year; and still less the third year.

10. If a calf weighed 75 lbs. at birth, and increased at an average rate of 2·7 lbs. for the first 92 days, and 1·9 lbs. for 170 days, what was its weight on the 262nd day?

11. If in 1 ton of linseed cake there were 8·7 parts of oil, and each part weighed 21·8 lbs., how many lbs. of oil would there be in 8 tons of cake?

12. If in 1 ton of nitrate of soda there are 19·6 parts of nitrogen, and each part weighs 21·9 lbs., what will be the weight of nitrogen in 30 tons of nitrate of soda?

13. Find the amount of seed required to sow :—

(*a*)	7·25	ac. of wheat	with	$2\frac{1}{2}$	bus. of seed	per	acre
(*b*)	16·50	,, barley	,,	3	,,	,,	
(*c*)	9·30	,, oats	,,	4	,,	,,	
(*d*)	3·10	,, maize	,,	$2\frac{3}{4}$	,,	,,	
(*e*)	10·75	,, beans	,,	$3\frac{1}{3}$	,,	,,	
(*f*)	2·20	,, rye	,,	$3\frac{1}{2}$	,,	,,	

14. If the cost of thorns for a hedge be 20s. per 1,000 and the labour of planting 8 in. apart and preparing bed for the same be 3s. per 100, what would be the cost of planting a hedge composed of 2,360 plants?

15. A Clydesdale horse performing heavy work receives the following daily ration: Hay, 16 lbs.; oats, 10 lbs.; beans, 5 lbs.; maize, 4 lbs.; bran, 2 lbs. Express the proportion of each food as a decimal of the whole.

CHAPTER III

FACTORS, PRIME NUMBERS, FRACTIONS

WHEN one number is exactly divisible by another, the latter is called a factor of the first. Thus 15 has factors 5 and 3.

A multiple of a number is one which contains it an exact number of times. Thus 14 is a multiple of 7.

Prime numbers are those which have no factors but themselves and unity. Thus 2, 3, 5, 7 are prime numbers.

Numbers are prime to one another when they contain no common factor except unity.

Divisibility Rules.—A number is divided by—

2 if the last digit is even.

3 if the sum of the digits is divisible by 3.

4 if the number formed by the last two digits is divisible by 4.

5 if the last digit is 0 or 5.

6 if it is divisible by 2 and also by 3.

7 No rule.

8 if the number formed by the last three digits is divisible by 8.

9 if the sum of the digits is divisible by 9.

10 if the number ends in 0.

11 if the sum of one set of alternate digits differs from the sum of the other set by 0 or is a multiple of 11.

12 if it is divisible by 4 and also by 3.

To split a number into prime factors proceed thus:—

Take 7,623—

3 | 7623
3 | 2541
7 | 847
11 | 121
 | 11

$\therefore \quad 7623 = 3 \times 3 \times 7 \times 11 \times 11$ or $3^2 \times 7 \times 11^2$.

Highest Common Factor (H.C.F.)

The Highest Common Factor of two or more numbers is the greatest number which divides each of them exactly.

Find the H.C.F. of 2,880 and 945.

10 | 2880
8 | 288
4 | 36
 | 9

9 | 945
5 | 105
7 | 21
 | 3

$\therefore \quad 2880 = 10 \times 8 \times 4 \times 9 = 2^6 \times 3^2 \times 5$
$945 = 3 \times 7 \times 5 \times 9 = 3^3 \times 5 \times 7$

Now we can pick out the H.C.F. It is evidently $3^2 \times 5$ or 45.

Another method is the following:—

Find the H.C.F. of 6,239, 7,684.

1	6239	7684	1
6	459	1445	3
3	51	68	1
	...	17	

Explanation.—

Divide 7,684 by 6,239, quotient is 1 and remainder 1,445.
Divide 6,239 by 1,445, quotient is 4 and remainder 459.
Divide 1,445 by 459, quotient is 3 and remainder is 68.
Divide 459 by 68, quotient is 6 and remainder is 51.

Divide 68 by 51, quotient is 1 and remainder is 17.

Divide 51 by 17, quotient is 3 and there is no remainder.

H.C.F. is 17.

It will be seen that each remainder is *divided into* the divisor last used until there is no remainder. The last divisor is the H.C.F.

Least Common Multiple (L.C.M.)

The Least Common Multiple of two or more numbers is the smallest number which is exactly divisible by each of the numbers.

Ex.—Find the L.C.M. of 18, 24, 39, 15.

$18 = 2 \times 3^2$
$24 = 2^3 \times 3$
$39 = 3 \times 13$
$15 = 3 \times 5$

$\text{L.C.M.} = 2^3 \times 3^2 \times 5 \times 13 = 4680.$

The 2 is contained in 2^3.

$\therefore$ Any number containing 2^3 *contains* 2.

$\therefore$ The 2 may be cut out.

Similarly the 3 is contained in 3^2 and may be cut out.

The work may also be arranged thus:—

2	18	24	39	15
3	9	12	39	15
	3	4	13	5

2 is contained in some of the numbers, divide by 2 and leave unaltered those not containing 2. 3 is contained in the numbers. Divide by 3. The quotients *left* are prime to each other. The product of these final quotients and of the divisors on the left form the L.C.M. Answer—4680 as before.

When arranging the work in this way take care to divide by prime numbers *only*. If you divide by composite numbers you will get a common multiple, but it may not be the *least* common multiple.

The L.C.M. of two numbers can also be obtained by dividing the product of the two numbers by the H.C.F. For

three numbers find the L.C.M. of two and then the L.C.M. of this result and the third.

Find the L.C.M. of 1,131, 1,885, 2,175.

$$1\,|\,1131\,|\,1885\,|\,1$$
$$-\,|\,377\,|\,754\,|\,2$$

$\therefore$ H.C.F. of 1131, 1885 is 377.

$$1131 = 377 \times 3$$
$$1885 = 377 \times 5$$

$\therefore$ L.C.M. of these two $= 377 \times 3 \times 5 = 13 \times 29 \times 3 \times 5$,
and $2175 = 15 \times 145 = 3 \times 5 \times 5 \times 29$
$\therefore$ L.C.M. $= 13 \times 29 \times 3 \times 5 \times 5$
$= 28275$.

Vulgar Fractions

A fraction means a part of a whole. Measure the edge of your book. You will probably find that it is a certain *number of whole inches and a bit over. That bit over is a* fraction of an inch.

If you look at a foot-rule you will find that an inch is divided into 8 equal parts. Each part is therefore called one eighth of an inch. If the inch is divided into 10 equal parts, we call each part one-tenth of an inch, and so on.

Suppose you draw a straight line on paper, and measure it, and find its length to be 3 in. and 7 tenths, we write the result $3\frac{7}{10}$ in., or of course 3·7 in., because 3 will be in the units' place and 7 in the tenths' place.

You notice that a fraction consists of two numbers written one over the other, and that the bottom number shows into how many equal parts the whole is divided, and tells what kind of fraction we are considering. Therefore the name given to the bottom number is *Denominator*.

The top number tells us the number of the equal parts which come in the fraction, and therefore the name given to it is *Numerator*.

Ex.—$\frac{5}{13}$ means (1) the whole is divided into 13 equal

parts and that the kind of fraction thought of is thirteenths; (2) that 5 of these equal parts are before us.

Fractions which have for denominators 10, 100, 1,000..... are called decimal fractions and can be expressed in the same way as ordinary numbers by the use of the decimal point, as has been already pointed out. All other fractions are called vulgar, *i.e.*, common, every-day fractions.

A Proper Fraction is one whose numerator is less than its denominator, *e.g.* $\frac{5}{7}$.

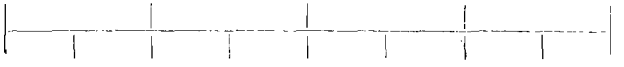
An Improper Fraction is one whose numerator is greater than its denominator, *e.g.*, $\frac{25}{8}$.

It is plain that an improper fraction can be expressed as a whole number and a fraction thus: —

$$\frac{25}{8} = \frac{24}{8} + \frac{1}{8} = 3 + \frac{1}{8} = 3\frac{1}{8}.$$

This result, consisting of a whole number (or integer) and a fraction, we call a mixed number—you remember that we apply the same adjective to a tin of biscuits of more than one sort.

Draw a straight line on paper and divide it into 8 equal parts on the bottom side, 4 equal parts on the top.



You see that

$$\frac{1}{4} = \frac{2}{8},$$
$$\frac{3}{4} = \frac{6}{8},$$

so that the same fractions can be expressed in more than one way.

Divide another line into 12 equal parts, and see for yourself that

$$\frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{6}{12}.$$

Hence *the value of a fraction is not altered if we multiply or divide the numerator and denominator by the same quantity.*

This is important—see that you firmly grasp this fact.

When the numerator and denominator contain no common factors, the fraction is in its lowest terms.

Ex.—$\frac{7}{8}$ is in its lowest terms. $\frac{24}{56}$, we can bring this lower by dividing by 8, and we get $\frac{3}{7}$.

Addition of Fractions

If we wish to add quantities they must be of the same kind. We cannot add $\frac{2}{7}$ to $\frac{3}{4}$ as they stand, because the former fraction belongs to sevenths and the latter to fourths, but $\frac{2}{7} = \frac{8}{28}$ and $\frac{3}{4} = \frac{21}{28}$. The sum of $\frac{2}{7}$ and $\frac{3}{4}$ is the same as the sum of $\frac{8}{28}$ and $\frac{21}{28}$, *i.e.*, $\frac{29}{28}$.

So if we wish to add fractions we must express all of them with the same denominator.

Ex.—

$$\frac{2}{3} + \frac{1}{4} + \frac{5}{9}.$$

The common denominator is got by finding the L.C.M. of 3, 4, and 9. It is plainly 36.

Multiply numerator and denominator of the first fraction by 12, of the second by 9, of the third by 4.

We get

$$\frac{24}{36} + \frac{9}{36} + \frac{20}{36} = \frac{53}{36} = \frac{36}{36} + \frac{17}{36} = 1\frac{17}{36}.$$

The work should be shown thus—

$$\frac{2}{3} + \frac{1}{4} + \frac{5}{9} = \frac{24+9+20}{36}$$
$$= \frac{53}{36}$$
$$= \underline{1\frac{17}{36}}.$$

Ex. 2—Add

$$2\frac{1}{3} + 4\frac{3}{7} + 1\frac{2}{49}.$$

Never turn the mixed numbers into improper fractions, as is sometimes done. To do this causes needless trouble. Add the integers at once, then, having found the L.C.M. of 3, 7, 49, which is 147, proceed as before.

$$2\frac{1}{3} + 4\frac{3}{7} + 1\frac{2}{49} = 6\frac{49+63+36}{147}$$
$$= 6\frac{148}{147}$$
$$= \underline{7\frac{1}{147}}.$$

Subtraction of Fractions

As in addition, we must bring fractions to the same denomination before we can do subtraction.

Ex. 1.—

$$\tfrac{4}{5} - \tfrac{8}{30} = \frac{24-8}{30} = \tfrac{16}{30} = \tfrac{8}{15}.$$

Ex. 2.—

$$6\tfrac{8}{9} - 2\tfrac{7}{27} = 4\frac{24-7}{27} = 4\tfrac{17}{27}.$$

As in addition, deal with the integers first of all.

Ex. 3.—

$$6\tfrac{1}{9} - 2\tfrac{11}{27} = 4\frac{3-11}{27}.$$

Here is a difficulty because we have to take 11 from 3, and the demand exceeds the supply. But we have a store on which we can draw in the 4. Use one of the units, which will be $\frac{27}{27}$ with the $\frac{3}{27}$, this makes $\frac{30}{27}$. Now take away $\frac{11}{27}$, and we have $3\frac{19}{27}$.

Ex.—Find value of :—

$$\begin{aligned} &\tfrac{1}{6} + 2\tfrac{1}{7} + 5\tfrac{7}{8} - 1\tfrac{5}{12} - \tfrac{2}{3}. \\ &= 6\frac{28+24+147-70-112}{168} \\ &= 6\tfrac{117}{168}. \end{aligned}$$

Deal with the integers first of all.

Bring all fractions to the same denomination.

17 and 168 have no common factors, so that $6\frac{17}{168}$ is in its lowest terms.

Remember that in working addition or subtraction mixed numbers should never be turned into improper fractions.

Multiplication of Fractions by Integers

Ex.—

$$\tfrac{7}{8} \times 5.$$

The fraction means that unity is divided into 8 equal parts and 7 of these are before us. If we have to multiply by 5 we must have 35 of these parts.

$$\therefore \quad \tfrac{7}{8} \times 5 = \tfrac{35}{8} = 4\tfrac{3}{8}.$$

Hence to multiply a fraction by an integer, we multiply the numerator by the integer.

Again

$$1\tfrac{1}{7} \times 8 = \tfrac{8}{7} \times 8 = \tfrac{8}{7} = 12\tfrac{4}{7}.$$

Mixed numbers must be turned into improper fractions when doing multiplication of fractions.

Division of Fractions by Integers

Ex.—

$$\tfrac{7}{8} \div 5.$$

The fraction means that unity is divided into 8 equal parts and 7 of these parts are before us. We shall divide by 5 if we make the parts 5 times smaller than before, that is, make them fortieths instead of eighths.

$$\therefore \quad \tfrac{7}{8} \div 5 = \tfrac{7}{40}.$$

Therefore to divide a fraction by an integer we multiply the denominator by the integer.

Again

$$1\tfrac{1}{7} \div 8 = \tfrac{8}{7} \div 8 = \tfrac{1}{7}.$$

Mixed numbers must be turned into improper fractions when doing division of fractions.

Multiplication of Fractions by Fractions

Suppose we wish to multiply $\frac{2}{3}$ by $\frac{5}{7}$. This means that we have to divide $\frac{2}{3}$ into 7 equal parts and take 5 of them.

$\frac{2}{3}$ divided by 7 gives $\frac{2}{21}$ and 5 times $\frac{2}{21}$ will be $\frac{10}{21}$.

∴ To multiply two fractions together we find the product of the numerators for the new numerator, and the product of the denominators for the new denominator.

Again

$$\tfrac{3}{4} \times \tfrac{24}{31} = \tfrac{72}{124} = \tfrac{18}{31}.$$

Here we bring $\frac{72}{124}$ to its lowest terms by dividing the numerator and denominator by 4.

This is better done earlier in the work thus :—

$$\begin{matrix} & & 6 \\ 3 & & 24 \\ \cancel{4} & \times & \cancel{124} \\ 1 & & 31 \end{matrix} = \frac{18}{31}.$$

Another example—

$$2\tfrac{1}{2} \times 4\tfrac{1}{5} \div 3\tfrac{1}{3}$$

$$= \frac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{2}}} \times \frac{\overset{7}{\cancel{21}}}{\underset{1}{\cancel{5}}} \times \frac{\overset{5}{\cancel{10}}}{\underset{1}{\cancel{3}}} = \frac{35}{1} \text{ or } 35.$$

We see that 5 is factor of numerator and denominator, so we may divide out by 5. Cut out the fives and place 1 over each.

Then 3 is a factor of 3 and 21. Cut out the 21 and place 7 over it, cut out the 3 and place 1 under it.

Also 2 is a factor of 10 and 2. Cut out the 10, and place 5 over it, cut out the 2 and place 1 under it.

Finally multiply together the numerators for the new numerator and the denominators for the new denominator.

Division by Fractions

Suppose we want to divide $\frac{2}{3}$ by $\frac{4}{7}$.

Here we want to find by what $\frac{4}{7}$ must be multiplied to produce $\frac{2}{3}$.

Now $\frac{4}{7} \times \frac{7}{4} = 1$.

$\therefore \quad \frac{4}{7} \times \frac{7}{4} \times \frac{2}{3} = 1 \times \frac{2}{3} = \frac{2}{3}$.

$\therefore \quad \frac{4}{7}$ must be multiplied by $\frac{7}{4} \times \frac{2}{3}$ to produce $\frac{2}{3}$.

$\therefore \quad \frac{2}{3} \div \frac{4}{7}$ must be the same as $\frac{4}{7} \times \frac{2}{3}$.

Now when two quantities multiplied together have unity as the product, the one quantity is called the reciprocal of the other.

$\frac{4}{7} \times \frac{7}{4} = 1, \quad \therefore \frac{7}{4}$ is the reciprocal of $\frac{4}{7}$.

$3 \times \frac{1}{3} = 1, \quad \therefore \frac{1}{3}$ is the reciprocal of 3.

Hence to divide one fraction by another we multiply the first by the reciprocal of the second.

Complex Fractions

We saw in ordinary division that $\frac{41}{7}$ may mean that 41 is to be divided by 7.

In the same way $\frac{\frac{2}{3}}{\frac{4}{5}}$ means that $\frac{2}{3}$ is to be divided by $\frac{4}{5}$. A fraction whose numerator and denominator are either or both fractions is called a Complex Fraction.

One or two worked examples—

(1) $\frac{2}{3} - \frac{3}{4}$ of $\frac{7}{9} + \frac{1}{5} = \frac{2}{3} - \frac{3}{4} \times \frac{7}{9} + \frac{1}{5} = \frac{2}{3} - \frac{7}{12} + \frac{1}{5}$

$$= \frac{40 - 35 + 12}{60} = \frac{17}{60}.$$

Note that the word "of" has the force of a bracket.

(2) $$\frac{21\frac{3}{10} \div 12}{7\frac{1}{8} + 2\frac{2}{5} - 1\frac{3}{8}} = \frac{\frac{213}{10} \times \frac{1}{12}}{\frac{15 + 80 - 72}{120}} = \frac{\frac{213}{120} \times \frac{1}{12}}{\frac{23}{120}}$$

$$= \frac{213}{10} \times \frac{1}{12} \times \frac{120}{23} = \frac{213}{23}.$$

(3) $$5\frac{1}{2} + 8\frac{3}{4} \div 5\frac{5}{13} = 5\frac{1}{2} + \frac{35}{4} \times \frac{13}{10} = 5\frac{1}{2} + 4\frac{5}{8}$$

$$= 6\frac{4+5}{8} = 6\frac{9}{8} = 7\frac{1}{8}.$$

Sometimes work of this sort is done: $5\frac{1}{2} + 8\frac{3}{4} \div 5\frac{5}{13}$—

$$8\frac{3}{4} \div 5\frac{5}{13} = \frac{35}{4} \times \frac{13}{70} = \frac{13}{8} + 5\frac{1}{2} = \frac{13}{8} + \frac{11}{2} = \frac{13 + 44}{8} = \frac{57}{8} = 7\frac{1}{8}.$$

Why is this work very bad?

In working complex fractions each stage of the work should show the whole fraction.

Remember that multiplication and division must be done before addition and subtraction.

Fractions of Concrete Quantities

We work out a few examples which should be carefully studied.

Ex. 1.—Find the value of $2\frac{3}{4}$ of £12. 8s. 9d. + $3\frac{7}{12}$ of £14. 1s. 8d.

£	s.	d.		£	s.	d.
4)12	8	9	$\times 2 =$	24	17	6
3	2	$2\frac{1}{4}$	$\times 3 =$	9	6	$6\frac{3}{4}$
12)14	1	8	$\times 3 =$	42	5	0
1	3	$5\frac{2}{3}$	$\times 7 =$	8	4	4 to nearest penny.
				£84	13	$4\frac{3}{4}$

Ex. 2.—What fraction of 4 ac. 3 r. is 2 r. 24 po.

To find what fraction one quantity is of another of the

same kind, bring each quantity to the same denomination and place one result over the other, and that quantity at the bottom which is next to the word "of."

Thus 4 ac. 3 r. = 760 po.
2 r. 24 po. = 104 po.
∴ Required fraction $= \frac{104}{760} = \frac{13}{95}$.

Ex. 3.—Reduce 2 qrs. 13 lbs. to the fraction of 4 tons.

2 qrs. 13 lbs. = 69 lbs.
4 tons = 80 cwt. = 8960 lbs.
∴ Required fraction $= \frac{69}{8960}$.

Ex. 4.—Find value of £2·461 to nearest penny.

2·461
20
9·22
12
2·64

Answer—£2. 9s. 3d.

Turn the decimal of a £, *i.e.*, ·461, into shillings, then the decimal of a shilling, *i.e.*, ·22, into pence.

Ex. 5.—Find value of 1·243 of £4. 6s. 7d. to nearest penny.

1·243
4
4·972
20
19·44
7·458 = 1·243 × 6
26·898
12
10·776
8·701 = 1·243 × 7
19·477

Answer = £4 + 26s. + 19d.
= £5. 7s. 7d.

Note.—8·24d. = 8d. to nearest penny.
8·5d. = 9d. ,, ,,
8·62d. = 9d. ,, ,,

When the first decimal figure is 5 or over increase the units figure by one, in all other cases leave the units figure as it is.

EXAMPLES VI

Fractions

1. By how much is $\frac{7}{9}$ of a chain greater than $\frac{1}{4}$ of a chain?

2. One-fourth of the arable land on a farm is sown with wheat, $\frac{1}{5}$ with barley, $\frac{1}{7}$ with oats, $\frac{1}{9}$ with beans, and the remainder with roots. What is the area of the root ground?

3. If $\frac{12}{100}$ of new milk consists of solid matter, what portion is liquid?

4. If, out of a milk churn containing $7\frac{3}{8}$ gals., $3\frac{5}{8}$ gals. are poured into one can, and $2\frac{2}{8}$ into another can, what quantity of milk remains in the can?

5. If a man spreads $\frac{3}{4}$ of a ton of manure on each of 18 manurial plots, how much manure will he require?

6. If 20 tons of manure are spread evenly over 9 ac. of wheat stubble to be ploughed for mangels, how much manure will be required for each acre?

7. If $2\frac{1}{2}$ gals. of Shorthorn milk make 1 lb. of butter, how many gallons of the same quality milk will be required to make 70 lbs. of butter?

8. If 15 lbs. of Jersey's milk make $\frac{19}{25}$ lb. of butter, how many lbs. of the same quality milk will it take to make 1 lb. of butter?

9. A gallon of water weighs 10 lbs., and if new milk is $1\frac{1}{19}$ times heavier than water, how many lbs. will 1 gal. of milk weigh?

10. If the dead weight of a prime Norfolk ox is $\frac{8}{14}$ of its live weight, what is the dead weight of a similar quality beast, which weighs $17\frac{3}{5}$ cwt. live weight?

11. How many times will a can, holding $\frac{1}{16}$ of a gallon, be filled from a vat holding $20\frac{1}{2}$ gals.?

12. How many hurdles, $5\frac{1}{2}$ ft. long, will be required to pen sheep on a rectangular plot of ground, two sides of which are each $172\frac{1}{2}$ ft. long, and the remaining two $84\frac{1}{6}$ ft. long?

13. If a rainfall of 1 in. is equivalent to 100 tons of water on an imperial acre, what quantity of water would fall on a field of 3 ac. 2 r. in area when the rainfall was $2\frac{1}{4}$ in.?

14. Express 230 sq. rods as the decimal of an acre.

15. What part of an acre is 3 r. 28 po.?

16. What part of an acre is 3,230 sq. yds.?

CHAPTER IV

UNITARY METHOD, RATIO, PROPORTION, PERCENTAGES, AVERAGES, INTEREST, SQUARE ROOT

If it costs £4. 7s. 6d. to keep 14 cows per week in food during winter, what would be the cost of keeping a herd of 60 cows?

Keep of 14 cows costs £4. 7s. 6d.

$\therefore$,, 1 ,, ,, £4. 7s. 6d. $\div 14 = \frac{55}{14}$ *half-crowns.*

$\therefore$,, 60 ,, ,, $\frac{\overset{5}{\cancel{55}}}{\underset{2}{\cancel{14}}} \times \overset{30}{\cancel{60}} = 150$,,

$= £18.\ 15s.\ 0d.$

In solving this problem we find the cost of keeping the 60 cows by first finding the cost of keeping *one* cow, which we obtain from the known cost of keeping 14 cows. Hence the name given to the method.

Ex.—What is the rent of 6 ac. 2 r., if the rent of 10 ac. 1 r. is £20. 10s.?

Here rent of 41 r. $= £20\frac{1}{2}$.

$\therefore$,, 1 r. $= 20\frac{1}{2} \div 41 = £\frac{1}{2}$.

$\therefore$,, 26 r. $= \frac{1}{2} \times 26 = £13$.

Or we might reason thus: Will 26 r. cost more or less than 41 r.? *Answer*, less.

$\therefore$ Multiply $£20\frac{1}{2}$ by $\frac{26}{41} = £13$.

EXAMPLES VII

Unitary Method

1. If 8 qts. of thick cream make $11\frac{1}{2}$ lbs. of butter, how many lbs. of butter will 35 qts. of similar quality cream produce?

2. If 62 black Orpington hens require 197 oz. of food per day, what quantity of food will 173 hens require per week?

3. If it costs 7s. 6d. to keep 70 Indian game cockerels in food for one week, what will be the cost of keeping 46 of the birds for one day?

4. If 15 men can mow 42 ac. with a scythe in 2 days, how many men can mow 28 ac. in 5 days?

5. If, when feeding oats costing 18s. per quarter, the oats for 20 horses cost £4. 10s. per week, how many horses can be fed for this sum when oats are 21s. 6d. per quarter?

6. If 33 cows consume 23,100 lbs. of pulped mangels in 14 days, how long would the same quantity of roots have lasted 9 cows?

7. If 20 doz. (240) eggs weigh 32 lbs., how many will there be in a crate containing a net weight of 112 lbs.?

8. If every 100 lbs. live weight of a fat bullock gives 56 lbs. dead weight, find the dead weight of a bullock the live weight of which was 1,680 lbs.

9. 5 ac. 2 r. 30 sq. perches of strawberry-growing land were sold for £620; while another plot of 2 ac. 3 r. 39 sq. perches was sold at the same rate. What was the cost of the latter?

10. If a bacon hog was sold at 10s. 6d. per score lbs., what was its value per stone of 8 and 14 lbs. respectively?

11. Beef is worth 4s. 10d. per stone of 8 lbs. What is its value per stone of 14 lbs.?

12. If an Ayrshire cow fed on moderately good pasture produces 5 cwt. of cheese from 600 gals. of milk, containing 3·5 per cent. of butter fat, what weight of cheese will be produced from a cow of the same breed producing only 470 gals. of similar quality milk in the year?

13. If 25 lbs. of Ayrshire cows' milk, containing 3·75 per cent. of butter fat, is required to produce 1 lb. of butter, what amount of butter is obtained from a cow which gives a yearly yield of 550 gals.? Weight of a gallon of milk about 10 lbs.

14. If the inclusive cost of keeping a horse for one year is

£28. 10s. 6d., what would be the cost of keeping the horse for 9 months?

15. If, on an average, 4 lbs. of lean meat give off 3 lbs. of water when dried in an oven, how much water will be contained in a hind quarter of beef weighing 22 st. 5 lbs.?

16. If 16 lbs. of oxygen unite with 2 lbs. of hydrogen to form 18 lbs. of water, what weights of oxygen and hydrogen must unite to produce 180 lbs. of water?

17. If 14 lbs. of nitrogen and 3 lbs. of hydrogen form 17 lbs. of ammonia, what amount of nitrogen will 70 lbs. of ammonia contain?

18. If it occupies a horse 1 hr. to remove 20 c. ft., weighing 1 ton, of sandy loam, how many hours will it take to clear a heap the contents of which are estimated at 250,000 c. yds.?

19. If a horse removes 35 c. ft., weighing 1 ton, of wet peat every 2 hrs., how many days of 8 hrs. each will it take to remove 32,000 c. ft.

20. If the following mixture and total amount of seed is required to sow an acre of lawn, how much would be required for a plot measuring 17,000 sq. yds.? Crested dogstail, 5 lbs.; fine-leaved sheep's fescue, 4 lbs.; hard fescue, 3 lbs.; red fescue, 5 lbs.; perennial rye grass, 15 lbs.; smooth-stalked meadow grass, 6 lbs.; evergreen meadow grass, 5 lbs.; perennial white clover, 6 lbs.; yellow suckling, 3 lbs. Total, 52 lbs.

21. To cut and stook 50 ac. of wheat costs £12. 15s. How many acres would be cut and stooked for £30?

22. If a fat steer, when slaughtered, lost 6 lbs. in every 14 lbs. live weight, due to the removal of the offal (head, skin, intestines, etc.), what would be the carcass weight of a live Aberdeen-Angus steer weighing 1,240 lbs.?

23. If a statute acre of land is dug by a man with a spade to a depth of 9 in. in 15 days, how much time will be occupied in digging 20 sq. rods of the same land to a like depth?

24. If 143 lbs. of pig-iron be required to make 68 cart-horse shoes, how many lbs. would be required to make 824 shoes?

25. If 1 in. of rain is equivalent to 100 tons per acre, how many tons per acre would be represented by an annual rainfall of 27·84 in.?

26. If 1 ton of water is equal to 224 gals., how many gals. will be contained in 15 cwt. of water?

Ratio

When we compare one quantity with another of the same kind the result is sometimes called the ratio of the first quantity to the second. Thus the ratio of £1 (= 8 half-crowns) to a crown is 8 to 2 or 4 to 1, and is written $\frac{4}{1}$ or 4 : 1.

The number of times 7 cwt. contains 8 cwt. can be written $\frac{7}{8}$, or we can say that the ratio of 7 cwt. to 8 cwt. is 7 : 8, or we can also say that 7 cwt. is $\frac{7}{8}$ of 8 cwt. So you see that a ratio and a fraction mean the same thing.

The two numbers which form a ratio are called the terms of the ratio; the first, or the numerator of the fraction, is called the antecedent, and the second, or the denominator of the fraction, is called the consequent.

Proportion

When two ratios are equal to one another the four terms are said to be in proportion, thus 2 : 3 = 10 : 15 form a proportion. This is read, 2 is to 3 as 10 is to 15, but the best way to write a proportion is in the fraction shape $\frac{2}{3} = \frac{10}{15}$.

When we know any three of the terms we can always find the one which is unknown.

Ex.—What number of acres bears to 18 ac. the ratio 5 : 2?

Call "n" the unknown number of acres.

$$\text{Then } \frac{n}{18} = \frac{5}{2}.$$

$$\therefore \frac{n}{18} = \frac{45}{18}.$$

$$\therefore n = 45.$$

Or more shortly multiply each ratio by 18, then $n = 45$ ac.

EXAMPLES VIII

Ratio

1. The rent of an upland farm is 12s. per acre, while the rent of a woodland farm is 26s. per acre. Compare the former with the latter.

2. A farm, the soil of which is a fertile loam, yielded 520 tons of mangolds from 13 ac.; while on a farm, the soil of which was light loam resting on chalk, 726 tons were produced from 33 ac. Compare the relative productiveness of the two soils.

3. Compare the following fat weights with initial weights; correct to 3 decimals:—

A steer weighing 935 lbs. was fattened and then weighed 1,430 lbs.

A store pig weighing 32 lbs. when fattened as a bacon hog scaled 200 lbs.

A store pig weighed 27 lbs. and when fattened as a porker weighed 80 lbs.

A lamb weighing 32 lbs. was fattened as a teg and then weighed 112 lbs.

A litter of 12 pigs, weighing 306 lbs. at 8 weeks old, weighed 43 lbs. each when sold as stores at 16 weeks.

4. In an experiment with potatoes, Up-to-Dates yielded 14 tons 8 cwt. per acre; while Farmer's Glory produced 10 tons 12 cwt. Compare the produce per acre of Up-to-Dates with Farmer's Glory.

5. If the cost per 100 lbs. live weight increase of bullocks from birth to 6 months is 10s. 2d., 6 to 12 months 18s. 3d., 1 to 2 years 23s. 9d., $2\frac{1}{2}$ to 3 years 26s. 8d., and from $3\frac{1}{2}$ to 4 years 33s. 10d.; what is the cost to the farmer during the last 2 years' feeding, as compared with the first 2 years?

Percentages

Suppose a man grows 30 cwt. of hops and damages 3 per cent. by careless drying. This means that 3 cwt. out of every

100 cwt. will be damaged, *i.e.*, $\frac{3}{100}$ of his crop will be damaged, and this amounts to $\frac{3}{100} \times 30$ cwt. $= \frac{9}{10}$ cwt.

The term "per cent." means "for each hundred," and is denoted by the symbol $\%$. Always write percentages as fractions, thus $6\% = \frac{6}{100} = \frac{3}{50}$.

Ex. 1.—A man sold his hops in November 1911 for £7 per cwt. Had he waited till January 1912 he could have obtained £13 per cwt. What is his loss per cent.?

His loss on £7 is £6.
∴ ,, ,, £1 is £$\frac{6}{7}$,
∴ ,, ,, £100 is £$\frac{6}{7} \times 100 =$ £$85\frac{5}{7}$.

Of course it is not fair to consider the actual lo great as this—why not?

Remember that profit or loss on any transaction must always be considered with reference to the original outlay or cost price.

Ex. 2.—How much is 35 % of £21.

35 % means $\frac{35}{100} = \frac{7}{20}$.
$\frac{7}{20} \times$ £21 = 147s. = £7. 7s.

Ex. 3.—4 gals. of cider leak out of a cask of 64 ga... What percentage is lost?

Here $\frac{1}{16}$ of the contents of the cask will be lost.

∴ Loss per cent. $= \frac{1}{16} \times 100 = \frac{25}{4} = 6\frac{1}{4}$.

Ex. 4.—A man, whose income is £412 per year, pays taxes to the amount of £15. 5s. What percentage is this of his income?

The fraction of his income which he pays away in taxes $= \frac{15\frac{1}{4}}{412} = \frac{61}{1648}$.

∴ Percentage $= \frac{6100}{1648} = \frac{1525}{412} =$ 3·7.

```
      3·7
412)1525
    1236
     289
     206
     ---
      83
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EXAMPLES IX

Percentages

1. If green Cheshire curd loses 25 per cent. in ripening, how much weight will be lost by $3\frac{1}{2}$ tons of curd?

2. An auctioneer charges 3 per cent. for selling live stock. What is his commission for selling 30 heifers, the total sales of which realise £350?

3. If milk used for hard cheese-making produces 85 per cent. of whey, what quantity of whey will be produced from 82 gals. of milk?

4. £5. 10s. 6d. is charged for a collection of vegetable seeds to sow 1 ac. of ground; 5 per cent. is allowed for payment within a month. What amount remains to be paid?

5. Of a sample of alsike clover seed, weighing 27·54 g., 3·72 g. were found to consist of impurities. What percentage of pure seed was present in the sample?

6. If out of 350 broad beans only 294 germinated, what was the percentage germination capacity?

7. If, in a sample of common sainfoin seeds, 95 per cent. were found to be pure seeds, and of this number only 75 per cent. germinated, how many plants were produced from every 100 seeds?

8. Cream contains 33·5 per cent. of butter fat. How many lbs. of butter fat are there in 45 lbs. 10 oz. of cream?

9. A farmer winnows 740 bus. of oats, after which he has 658 bus. left for sacking. What percentage of oats, weed seed, chaff, etc., has been lost in winnowing?

10. The feeding value of oats is estimated at 16s. per quarter, hay at 50s. per ton, and mangolds 8s. per ton. What would be their selling prices if each was increased in price by 30 per cent.?

11. If 100 lbs. of oats contain 50 lbs. of starch, 10 lbs. of albumin, and 5 lbs. of oil, what weight of these respective ingredients will be contained in 1 bus. of oats weighing 45 lbs.?

12. A crop of Magnum Bonum swedes, grown on light land, was increased 22 per cent. by the use of 3 cwt. of kainit per acre; the crop weighed 27 tons. What was the weight of increase?

13. If 100 lbs. of rye, barley, or wheaten flour contain 65 lbs. of starch, 10 lbs. of gluten or albumin, and 2 lbs. of oil, what are the respective weights of these ingredients in 1 st. of flour?

14. If 100 lbs. of potatoes contain 20 lbs. of starch and 2 lbs. of albuminous matter, what weight of these ingredients will exist in 1 cwt. of potatoes?

15. If a Shorthorn's milk contains 3·6 per cent. of butter fat, how much would you expect to get from 39 gals., assuming that ·02 per cent. is lost in the process of separation?

16. 64 gals. of Shorthorns' milk produced 20 lbs. of butter. If a gallon of milk weighed 10·3 lbs., find what percentage the weight of butter is of the weight of the milk.

17. If three farmers send 72, 140, and 170 store tegs respectively to graze a public park, what percentage of the rent should each farmer pay?

18. If 4·5 per cent. of the dead weight of a cow is incombustible, of a sheep 3·2 per cent., of a pig 2·2 per cent., what weight of ash would be represented by an ox weighing 99 st. dead weight, a sheep 10 st., and a fat sow 16 st.?

Experiments go to show that, in a fat ox, about 60 per cent. of the fatted live weight will be butchers' meat; in a fat sheep, about 88 per cent., and in a fat pig about 83 per cent.

The proportion of carcass increases during the fattening of an animal, thus the carcass of a store sheep will average 56·2 per cent., and of a heavy fat sheep 60·2 per cent.

19. Assuming the above estimates to be correct, what will be the carcass weight of a fat ox weighing 16 cwt. 2 qrs. 22 lbs.; a fat Hampshire Down weighing 1 cwt. 1 qr. 18 lbs.; and a fat bacon hog weighing 2 cwt. 0 qr. 15 lbs.?

20. If mild flavoured butter contains 2 per cent. of salt, what quantity will be required to salt 33 lbs.?

21. If 0·5 per cent. of boric acid or 5 per cent. of salt will preserve butter, how much of each ingredient must be added to 72 lbs. of butter?

22. If the quantity of boric acid added to cream is 0·25 per cent., how many grains will be required to preserve 1 gal. of cream? (Weight of 1 gal. of cream = 9·5 lbs.)

23. The legal standard for milk is 3 per cent. of butter fat and 8·5 per cent. of solids other than fat. What percentage of such milk is water?

24. If a dairyman sells milk containing 13·75 per cent. of fat and solids, how much per cent. in fat and solids is his milk above the Government standard?

25. If a mixed ration for horses is composed of 4 cwt. of chaffed clover hay with 1 cwt. of split tick-beans, $2\frac{1}{2}$ cwt. of white tartar oats and 3 cwt. of cracked feeding maize, find the percentage composition of this food; also, how much a horse will consume of each ingredient if he consumes 26 lbs. of the mixture per day?

26. If a horse consumes 24 lbs. of food per day, consisting of 52 per cent. of meadow hay chaff, 30 per cent. crushed oats, 5 per cent. beans, and 13 per cent. coarse bran; how much of each will he consume in a week of 7 days?

27. The fleeces of 50 blackfaced ewes totalled 235 lbs., which in cleaning showed a shrinkage of $6\frac{3}{4}$ per cent. What was the weight of washed wool, and how much did it realise at $8\frac{3}{4}$d. per lb.?

28. If barley straw contains half its weight of silica, 24 per cent. of potash, 7 per cent. of lime, 4 per cent of phosphoric acid, and $2\frac{1}{2}$ per cent. of magnesia; how many lbs. of the above ingredients will be contained in $7\frac{1}{2}$ cwt., or an average yield of straw from 1 ac. of ground?

29. If the ash of barley grain contains on an average 35 per cent. of phosphoric acid, 25 per cent. of potash, 25 per cent. of silica, $8\frac{1}{2}$ per cent. of magnesia, and $2\frac{1}{2}$ per cent. of lime, how many lbs. of the above ingredients will there be

in a crop of 12 sacks to the acre? (Weight of grain in a sack = 216 lbs.)

30. If, in making Bordeaux mixture, 15 lbs. of milk of lime be added to 30 lbs. of copper salt, what amount of water must be added in order to obtain a 3 per cent. solution for spraying charlock?

31. If a bacon hog aged 8 months and weighing 12 score lbs. yields 78 per cent. of carcass meat when killed, what is the loss, or weight of offal, in every stone of 14 lbs.; or what is the relation between live and dead weight?

32. If a plant when burnt leaves 5 lbs. of ash from every 100 lbs. of the dried plant, what amount of ash would be left after burning $9\frac{1}{2}$ cwt. of dried plants?

33. If 100 lbs. of dried wood leaves $\frac{1}{2}$ lb. of ash, 100 lbs. of oat straw $5\frac{1}{2}$ lbs. of ash, and 100 lbs. of potato haulm 15 lbs. of ash, what would be the amount left after burning 55 lbs. of each material?

34. If 100 lbs. of dried peat soil, when burnt, leave 35 lbs. of ash, while from 100 lbs. of loam 87 lbs. of inorganic matter is left behind, what would be the amount of ash obtained by burning 3 tons of each?

35. A sample of linseed cake contained 28·5 per cent. albuminoids, while a sample of undecorticated cotton cake contained 24·3 per cent. What excess of albuminoids does 1 cwt. of the linseed cake contain over the same weight of cotton cake?

36. The percentage of water in cow's milk is 87·5; sheep's milk, 81·3; and goat's milk, 86·8. Find how much water there is in 50 gals. of each kind of milk.

37. If 32 per cent. is lost in drying rough bark, and 42 per cent. in drying smooth bark, what would be the total loss in drying 3 tons 5 cwt. of oak bark, as compared with the same weight of the young "silver bark" from coppices?

38. If, in the horse-bean, 15 per cent. by weight of the nature seed is husk, what weight of husk will there be in 1 ton 6 cwt. of beans?

Averages

The average of a series of unequal numbers is their arithmetic mean, that is, the result of dividing the sum of the numbers of the series by their number.

Thus, if 27·23, 28·45, 29·04, and 30·72 are four readings of a barometer, the average of these is

$$(27{\cdot}23 + 28{\cdot}45 + 29{\cdot}04 + 30{\cdot}72) \div 4 = \frac{115{\cdot}44}{4} = \underline{28{\cdot}86.}$$

And, generally, if a, b, c, d . . . z be any n numbers, their average is equal to $(a + b + c + d + \ldots + z) \div n$.

At three lamb sales in a county the average prices of blackfaced Down lambs were 32s. 6d., 33s. 6d., and 34s.

The average of these, viz. :—

$$\frac{(32\text{s. } 6\text{d.} + 33\text{s. } 6\text{d.} + 34\text{s.})}{3} = 33\text{s. } 4\text{d.},$$

gives only a rough estimate of the selling price of a lamb in the county.

If the numbers sold at the sales are respectively 2,740 3,950, and 7,840, we find the average price to be—

$$\frac{(2{,}740 \times 32\text{s. } 6\text{d.} + 3{,}950 \times 33\text{s. } 6\text{d.} + 7{,}840 \times 34\text{s.})}{2{,}740 + 3{,}950 + 7{,}840} = 33\text{s. } 6\tfrac{9}{10}\text{d.}$$

But if we assign to the prices, 32s. 6d., 33s. 6d., and 34s., the numbers 3, 4, and 8, which are approximately proportional to the numbers sold, we find the weighted average to be—

$$\frac{(3 \times 32\text{s. } 6\text{d.} + 4 \times 33\text{s. } 6\text{d.} + 8 \times 34\text{s.})}{3 + 4 + 8} = 33\text{s. } 6\tfrac{8}{10}\text{d.},$$

which only differs from the true average by a very small fraction.

EXAMPLES X

1. If the prices of 1st, 2nd, and 3rd quality dairy cows in full milk with calf by side were £24. 15s., £18. 10s., and £13. 5s. respectively, what was their average price?

2. If, from an acre of ground, the following yields of straw or haulm were produced, what was the average amount produced?

Wheat Straw, per acre	=	1	ton	10	cwt.
Barley ,, ,,	=	0	,,	18	,,
Oat ,, ,,	=	1	,,	10	,,
Rye ,, ,,	=	1	,,	15	,,
Bean Haulm ,,	=	1	,,	5	,,
Pea ,, ,,	=	1	,,	0	,,

3. The following were the average yields per day of milk from 10 Guernsey cows at various stages of lactation: 20·4 lbs., 19·7 lbs., 30·9 lbs., 13·4 lbs., 8·6 lbs., 17·8 lbs., 29·7 lbs., 18·1 lbs., 12·6 lbs., 27·2 lbs. What was the average quantity of milk per day per cow?

4. 1 cwt. 2 qrs. 14 lbs. of mangel seed were used in sowing at the rate of 7 lbs. per acre; how many acres were sown?

5. 54 lbs. of Swede seed were used in sowing at the rate of 4 lbs. per acre; how many acres were sown?

6. The heights of the following peas are: Gradus, 3½ ft.; Sangster's No. 1, 3 ft.; William 1st, 4½ ft.; Centenary Marrowfat, 5 ft.; Duke of Albany, 5½ ft.; Gladstone, 4 ft.; American Wonder, 1 ft.; Green Gem, 1 ft. 6 in.; May Queen, 2½ ft.; and Pioneer, 2 ft. What is their average height; and if a foot of width of space be required for every 1 ft. of height, what width of ground would be required to contain the above varieties?

Interest

Interest is payment for the use of a loan of money. It is just the same sort of thing as rent, but, instead of a house or land that the person has the use of, it is money. The money lent is called the Principal. Interest is calculated at so much for every £100 lent for a year, and is of two kinds. When the interest is paid at the end of each year it is called

Simple Interest (S.I.), but if, instead of being paid at the end of each year, it is added to the principal, it is called Compound Interest (C.I.). Total interest added to principal is called the Amount.

Suppose £200 is lent at S.I. for 3 years at 2 per cent. per annum. At the end of each year the interest to be paid is £4; therefore for 3 years the interest is £12.

Hence the simple interest (I.) on a principal (P.) lent for n years at r per cent. can be obtained from the formula:—

$$I = \frac{P \times n \times r}{100}.$$

Ex. 1.—Find the S.I. on £246. 4s. 8d. for 2 years at 5 per cent.

$$I = \frac{\text{£246. 4s. 8d.} \times 2 \times 5}{100} = \frac{\text{£246. 4s. 8d.}}{10}$$

$$= \underline{\text{£24. 12s. 6d. nearly.}}$$

Ex. 2.—Find S.I. on £230 from 1st January to 4th May 1912 at $2\frac{1}{2}$ per cent.

Jan.	30
Feb.	29
March	31
April	30
May	4
	124 days

$$124 \text{ days} = \frac{124}{365} \text{ of a year.}$$

$$\therefore \text{S.I.} = \frac{230}{100} \times \frac{124}{365} \times \frac{5}{2}$$

$$= \frac{713}{365}$$

$$= \underline{\text{£1. 19s. 1d.}}$$

£1. 19s. 1d.

365)713

348
20
6960
3310
25
12
300

Compound Interest

Ex.—Find the C.I. on £1,000 for 3 years at $2\frac{1}{2}$ per cent.

	£	
	1000	= P for 1st year.
$2\frac{1}{2}$ per cent. $= \frac{1}{40}$	25	= I for 1st year.
	1025	= P for 2nd year.
	25·625	= I for 2nd year.
	1050·625	= P for 3rd year.
	26·26563	= I for 3rd year.
	1076·89063	
	20	
	17·8126	
	12	
	10·	

∴ Amount = £1,076. 17s. 10d.
Interest = £76. 17s. 10d.

Compound interest is often added to the principal half-yearly or quarterly. In these cases the amount in a given number of years is the same as in twice or four times the number of years at half or a quarter the given rate per cent. For example, the amount of £200 in 3 years at 3 per cent. when interest is payable half-yearly is the same as the amount of £200 in 6 years at $1\frac{1}{2}$ per cent.

Interest need never be calculated nearer than to the nearest penny, so that more than five decimal figures need not be kept.

EXAMPLES XI

Interest

1. Find the simple interest on—
   (*a*) £200 for 2 years at 4 per cent.
   (*b*) £783 for 1 year 8 months at 5 per cent.
   (*c*) £216 for 10 months at 2 per cent.

2. Find the compound interest on—

(*a*) £500 for 2 years at $2\frac{1}{2}$ per cent.

(*b*) £750 for 2 years at 5 per cent., payable half-yearly.

(*c*) £400 for $2\frac{1}{2}$ years at 4 per cent.

Square Root

The square root of a number is another number, which, when multiplied by itself, *i.e.*, when squared, will give the first number. Thus the square root of 49 is 7, written thus, $\sqrt{49} = 7$. $\sqrt{}$ is the symbol for root—it is the letter *r* somewhat out of shape.

If the prime factors of a number can be found we can easily see what the square root of the number is. For example, consider 2,304.

$$\begin{array}{r|l} 2 & 2304 = 2^4 \times 12^2. \\ \hline 2 & 1152 \\ \hline 2 & 576 \\ \hline 2 & 288 \\ \hline & \underline{144} = 12^2. \end{array}$$

$\therefore$ Square root of $2304 = 2^2 \times 12 = 48$.

The reason for the steps in the next method of finding a square root will be known to those who are acquainted with a little algebra. We give here the necessary directions only.

Another method—

$$\begin{array}{r|l} 23'04 & (48 \\ 16 & \\ \hline 88 & 704 \\ & \underline{704} \end{array} \qquad \text{or} \qquad \begin{array}{r|l} 23'04 & (48 \\ \hline 88 & \underline{704} \end{array}$$

The steps of the work are as follows:—

1. Mark off the digits of the number in pairs beginning with the units digit.

2. Take the left pair (or single digit) 23, and find the

number whose square is nearest to 23 and not greater than it; it is 4. 4 is then the first digit in the answer.

3. Square 4, subtract from 23, and bring down the next pair of digits 04.

4. Double the 4 (*i.e.*, the answer so far as obtained); add a cipher mentally. This gives 80.

5. How many times is 80 contained in 704; answer 8; make the divisor 88.

6. 88 is contained 8 times in 704. 8 is the next digit in the answer.

Ex. 2.—

```
      4'53'69(213
      4
     ------
41 |  53
      41
     ------
423|  1269
      1269
     ======
```

or

```
      4'53'69(213
     ------
41 |  53
     ------
423|  1269
     ======
```

The steps of the work are exactly the same as before.

1. Mark off the digits of the number in pairs beginning with the units digit.

2. Take the left pair, or single digit, 4, and find the number whose square is nearest 4 and not greater than 4; it is 2.

3. Square 2 and subtract from 4, bring down the next pair of digits.

4. Double the 2 (the answer so far as obtained), add a cipher mentally; this gives 40, and 1 is the next digit in the answer.

5. How many times is 40 contained in 53; answer, once; make the divisor 41.

6. 41 is contained once in 53, 12 over; bring down the next pair of digits, 69.

7. Double 21 (the answer so far as obtained), add a cipher mentally; this gives 420.

8. How many times is 420 contained in 1,269; answer, 3; make the divisor 423.

9. 423 is contained in 1,269 3 times.

The next digit in the answer is 3.

Ex. 3.—

```
          3'41·14'09'(18·47
          1
          ----
      28 |241
         |224
          -----
     364 | 1714
         | 1456
          ------
    3687 |  25809
         |  25809
          =======
```

or

```
          3'41·14'09'(18·47
          ----
      28 |241
          -----
     364 | 1714
          ------
    3687 |  25809
          =======
```

Decimals are worked like ordinary numbers.

The marking off in pairs is done from the decimal point, and goes right and left.

Place the decimal point in the root when you have finished with digits in the integral part of the number whose square root you are finding.

To find the Square Root of a Fraction

1. See that the fraction is in its lowest terms.

2. If you are dealing with a mixed number, turn it into an improper fraction.

3. Find the square root of the numerator, and then of the denominator.

4. Then required root $= \dfrac{\text{square root of numerator}}{\text{square root of denominator}}$.

Ex. 1.—**Find** square root of $\frac{289}{441}$

$$\begin{array}{rl} 2'89(17 & \qquad 4'41(21 \\ 27|\underline{189} & \qquad 41|\underline{41} \end{array}$$

$$\therefore \sqrt{\frac{289}{441}} = \frac{17}{21}.$$

Ex. 2.—**Find** square root of $8\frac{17}{64}$.

$$\sqrt{8\tfrac{17}{64}} = \sqrt{\frac{529}{64}} = \frac{23}{8} = 2\tfrac{7}{8}.$$

EXAMPLES XII

Square Root

Find the square root of—

(1) 4096.
(2) 529.
(3) 141376.
(4) 257049.
(5) $20\frac{1}{144}$.
(6) 5507·1241.

If more practice in working out square roots be needed anyone can easily manufacture examples by making square numbers.

CHAPTER V

MENSURATION

MENSURATION deals with the determination of lengths, areas, and volumes. Without a knowledge of mensuration farmers are often hampered when a simple problem presents itself.

It is important that every young farmer should know how to use a chain and tape measure. He should not rely on the local schoolmaster to measure up such areas or volumes as may be necessary in the determining of payment by piecework, or estimating work by contract. Too often haphazard methods of measuring thatching and other work are adopted.

Areas

The area of a surface means the amount of surface within its boundaries. Area is measured in square units.

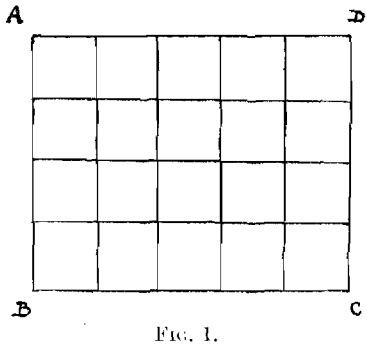


FIG. 1.

Rectangle.—A rectangle is a four-sided figure with each of its angles a right angle.

ABCD is a rectangle whose length AD is 5 in. say, and breadth AB 4 in.

Divide AD into 5 equal parts and AB into 4, and draw lines through the points of division parallel to AD and AB, then it is plain that the rectangle contains 4 strips and each strip contains 5 sq. in.

$\therefore$ Area of rectangle $= (5 \times 4)$ sq. in.

If the length and breadth had been measured in yards we should have obtained the area as 20 sq. yds.

Generally, if the length be l units of length and the breadth be b units of breadth—

$$\text{The area } (A) = (l \times b) \text{ square units.}$$

Ex.—Find the area of an onion bed whose length is a pole and whose width is 8 ft.

$$\text{Here } l = 5\tfrac{1}{2} \text{ yds.} = 16\tfrac{1}{2} \text{ ft.}$$
$$b = 8 \text{ ft.}$$
$$\therefore \quad A = 16\tfrac{1}{2} \times 8$$
$$= 132 \text{ sq. ft.}$$
$$= 14 \text{ sq. yds. } 6 \text{ sq. ft.}$$

Parallelogram.—A parallelogram is a four-sided figure with its opposite sides parallel.

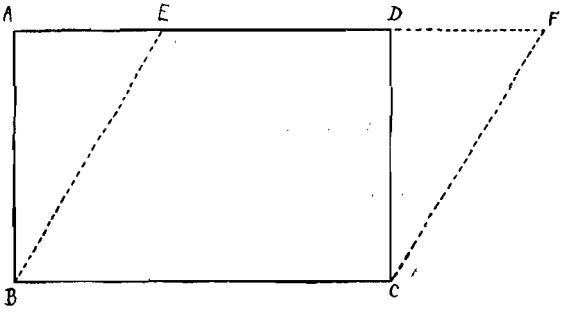


FIG. 2.

ABCD is a rectangle and EBCF is a parallelogram on the same base BC, and of the same height as the rectangle.

It is plain that the area of the parallelogram is equal to the area of the rectangle, for the size of the triangle ABE is equal to the size of the triangle CDF.

Mark that the breadth of the rectangle is the height of the parallelogram, and so we get, if BC $= l$ units of length and AB $= h$ units of length—

$$\text{Area of parallelogram } (A) = l \times h \text{ sq. units.}$$

It is a common mistake to take EB as the height of the parallelogram. Beware of this!

When working out areas always draw a figure—it need not be to scale, but should be clear and of a fair size. A good figure is often half the battle.

Ex.—A field is in the shape of a parallelogram. The

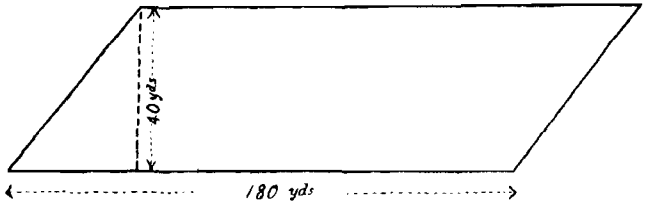


Fig. 3.

length of it is 180 yds., and the adjacent side reaches to a point whose shortest distance from the 180 yds. side is 40 yds. Find its area.

$l = 180$ yds.
$h = 40$ yds.
A $= 180 \times 40$ sq. yds.
$= 7200$ sq. yds.
$= 1\frac{1}{2}$ ac. nearly.

Triangle.—A triangle is a figure bounded by three straight lines.

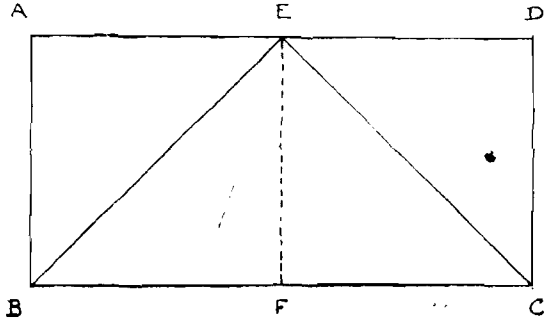


Fig. 4.

ABCD is a rectangle, and EBC is a triangle on the same base BC, and of the same height EF.

It is evident that triangle EBF is half of ABFE, and that triangle EFC is half of EFCD.

$\therefore$ *Triangle* EBC *is half of the rectangle* ABCD.

$\therefore$ if BC $= b$ units of length,

and EF $= h$ units of length,

then area $A = \frac{1}{2}b \times h$ sq. units.

Ex.—The base of a triangular flower bed is $6\frac{1}{2}$ ft. and its height is 4 ft. Find its area.

Here $b = 6\frac{1}{2}$ ft., $h = 4$ ft.

$\therefore \quad A = \frac{1}{2}(\frac{13}{2} \times 4)$

$= 13$ sq. ft.

The area of a triangle, when the lengths of the sides are known, can be obtained from the formula:—

$$\sqrt{s(s-a)(s-b)(s-c)},$$

where $s = \frac{\text{perimeter}}{2}$, and a, b, c are the lengths of the sides.

Ex.—The lengths of the sides of a triangle are 14 yds., 10 yds., and 8 yds. Find its area.

$s = \frac{14+10+8}{2} = 16$ *yds.*

$s - a = 16 - 14 = 2$,,

$s - b = 16 - 10 = 6$,,

$s - c = 16 - 8 = 8$,,

Area $= \sqrt{16 \times 2 \times 6 \times 8}$

$= 16\sqrt{6}$

$= 16 \times 2{\cdot}45$

$= 39{\cdot}2$ sq. yds.

Area of Four Walls of a Room.—Take a match box, strip off the four sides, and place them flat on a table. We have a rectangle like the figure.

The area of the four sides of the box is the area of the rectangle.

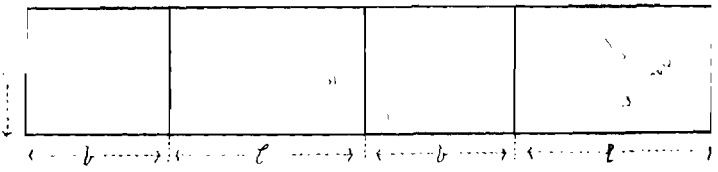


FIG. 5.

Let the breadth of the box be b units of length.

,, length ,, ,, l ,, ,,

,, height ,, ,, h ,, ,,

Then the length of the rectangle $= 2(l + b)$ units = the perimeter or distance round the box.

The breadth of the rectangle is h units.

$$\therefore \text{ Area} = 2(l + b) \times h \text{ sq. units.}$$

Hence, to get the area of the walls of a room, we multiply the number of units of length in the perimeter by the number of units of length in the height.

Ex.—The sides of a rectangular pit 22 ft. by 8 ft. and 4 ft. deep are to be boarded; how many square feet of wood will be required?

Perimeter $= (22 + 8) \times 2$
$= 60$ ft.
Height or depth $= 4$ ft.
Area $= 60 \times 4$ sq. ft.
$= 240$ sq. ft.

Trapezium.—A four-sided figure with two sides parallel and unequal is a trapezium.

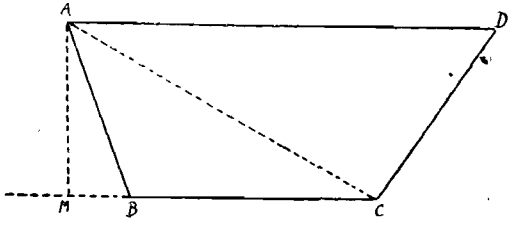


FIG. 6.

ABCD is a trapezium. Divide it into two triangles ABC and ACD.

Draw a perpendicular from A to BC, produced if necessary, meeting it at M.

AM is the height of the triangle ABC and also of triangle ACD.

Let AD contain a units of length.

" BC " b " "

" AM " h " "

Then the area of triangle ACD $= \frac{1}{2}ah$ sq. units.

ABC $= \frac{1}{2}bh$ "

$\therefore$ Area of trapezium $= \frac{1}{2}ah + \frac{1}{2}bh$

$= \frac{1}{2}h(a+b)$ sq. units.

Instruments used in Land Surveying

Gunter's Chain.—About the beginning of the seventeenth century Edmund Gunter devised the lineal measure called Gunter's Chain to facilitate the measurement of land and the computation of acreage. It is nearly always used in the British dominions.

A chain is 66 ft., or 22 yds., or 4 perches in length, and is divided into 100 links, each 7·92 in. long; thus—

$$\frac{66}{100} \text{ of 1 ft. or } \frac{66 \times 12}{100} = 7{\cdot}92 \text{ in.}$$

Square links are converted into acres by dividing by 100,000 (the number of square links in 1 acre), or by merely moving the decimal point five places to the left. At every tenth link from either end of the chain a piece of notched brass is attached. That at the tenth link has one notch, that at the twentieth link two notches, and so on to the fiftieth link, which is marked with an oval shaped piece of brass. By this arrangement any distance on the chain may be easily counted.

The Cross-staff.—To ascertain a point on the chain line from which a perpendicular will meet an observed point on the boundary of a field, the cross-staff is used. It is usually composed of a round piece of mahogany or boxwood with a

diameter of about 8 in., on which two fine grooves are sawn at right angles to each other. It is usually fixed on a staff of convenient length for use, one end being spiked for sticking in the ground.

A simple instrument called the Optical Square is now more generally employed for taking right angles to the chain line. It consists of a small circular metal box containing two small mirrors whose planes make with each other an angle of 45°.

The Offset Staff is used for measuring short distances, called offsets, perpendicular to the main line of measurement. It is usually 10 links in length, the links being painted alternately in red, white, and black, or numbered 1, 2, 3, etc. It is generally pointed with iron at the heaviest end for fixing in the ground for marking stations, etc.

Method of Measuring with the Chain.—Ten iron arrows about 12 in. long, pointed at one end and turned at the other to form a ring or handle, through which a piece of red or white cloth is tied to enable the arrows to be more readily seen in long grass, are handed to an assistant or chain leader, who moves off in the direction of the station the distance to which is to be measured, with one end of the chain in his right hand and the ten arrows in his left, while the follower remains at the starting point, holding the other end of the chain, and, looking along the chain line, directs the leader to range with the station staff. The leader then puts down one of the arrows, after which the follower advances towards the first arrow and draws it from the ground, while the leader puts down another arrow. They proceed in like manner until the leader has put down all his arrows. Then, advancing a chain farther, the leader sets his foot upon the end of the chain and calls out "Change," when the follower comes up and hands him the ten arrows, one of which is put down.

The Field Book.—This book is in three columns. In the centre column, beginning at the bottom, are entered the distances successively marked on the chain line. In the right

and left hand columns are entered the perpendiculars from points in the boundary on the right and left of the chain line, respectively, forming the ordinates or offsets for side areas.

To Find the Area of an irregular Field, ABCDEF

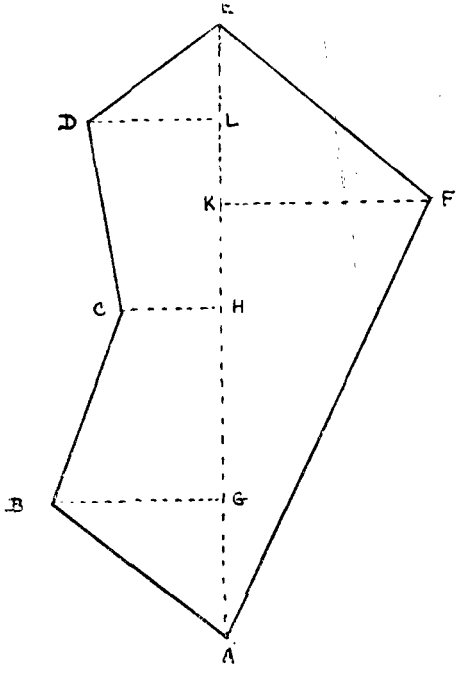


FIG. 7.

Take AE for the base line and let the perpendiculars to AE from B, C, D, F meet it in G, H, L, K. These perpendiculars are called offsets.

The field is now divided into triangles and trapezia.

To find the area of the triangles and trapezia we measure the distances of the points G, H, K, L from A, and the lengths

of the offsets, and enter the measurements, which are made with a chain, in a note-book as follows :—

Links

	To E.	
	2000	
(D.) 650	1400	
	800	600 (F.)
(C.) 150	700	
(B.) 400	300	
	From A.	

This table means that the offsets on the left beginning with BG are 400, 150, 650 links; AG, AH, AK, AL, AE, are 300, 700, 800, 1,400, 2,000 links; and that KF is 600 links.

We calculate the areas of the various pieces thus :—

Triangle BGA	$= \frac{1}{2}$AG × BG $= \frac{1}{2} \times 3 \times 4$	=	6	sq. ch.
Trapezium BGHC	$= \frac{1}{2}$(BG + CH)HC $= \frac{1}{2} \times 5{\cdot}5 \times 4 =$		11	,,
,, CHLD	$= \frac{1}{2}$(CH + DL)HL $= \frac{1}{2} \times 8 \times 7$	=	28	,,
Triangle DLE	$= \frac{1}{2}$(DL × LE) $= \frac{1}{2} \times 6{\cdot}5 \times 6$	=	19·5	,,
,, EFA	$= \frac{1}{2}$(AE × KF) $= \frac{1}{2} \times 20 \times 6$	=	60	,,
	Total area	=	124·5 sq. ch.	

124·5 sq. ch. = 12·45 ac. = 12 ac. 1 r. 32 po.

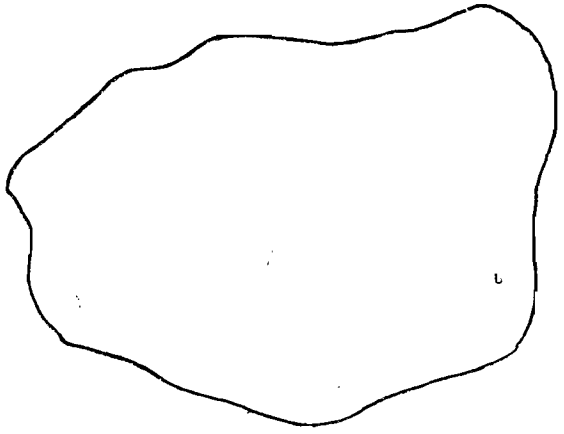


FIG. 8.

To set out Rectangles.—Having ascertained the desired area and length expressed in the same unit, divide the former by the latter. The quotient is the required breadth. For example, if 1 ac. of ground or 10 sq. ch. is 5 ch. long it must be 2 ch. wide.

To set out Triangles.—The area and the base being given, divide the former by half the latter to obtain the required height. At any point on the base erect a perpendicular equal to the height obtained, the end of which will be the vertex of the triangle.

To set out an Equilateral Triangle. — The area being given, multiply the square root of the area by 1·520. The product will be the length of the required side.

To set out Circles.—The area being given, multiply the area by 7, divide the product by 22, and extract the square root of the quotient, which is the radius whereby the circle can be described on the ground.

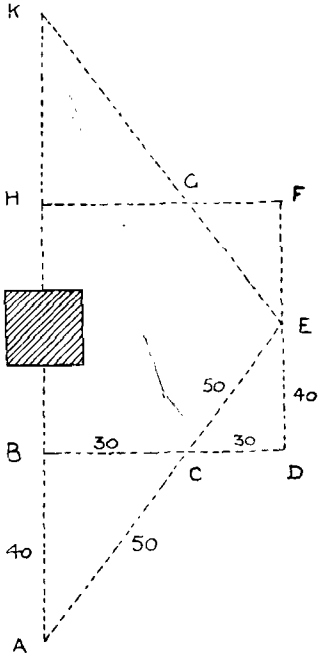


FIG. 9.

To Find the Area of an irregular Figure by Weighing

Suppose Fig. 8 represents a piece of ground drawn to scale as nearly as possible. Trace out the figure on a piece of cardboard of uniform thickness. Cut out the figure with great care. Weigh it. Cut out a square inch of the same cardboard and weigh it.

Divide the weight of the figure by the weight of the square inch and we get the number of square inches in the figure.

If the scale was 1 in. = 1 ch., we get the number of square chains in the ground.

To Measure past an Object such as a House (Fig. 9)

With the end of the chain at A set off 40 links to B. At right angles to AB make BC = 30 links. CA will then be found to measure 50 links. Continue BC in a straight line to D, and similarly produce AC to E. CD will then be 30 links, DE 40 links, and CE 50 links. Produce DE to F, making EF = 40 links, and set off FG = 30 links at right angles to EF, and make GE = 50 links. Continue FG to H, making GH = 30 links. Produce EG to K, making GK = 50 links; then HK should be 40 links. The straight line HK will then be in the same direction as AB.

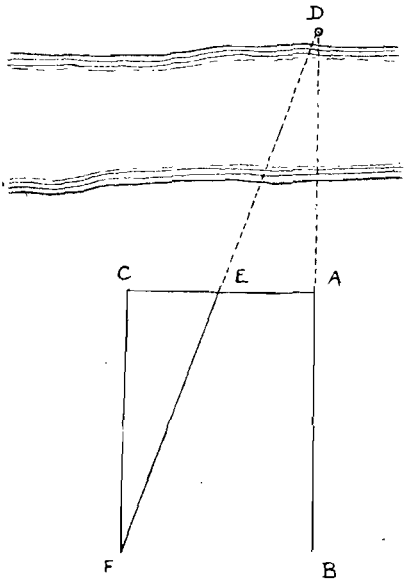


Fig. 10.

To find the Breadth of a River

When base line is nearly at right angles to river (Fig. 10), on the base line AB set off AC at right angles to DA, and bisect AC in E. Set off CF at right angles to AC until F ranges in line with DE; then CF = DA.

Another simple method of measuring the breadth of a river is as follows (Fig. 11):—

Let A be an object close to the river; B is an object

on the other side, also close to the river, and directly opposite to A.

Draw a straight line AC at right angles to AB, of any

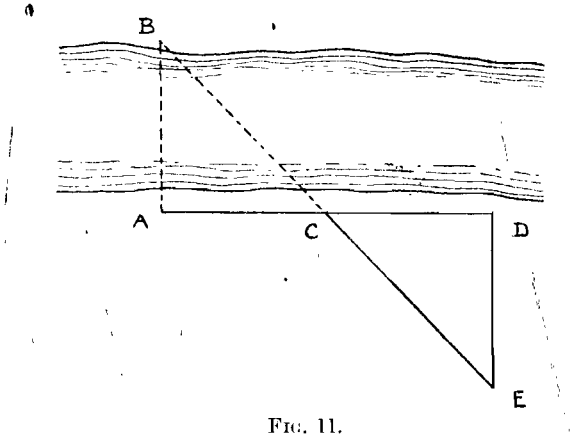


FIG. 11.

convenient length, and fix a picket at C. Produce AC in a straight line to D and make CD = CA.

From D draw a straight line at right angles to AD, and in it find the point E in a line with BC. The triangle CAB = CDE, and DE = AB.

Levelling

Use a Gravatt's or dumpy level for preference. Place the instrument midway between the two stations, making the legs firm in the ground, and the parallel plates as horizontal as possible, after which finally adjust by means of the four screws until the vertical axis and telescope are respectively vertical and horizontal. Move the eye-piece in or out until the wires of the telescope can be seen distinctly, meanwhile directing the telescope towards the staff and continuing to focus until the numbers on the staff are distinct. In simple levelling the instrument remains stationary, there being only one line of collimation; therefore all readings are taken from the same

position. The first reading is called a back-sight and the last a fore-sight; those between are called intermediates.

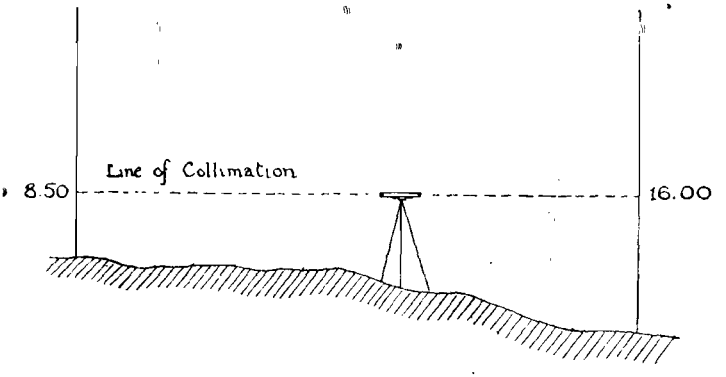


FIG. 12.

Back-sight at A - - -	8·50 ft.
Fore-sight at B - - -	16·00 ,,
Therefore fall from A to B - -	7·50 ft. difference.

When the fore-sight is greater, the ground falls, and *vice versa*.

To find the Difference in Level between Two Stations (A *and* B)

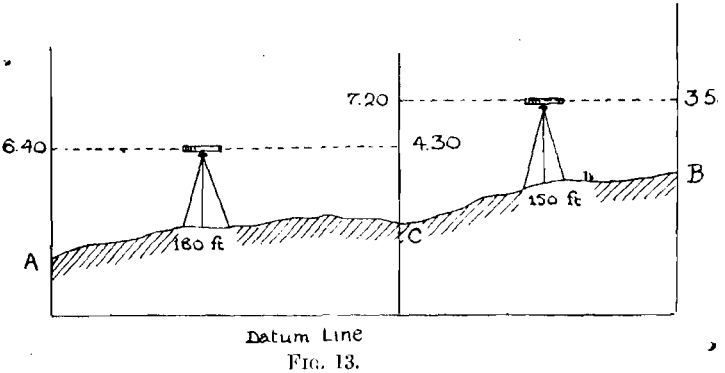


FIG. 13.

Erect a levelling staff at one station (A), and another at some point between A and B, say C. Set up the dumpy level midway between A and C; take the "back-sight" observation on the staff at A, and the "fore-sight" on the staff at C. Similarly, take readings between C and B. Measure the distance between the stations, and enter readings in levelling book as follows:—

Distance.	Back-Sights.	Fore-Sights.	Rise.	Fall.	Distance of Surface above Datum Line at	Remarks.
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
...	...	...	...	...	A 10·00	Datum or horizontal line below Station A.
180	6·40	4·30	2·10	...	C 12·10	
150	7·20	3·50	3·70	...	B 13·70	
330	13·60	7·80	5·80	...		
	7·80					
	5·80					

Thus there is a rise of 5·80 ft. from A to B, a distance of 330 ft., or nearly 1·75 ft. in 100 ft. Station A is 10 ft. above the datum line, C 12·10 ft., and B 13·70 ft.

Areas

A room 13 ft. 10 in. long, and 10 ft. 6 in. wide is covered with carpet 27 in. wide at 3s. 11d. per yard. What would be the amount and cost of material required?

The floor is a rectangle. The area of a rectangle = length × breadth.

$$\therefore \quad \text{Area} = 13\tfrac{5}{6} \times 10\tfrac{1}{2} \text{ sq. ft.}$$

This is also the area of the carpet in the roll 27 in. wide.

$$\therefore \quad \text{Length of carpet} = \frac{\text{area}}{\text{width}} = \frac{13\frac{5}{6} \times 10\frac{1}{2}}{2\frac{1}{4}} = \frac{83}{\cancel{6}_{\,3}} \times \frac{\overset{7}{\cancel{21}}}{\cancel{2}} \times \frac{\overset{2}{\cancel{4}}}{9}$$

$$= \frac{581}{9} = 64\tfrac{5}{9} \text{ ft.} = \underline{21 \text{ yds. } 1\tfrac{5}{9} \text{ ft.}}$$

$$\text{Cost} = \frac{83}{6} \times \frac{21}{2} \times \frac{4}{9} \times \frac{1}{3} \times \frac{47}{1} = \frac{27307}{27} = 1012\text{d. nearly}$$
$$= 84\text{s. } 4\text{d.} = £4.\ 4\text{s. } 4\text{d.}$$

EXAMPLES XIII

Areas

1. A farmer wishes to plant an acre of Drumhead cabbages in rows 34 in. apart, and the plants 26 in. apart in the rows; how many plants will be required, allowing 100 plants to make good any failures?

2. Strawberry plants are planted 22 in. apart between the rows, and 18 in. from plant to plant in the rows; how many plants are required to plant an acre?

3. A dairy, the inside dimensions of which are as follows: Milk-receiving and butter-making room, 20 ft. by 15 ft.; cheese-ripening room, 16 ft. by 10 ft.; boiler and washing-up room, 8 ft. by 12 ft.; office and laboratory, 12 ft. by 14 ft., is to be laid with granolithic slabs, each $1\frac{1}{2}$ ft. by 2 ft. (*a*) How many slabs are required? (*b*) What is the cost at 1s. 6d. per square yard?

4. If 500 bus. of Newton Wonder apples are produced from an acre of bush trees planted 12 ft. apart, what quantity may be expected from 60 sq. rods of ground similarly planted?

5. If a fruit room 30 ft. long and 20 ft. wide will hold 300 bus. of apples, what area of shelving will be required, estimating that 4 sq. yds. can be made to hold 1 bus. of fruit?

6. How many plants of Drumhead cabbage or Thousand-Headed kale 2 ft. 9 in. between the rows and 2 ft. from plant to plant in the rows, will be required to plant 1 ac. of ground?

7. How many loads of dung placed 8 ft. apart will be required to manure $2\frac{1}{2}$ ac. of ground, 6 heaps going to the load?

8. How many standard apple trees on the crab stock, or pears on the pear stock, 24 ft. apart, will be required to plant an acre of ground?

9. How many bush apple trees, 15 ft. each way, can be planted on 1 ac. of ground?

10. The cost of covering roofs, or thatching ricks, is calculated at per square of 100 sq. ft. What is the cost of tiling a collar-beam roof, 62 ft. long and 16 ft. from ridge to ridge, at £3 per square?

11. A plain tile is $10\frac{1}{2}$ in. $\times$ $6\frac{1}{4}$ in. $\times$ $\frac{5}{8}$ in., weight $2\frac{1}{4}$ lbs. What would be the weight of 1,000 such tiles?

12. If, in flat roofing, 210 tiles are required to cover 1 square (100 sq. ft.), how many tiles will be required to cover the roof of a lean-to cart shed 58 ft. long and 12 ft. wide?

13. If an asphalt footpath costs 10s. per superficial yard, a substantial gravel footpath 4s. per superficial yard, and a tarred footpath 2s. 6d. per superficial yard, what would be the respective costs of making 800 yds. of paths, having a width of 4 ft. 6 in.?

14. What would be the cost of laying a barn floor, 36 ft. long and 18 ft. wide, with a concrete foundation at 1s. 8d. per yard super., and faced with Portland cement at 2s. per yard super.?

15. A turf is usually 1 yd. long by 1 ft. wide by $1\frac{1}{2}$ in. thick. State how many such turves will be required to lay a tennis lawn, 26 yds. by 12 yds., also a full size croquet ground 35 yds. by 28 yds.

16. When laying out tennis lawns the area should, if possible, be 50 yds. by 25 yds. in order to allow for shifting the nets. How many courts of these dimensions could be laid out on an acre of ground?

17. Take an ordinary brick, $8\frac{3}{4}$ in. $\times$ $4\frac{1}{4}$ in. $\times$ $2\frac{3}{4}$ in. and find the perimeter of each of its sides and ends, stating the answer in inches.

18. What length of wire-netting is required to enclose a poultry run of rectangular form 29 ft. long and 15 ft. wide?

19. What will be the cost of making a ditch around a rectangular field which is 87 ch. 52 links long, and 14 ch. 72 links wide, at 4d. per perch of $5\frac{1}{2}$ yds.?

20. Which will enclose the larger area, a pigsty 8 ft. 6 in. by 7 ft. or a pigsty 8 ft. square?

21. If 264 hurdles are required to fence a boundary to a rectangle, the length of which is twice its breadth and which contains 3 ac. 2 sq. ch., what is the length of each hurdle?

22. If a field is 17 ch. wide, and a harrow is $6\frac{1}{2}$ ft. wide, how many times must the harrow be drawn up and down the field to cover the ground once, allowing for an overlap of 6 in. each time?

23. How many paving bricks each having an area of $40\frac{1}{2}$ sq. in. will be required to cover 72 sq. ft.?

The Circle

Draw a large circle on paper, using a pair of compasses stretched out a distance of $3\frac{1}{2}$ in.

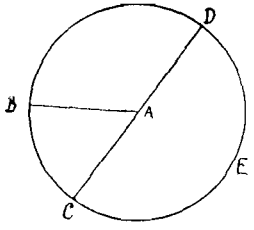


FIG. 14.

A is the centre.

AB is a radius.

CAD is a diameter and is of course twice a radius.

The perimeter CBDE is the circumference.

Place a piece of thread along the circumference taking care that the thread does not slip.

Measure the thread and so get the length of the circumference.

If you do this carefully you will find

$$\text{circumference} = 22 \text{ in. nearly.}$$
$$\text{diameter} = 7 \text{ in.}$$
$$\therefore \frac{\text{circumference}}{\text{diameter}} = \frac{22}{7} = 3\frac{1}{7} \text{ nearly.}$$

Now do the same measurements in a different way.

Take the largest cylinder you can find—a good sized drain pipe. Wrap a piece of string round it, measure the

length of the string and so get the length of the circumference. Measure the diameter.

Work out the ratio $\frac{\text{circumference}}{\text{diameter}}$, and you will find that you get the same result as before, *i.e.*, $3\frac{1}{7}$ nearly.

Whatever the circle you may work with, the result obtained is always the same.

We denote this ratio, $\frac{\text{circumference}}{\text{diameter}}$, by the Greek letter π, called pi, and so π stands for the number $3\frac{1}{7}$.

A more accurate value is 3·1416. The value of π has been worked out to over 700 decimal figures by mathematical methods, but $3\frac{1}{7}$ is generally good enough for everyday work.

To Find the Centre of a Circle

A straight line joining two points on the circumference, as AB, is called a chord.

Draw two chords AB, EF not parallel; find their midpoints C, G.

At C and G draw perpendiculars to AB and EF respectively.

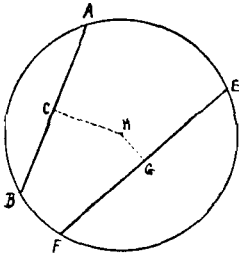


FIG. 15.

These perpendiculars meet in the centre of the circle.

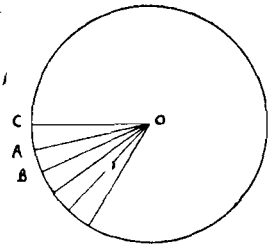


FIG. 16.

Area of a Circle

To find the area of a circle we may proceed thus: Draw a large circle on paper and cut it through along a diameter.

Divide the arc of each semicircle into a number of small equal parts such as CA, AB, ...

With a pair of scissors cut along the radii OA, OB, ..., stopping just short of the circumference. Open out the paper and place it on the table.

We get a figure like this:—

FIG. 17.

The other semicircle is treated in the same way and fitted into the first.

FIG. 18.

If the arcs are very small we get a figure which is nearly a rectangle, whose length is half the circumference of the circle, and whose breadth is the radius.

But the circumference $= \pi \times$ diameter.

$\therefore$ Semicircle is $\pi \times$ radius.

$\therefore$ Area of rectangle is $\pi \times$ radius $\times$ radius.

$\therefore$ Area of circle $= \pi \times r^2$, if r units $=$ the radius.

$$\text{Area of circle} = \pi \times r^2 = \frac{4\pi^2 \times r^2}{4\pi} = (\text{circumference})^2 \times \frac{7}{88}$$

$$= (\text{circumference})^2 \times \cdot 08 \text{ nearly.}$$

The circle contains a greater area than any other plane figure of the same perimeter.

Since the area of a circle of radius r units is $\pi \times r^2$ square units, it is seen that if we double the radius we make the area four times greater than before, and so on.

Areas of circles are to one another as the squares of their radii.

It is shown in geometry text-books that the areas of similar figures are to one another as the squares on corresponding sides.

Right-Angled Triangles.—In any triangle which has

a right angle (90°) amongst its angles, the side AC opposite the right angle is called the hypotenuse.

Describe squares on each side.

It will be found that the square on AC equals the sum of the squares on AB and BC.

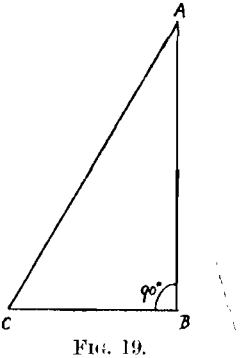


FIG. 19.

Area of the Sector of a Circle

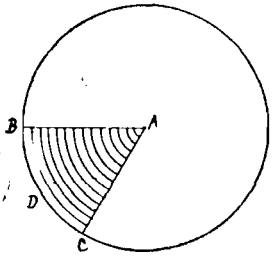


FIG. 20.

A figure which is bounded by two radii and an arc, such as ABDC is called a sector of a circle.

To find its area we may measure the length of the arc BDC and find the circumference of the circle by multiplying the diameter by $3\frac{1}{7}$.

Then it is plain that :—

$$\frac{\text{area of sector}}{\text{area of circle}} = \frac{\text{length of arc of sector}}{\text{length of circumference of circle}}.$$

$$\therefore \text{ Area of sector} = \frac{\text{arc-sector} \times \pi r^2}{2\pi r} = \tfrac{1}{2}r \times \text{arc of sector}.$$

Or we may measure the size of the angle BAC instead of the arc BDC, and again it is plain that :—

$$\frac{\text{area of sector}}{\text{area of circle}} = \frac{\text{number of degrees in BAC}}{360°}.$$

Ex.—Length of arc of a sector is 38 in., radius is 14 in. Find its area.

$$\frac{\text{area of sector}}{3\frac{1}{7}\times(14)^2}=\frac{38}{3\frac{1}{7}\times 28}.$$

$$\therefore \text{ Area of sector}=\frac{38}{28}\times 14\times 14=38\times 7 \text{ sq. in.}=\underline{266} \text{ sq. in.};$$

or, we may say at once:—

$$\text{area of sector}=\tfrac{1}{2}\,r\times\text{arc}=7\times 38=\underline{266} \text{ sq. in.}$$

Ex. 2.—The angle of a sector is 24° and the radius is 12 in. Find its area.

$$\frac{\text{area sector}}{\text{area circle}}=\frac{24}{360}=\frac{1}{15}$$

$$=\frac{1}{15}\times\text{area of circle}$$

$$=\frac{1}{15}\times\frac{22}{7}\times 12\times 12 \text{ sq. in.}$$

$$=\frac{1056}{35}=\underline{30{\cdot}17 \text{ sq. in.}}$$

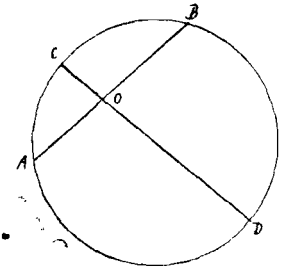


Fig. 21

If we draw any chord AOB in a circle ACBD the two parts into which the circle is divided are called *segments*.

O is the mid point of AB and COD is a diameter at right angles to AB.

The heights of the *segments* are CO and OD respectively.

It is shown in geometry text books that:—

$$CO\times OD=OB^2.$$

$$\therefore \quad CO=\frac{OB^2}{OD},$$

so that, if we know any two of the lengths CO, OD, OB, we can get the third.

Ex.—The height of a segment of a circle is 10 ft., the length of the chord, or base, is 30 ft. Find the diameter of the circle.

Here OD = 10 ft., OB = 15 ft.

$$\therefore \quad CO = \frac{15 \times 15}{10} = \frac{45}{2} = 22\tfrac{1}{2} \text{ ft.}$$

$$\therefore \quad \text{Diameter} = CO + OD$$
$$= 22\tfrac{1}{2} + 10$$
$$= \underline{32\tfrac{1}{2} \text{ ft.}}$$

The area of a segment of a circle is approximately found by the formula :—

$$\tfrac{2}{3}ah + \frac{h^3}{2a}.$$

Where a = length of AB,
h = length of ED, the height.

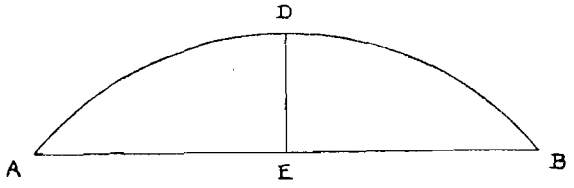


FIG. 22.

Ex.—The length of the chord of a segment is 4 ft., the height is 2 ft. Find its approximate area.

$$\text{Area} = \tfrac{2}{3} \times 4 \times 2 + \frac{8}{2 \times 4} \text{ sq. ft.}$$
$$= (5\tfrac{1}{3} + 1) \text{ sq. ft.}$$
$$= \underline{6\tfrac{1}{3} \text{ sq. ft.}}$$

The Ellipse

In the ellipse, DE, the longest chord, is called the major axis.

ACB, the chord bisecting AB at right angles, is called the minor axis.

C is the centre of the ellipse.

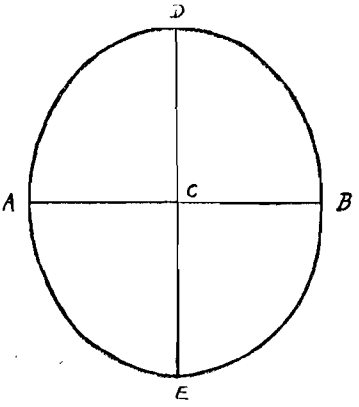


FIG. 23.

Suppose the length of AB is $2a$ units and the length of DE is $2b$ units.

Then the circumference is $\pi(a+b)$ units nearly. The area is πab.

Volumes

By the volume of a body we mean the amount of space contained within its bounding surfaces. Other names for volume are capacity and solidity.

Volume is measured in cubic units.

A Rectangular Solid

A rectangular solid, whose length, breadth, and height are equal, is a cube.

Suppose Fig. 24 represents a rectangular solid of length 5 ft., breadth 3 ft., height 4 ft., we can divide the solid into

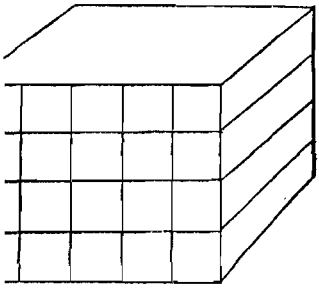


FIG. 24.

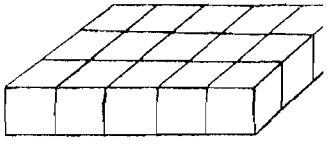


FIG. 25.

four strips like Fig. 25, and each strip can be divided into 15 cubes, each containing 1 cubic foot.

$$\therefore \text{ Total number of cubic feet} = 5 \times 3 \times 4 = 60.$$

Hence we see that the volume of such a solid is length × breadth × height cubic units.

Or volume $= l \times b \times h$ cubic units,

When l = length, b = breadth, h = height.

The Cylinder

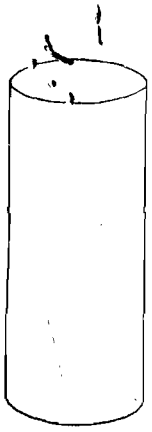


FIG. 26.

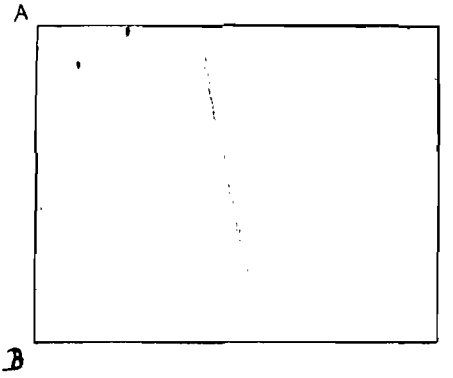


FIG. 27.

Make a paper cylinder like Fig. 26.

Cut the cylinder *along* the height AB.

Place the paper flat like Fig. 27.

We get a rectangle, whose width is the height of the cylinder and whose length the circumference of the cylinder.

Let the radius of the cylinder be r units, and the height h units.

Then the area of the curved surface is $2\pi rh$ square units.

The volume is the area of base × height $= \pi r^2 h$ cubic units.

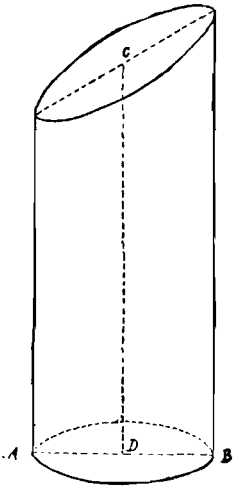


FIG. 28.

A solid, formed by cutting an upright cylinder by a plane not parallel to the base as in figure, has a curved surface and volume equal to that of an upright cylinder of the same base and of average or mean height CD.

The Sphere

If a sphere has a radius of r units the area of the surface is $4\pi r^2$.

The volume of the sphere is $\frac{4}{3}\pi r^3$.

The Cone

A cone is called a right cone if the perpendicular from the vertex meets the base at its centre.

To find the area of the curved surface, make a cone of paper like the figure. Then cut along AB and place the paper

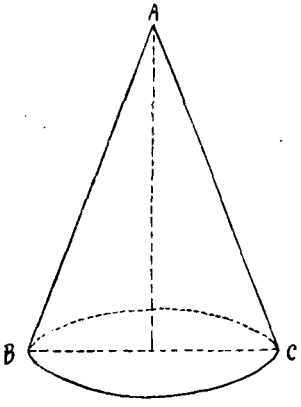


FIG. 29.

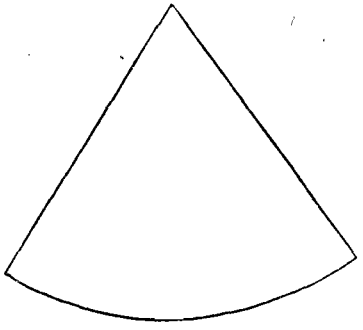


FIG. 30.

flat on the table. We get a sector of a circle of which the arc is the circumference of the base of the cone and the radius is the slant height AB.

Call the length of the radius of the base of the cone r units and the length of the slant side l units.

Then the area of curved surface of cone = area of sector

$$= \tfrac{1}{2} \text{ arc} \times \text{radius} = \tfrac{1}{2} \times 2\pi r \times l = \pi r l \text{ sq. units.}$$

The volume of a cone is one-third of the volume of a cylinder of the same height and base, and is therefore $\frac{1}{3}\pi r^2 h$

cubic units, if the height of the cone be "h" units and the radius of the base be "r" units.

The Prism

A prism is a solid bounded by plane faces, of which two are similar, equal, and parallel figures, and the other faces are parallelograms.

Prisms on the same base and of the same height have the same volume.

$\therefore$ Volume of a prism = (area of base) × height.

The surface area will be the sum of the area of the faces.

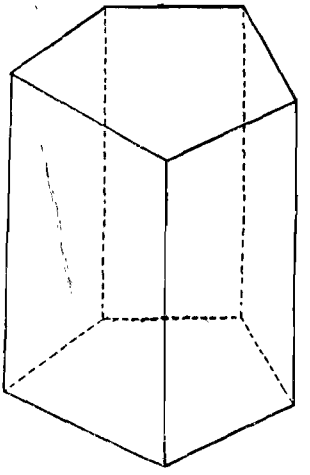


FIG. 31.

The Pyramid

A pyramid is a solid bounded by plane faces, of which one, called the base, is any rectilineal figure, and the rest are triangles with some point, not in the plane of the base, as common vertex.

The volume of a pyramid is one-third the volume of a prism on the same base and of the same height.

$\therefore$ Volume of pyramid = $\frac{1}{3}$ (area of base) × height cubic units.

The surface area is obtained by finding the sum of the areas of the faces.

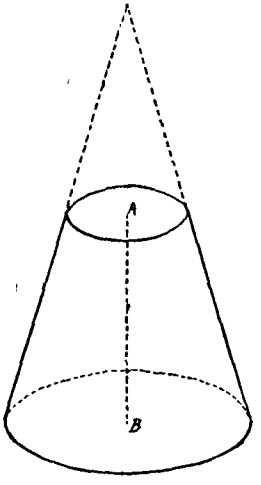


FIG. 32.

Volume of a Frustum of a Cone or Pyramid

A frustum of a pyramid or cone

is the part contained between the base and a plane parallel to the base.

The faces A, B are called the ends.

The perpendicular distance between the ends is the thickness.

Let the area of the end A be X units.

Let the area of the end B be Y units.

Let the thickness be h units.

Then $\text{volume} = \frac{1}{3}h(X + Y + \sqrt{X\,Y})$.

We find this useful in obtaining the contents of some haystacks.

A Solid Circular Ring

Let the figure represent a solid circular ring. The dotted circle, which has a radius equal to the average of the inner and outer radii of the bounding circles, is called the length of the ring.

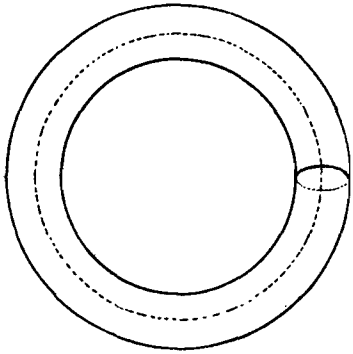


FIG. 33.

The surface and volume of a solid ring are equal to those of a cylinder whose base is the cross section and whose height is the length of the ring.

$\therefore$ Surface = circumference of cross section × length of ring.

Volume = area cross section × length of ring.

Buckets, Barrels

The volume of a bucket can be obtained approximately by finding the average diameter, then multiplying the area of the circle to which the diameter belongs by the inside height of the bucket.

The volume of a barrel can be found in the same way.

If we cannot measure the inside diameters we can get the average outside circumference and from this we get the outside diameter and allow for the thickness of the material of which the vessel is made.

Simpson's Rule

Let there be an area bounded by the straight line AP, the straight lines A*a*, P*p*, at right angles to AP and the curve *abp*.

Divide AP into any even number of equal parts AB, BC.....at B, C....., draw straight lines B*b*, C*c*,.....at right angles to AP to meet the curve. These are called ordinates.

Let I = the common interval AB.

L = sum of the extreme ordinates A*a*, P*p*.

E = sum of the even ordinates.

O = sum of the odd ordinates.

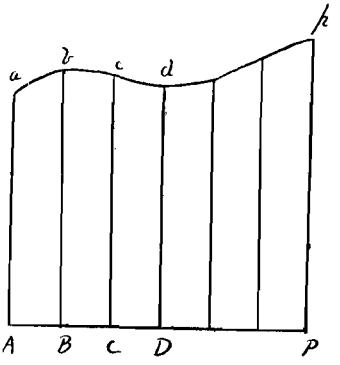


FIG. 34.

Then Simpson's rule is :—

$$\text{Area} = \frac{I}{3}(L + 4E + 2O).$$

Ex.—Suppose the lengths of the ordinates are 3, 7, 15, 8, 4 ft., and the common interval 2 ft.

$$\text{Area} = \tfrac{2}{3}(7 + 60 + 30)$$
$$= \frac{194}{3}$$
$$= 63\tfrac{2}{3} \text{ sq. ft.}$$

For the sum of the extreme ordinates = 3 + 4 = 7.
,, ,, even ,, = 7 + 8 = 15.
,, ,, odd ,, = 15.

The volume of an irregular solid of oblong shape may be

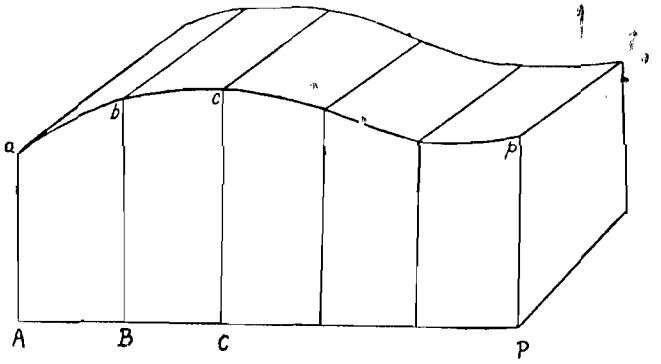


FIG. 35.

found thus: Divide the solid into several equidistant sections perpendicular to some line which measures the length of the solid; find the areas of these sections and proceed with these areas exactly as with equidistant ordinates in Simpson's rule, and the result will be the cubic contents – V.

$$\text{Or } V = \frac{I}{3}(L + 4E + 2O).$$

Where I = the common interval AB.
L = sum of the extreme areas at A and P.
E = sum of the even areas at B*b*, D*d*, etc.
O = sum of the odd areas at C*c*, E*e*, etc.

Ex.—Find the solidity of an oblong solid whose length is 200 ft. and the areas of five equidistant sections are 50, 80, 30, 90, 42 sq. ft.

Here I = 50 ft.
L = 50 + 42 = 92 sq. ft.
E = 80 + 90 = 170 sq. ft.
O = 30 sq. ft.

$$\therefore V = \frac{50}{3}(92 + 680 + 60) \text{ c. ft.}$$
$$= \frac{50}{3} \times \frac{832}{1}$$
$$= \frac{41600}{3}$$
$$= 13869\tfrac{2}{3} \text{ c. ft.}$$

The volume of earthwork over large areas of irregular depth may be found thus: Divide the surface into triangles, multiply the area of each by one-third of the sum of the vertical depths taken at the angles, add the results so obtained for all the triangles and we get an approximate value for the volume.

Grain and Root Heaps

For measuring grain in the heap, take the cubic contents in feet and multiply by ·8 to give bushels. A cubic foot is 1,728 c. in., and a bushel 2·219·7 c. in., or as 1 to 1·285; that is as ·778 (say ·8) to 1. In practice 4 bus. equal 5. c. ft.

3·64 c. ft., New Oats = 1 cwt.
2·38 ,, ,, Barley = 1 ,,
2·20 ,, ,, Wheat = 1 ,,

For measuring roots in clamp, take the cubic contents in feet, when the weight may be estimated by the use of one of the following factors :—

	Lbs. per cubic ft.	Cubic ft. per ton.
Turnips	31	72
Swedes	34	65
Mangels	35	63
Potatoes	38	59
Carrots	31	72
Parsnips	31	72

Ullage of Casks

To find the contents of a lying cask when partly full :—

Divide the depth of the liquid in inches by the bung diameter in inches, and, if the quotient is less than ·5, deduct from it one-fourth of the difference; but if the quotient exceeds ·5, add one-fourth of that excess to it, and multiply either the remainder in the former case or the sum in the latter by the whole capacity of the cask, then the product will be the contents in Imperial gallons.

To find the contents of a standing cask when partly full :—

Divide the depth of the liquid by the length of the cask, both in inches; then, if the quotient is less than ·5, subtract from it one-tenth part of the difference; but if greater than ·5, add one-tenth of its excess, and multiply the remainder in the former case and the sum in the latter by the whole capacity of the cask, then the product will represent the contents in Imperial gallons.

Gauging of Casks

Let M = the middle or bung diameter.
D = diameter at end.
l = length of cask.

For casks considerably curved :—

Capacity in Imp. gals. = $\cdot 0009442l(2M^2 + D^2)$.

For casks moderately curved :—

Capacity in Imp. gals. = $\cdot 0009442l\left\{(2M^2 + D^2) - \frac{2}{3}(M - D)^2\right\}$

For casks slightly curved :—

Capacity in Imp. gals. = $\cdot 0014162l(M^2 + D^2)$.

Hutton's rule for casks of any form :—

Capacity in Imp. gals. = $\cdot 00003147l(39M^2 + 25D^2 + 26MD)$.

EXAMPLES XIV

Volumes

An acre inch represents the amount of water required to cover an acre of ground 1 in. deep.

1. An acre contains 43,560 sq. ft. What quantity of water would cover this area to a depth of 3 in. ?

2. If there are 277·274 c. in. in 1 gal. of water, how many gallons of water will be represented by a rainfall amounting to 1·6 in. per acre ?

3. If 1 ac. in. of water equals approximately 22,622 gals.

what quantity of water per acre will be represented by a yearly rainfall of 27 in.?

4. A cord or stack of wood is 8 ft. × 4 ft. × 3 ft.; how many cubic feet does it contain?

5. Find the capacity of a liquid manure tank 9 ft. 3 in. long, 3 ft. 3 in. wide, and 3 ft. deep. (1 c. ft. of manure water = $6\frac{1}{4}$ gals.)

In estimating the contents of a dung heap it is necessary to take a number of measurements in order to strike averages.

6. Allowing a cubic yard of dung, weighing 14 cwt., to the load; how many cubic yards, and what weight of dung would be contained in a heap (Fig. 36) having the following dimensions: length 30 ft., width 15 ft.?

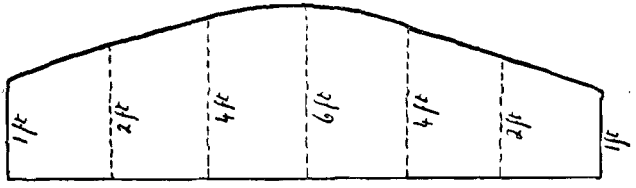


FIG. 36.

7. The cubic content of a cistern 6 ft. by 4 ft. is 20 c. ft. What is its depth?

8. What is the cost of constructing a wall 120 yds. long,) ft. 6 in. high, and 1 ft. 6 in. thick, with rough rubble stone, t 15s. 6d. per cubic yard?

9. What is the capacity of a Scotch cart the inside measurements of which are 6 ft. × $3\frac{1}{4}$ ft. × $2\frac{1}{2}$ ft.?

10. The most convenient size in which to make up lbs. of utter is $5\frac{5}{8}$ in. × $2\frac{1}{2}$ in. × $2\frac{3}{8}$ in. What would be the inside imensions of a box to take 24 lbs. in two layers?

11. In forming a bowling green it is usual to remove about in. of the subsoil in order to obtain a sunken panel or owered surface. If this depth be removed from an area of ,764 sq. yds., how many cubic yards will need to be ex-avated?

12. A man is paid 6d. per cubic yard for raising and burning clay soil. How much will he earn after having removed and burnt the soil in a 5-ac. field to a depth of 10 in.?

13. If, in laying an asphalt path, 500 yds. long and 4 ft. wide, the soil be excavated to a depth of 10 in., how many cubic yards of soil will require to be removed?

14. If, in making the above path, cement concrete is laid to a depth of 7 in., and floated over with a mixture of cement and washed road grit, or sharp sand, to a depth of 1 in., the surface being finally spread over with 2 in. of Val de Travers ground, powdered asphalt, how many cubic yards of each material will be required?

15. If, in excavating a drain, 150 rods in length, the soil is removed to a depth of 3 ft., in such a form that the top of the drain is 14 in. wide and the bottom 3 in., or a mean width of $8\frac{1}{2}$ in., what number of cubic yards of earth will be excavated from each rod?

16. If a straining post is 7 ft. 6 in. in length, and squared to 6 in., how many cubic feet of timber does it contain?

17. If standards, or intervening posts, are each 6 ft. long and $3\frac{1}{2}$ in. square, how many cubic feet of timber will be contained in 100 such posts or standards?

18. How many cubic yards of soil are required to cover an area of 3 ac. 3 r. $14\frac{1}{2}$ po. to a depth of 5 in.?

19. Assume that a square piece of ground, with a regular fall of 2 ft. in the side of 100 ft., is to be made quite level, top soiled to a depth of 5 in. and turved for a tennis lawn.

Prepare a detailed estimate of the cost, allowing 3s. per cubic yard for top soil, 10s. per 100 for turves, and 1s. 6d. per cubic yard for excavating soil on higher portion, and moving it over to level up lower portion of the site.

CHAPTER VI

THE LAND

Soils

No subject is more important to the student of agriculture than that of soils, and it is for this reason that much useful data with relation to soils has been introduced, which, if made use of by the teacher in formulating examples, will do much to impress facts on the minds of students, which are often not so readily assimilated in after years.

The importance of the mechanical as well as the chemical character of soils must not be lost sight of, while the capillarity of various soils has a very distinct bearing on their productiveness, and is an especially important factor in the preparation of seed beds. The capillarity of a soil is its power of raising water against the force of gravity. Dip the lower part of a lump of clay in water and watch.

The cost of various soil operations, excavating, transplanting, trenching, digging, and the many forms of soil tillage, are of considerable importance and involve a large expenditure, therefore any problem based on the following data will prove instructive.

Cubic Feet of Rock or Soil to weigh 1 *ton*

	Cubic feet
Clayey surface soil, when it has been compressed wet	16 to 18
,, ,, in tillage, but not recently stirred	18 ,, 20
,, ,, in a loose state	20 ,, 23
Common earth, unstirred	23 ,, 25
,, in a loose state	25 ,, 27·5
Common gravel	19 ,, 20
Dry peat	60 ,, 72
Dry sand	23 ,, 25
Gravelly clay	17 ,, 18
Grey chalk (in the solid)	13 ,, 15
Limestone	13 ,, 14

Cubic Feet of Rock or Soil to weigh 1 *ton* (continued)—

	Cubic feet
Marl	19 to 21
Rough water gravel	14 ,, 16
Sandy loam	21 ,, 22·5
Sandy soil, unstirred, wet	13 ,, 15
,, loose, wet	15 ,, 16·5
Sandstone (in the solid)	14 ,, 16
Shale	12 ,, 14
Wet peat	33 ,, 36
Wet sand	17 ,, 19

Comparative, Absorptive, Evaporative, and Hygroscopic Power of Soils

	Specific Gravity.	Water held per Cubic Foot in lbs.	Per cent. of Water absorbed by 100 parts of each Earth.	Per cent. of Water evaporated in 4 hours at 60° F.	Hours required to evaporate 90 per cent. of the Water.	Per cent. absorbed from Damp Air at 62° in 12 hours.
Silicious sand	2·65	27·3	25	88	4·6	0·0
Calcareous sand	2·64	31·8	29	76	4·7	0·3
Sandy clay	2·60	38·8	40	52	5·1	2·1
Strong clay	2·56	40·4	50	46	6·9	2·5
Loamy arable soil	2·40	40·8	52	46	7·8	3·0
Garden soil	2·33	48·4	89	32	11·2	3·5
Humus	1·37	50·1	190	21	17·5	8·0

Estimated Percentage of Elementary Substances in the Earth's Crust

1. Silica	53·0
2. Alumina	19·0
3. Lime	6·3
4. Magnesia	5·8
5. Soda	2·5
6. Potash	2·4
7. Carbonic anhydride 8. Iron oxides 9. Sulphuric anhydride 10. (Chlorides)	7·5
11. Other bodies	3·5
	100·0

Soil Temperature

The daily range of temperature affects soil only to a depth of 3 ft. The annual range penetrates 40 ft., but has little influence beyond 25 ft. The summer heat reaches 24 ft. deep at 4th January, the winter cold at 13th July, thus reversing the seasons. At 3 ft. deep the mean summer temperature is 57° F., mean winter temperature 37° F.

The average annual mean at 3 ft. is 45·8
,, ,, 6 ft. ,, 46·1
,, ,, 12 ft. ,, 46·4
,, ,, 24 ft. ,, 46·9

Proximate Constituents of a Typical Loam Soil

Sand, 50 per cent.
Clay, 25 per cent.
Calcic carbonate, 2 per cent.
Moisture (hydroscopic), 3 per cent.
Vegetable matter (humus), 5 per cent.
Gravel, 5 per cent.

Classification of Soils

Sandy	Under 10 per cent.	of clay.	
Sandy loam	10 to 20	,,	,,
Loam	20 ,, 30	,,	,,
Clay loam	30 ,, 50	,,	,,
Strong clay	over 50	,,	,,
Marly	5 to 20	,,	of calcic carbonate.
Calcareous	over 20	,,	,,
Humus	,, 5	,,	of vegetable matter.

Power of Soils to contain Water

	A Cubic Foot of Soil Weighs		A Cubic Foot of Wet Earth contains of Water
	In the Dry State.	In the Wet State.	
	Lbs.	Lbs.	Lbs.
Silicious sand	111·3	136·1	27·3
Calcareous sand	113·6	141·3	31·8
Sandy clay	97·8	129·7	38·8
Loamy clay	88·5	124·1	41·4
Pure grey clay	75·2	115·8	48·3
Humus	34·8	81·7	50·1
Garden mould	68·7	102·7	48·4

The Analysis of a Typical Loam is as follows :—

Insoluble silicates and sand	81·26
Alumina	3·58
Lime	1·23
Magnesia	1·12
Soda	1·20
Potash	0·80
Carbonic anhydride	0·92
Ferric oxide	3·41
Sulphuric anhydride	0·09
Chlorine	trace
Phosphoric anhydride	0·38
Organic matter and water of combination	5·66

Composition of an average Clay Soil (Air-dried)

Moisture	6·50 per cent.
Organic matter	9·00 ,,
Nitrogen	0·27 ,,
Phosphoric acid	0·12 ,,
Potash	1·10 ,,
Calcium carbonate	0·35 ,,
Magnesia	2·00 ,,
Alumina	9·00 ,,
Iron oxide	6·2 ,,
Oxide of manganese	0·15 ,,
Sulphuric acid	0·07 ,,
Chlorine	0·01 ,,
Phosphoric acid, soluble, 1 per cent. citric acid	0·012 ,,
Potash, soluble, 1 per cent. citric acid	0·026 ,,

In some experiments at Harpenden the following results were obtained regarding soil temperatures at various depths, on hoed and untouched plots. Readings are in degrees Centigrade.

Air Temperature.	Soil Temperatures. Depth.	Untouched.	Hoed Once Weekly.	Hoed Three Times Weekly.	Date.
					1910.
30°	½ in.	35·0°	31·5°	31·5°	20th June
	3 in.	30·5°	29·8°	28·8°	
	6 in.	27·0°	26·5°	24·0°	
18°	½ in.	17·5°	17·0°	17·0°	27th June
	3 in.	16·7°	16·3°	16·2°	
	6 in.	15·8°	15·5°	15·5°	

Similar experiments with grass land and bare land resulted as follows :—

Soil Temperatures.			Date.
Depth.	Grass Land.	Bare Land.	
			1910.
½ in.	13·0°	17·5°	24th Sept.
3 in.	12·5°	12·5°	
6 in.	12·5°	12·25°	
½ in.	15·5°	17·0°	5th Oct.
3 in.	15·0°	16·7°	
6 in.	14·5°	15·5°	

A man will dig and fill into carts or barrows the following quantities, in a day of ten hours :—

Sand	12 cub. yds.
Earth (easily got)	11 ,,
Strong clay	9 ,,
Hard earth or chalk	7 ,,
Soft stone	4 ,,
Hard stone	2 ,,
Very hard stone	1 ,,

French Garden

In the making of a French garden, one half acre will require 400 frame lights and about 1,500 cloches or bell jars for forcing, entailing a capital expenditure of about £320, while the cost of the pure horse manure required per annum will run to an additional £100.

Turfing and Seeding Lawns

Two methods are adaptable to the formation of lawns, turfing or seeding. In the former case the cost is about £100 per acre, whereas seeding will cost, say, £11 per acre according to the quantity of seed used; without including the cost of preparing the ground in either case.

Marl and Gravel Pits

Chalk and clay marls, when prevalent, are largely used for soil improvement, having a manurial value, in addition to altering the mechanical texture of the soils to which they are applied.

In excavating marl, clay, and gravel pits the sides are sloped, so as to prevent the upper edges from falling in.

Gravel is in continuous demand for road-making, and, as with marl or clay, excavations assume various shapes.

To find how many cubic yards have been dug out of a gravel pit, when the top and bottom of the pit are rectangular, in which case the pit is regarded as a prismoid.

RULE.—To the sum of the areas of the top and bottom, add four times the area of a section half-way between them; multiply this sum by the mean perpendicular depth, and one-sixth of the product will be the solidity.

NOTE.—When the sides and ends are regularly sloped, the length of the middle section will be equal to half the sum of the lengths of the top and bottom, and its breadth equal to half the sum of their breadths. Should the inclination of the sides and ends be not regular, the length and breadth of the middle section must be found by actual measurement. A mean depth will be found by taking several depths, at equal distance from each other, and dividing their sum by their number.

EX.—A gravel pit measures 172·7 ft. in length, and 43·5 ft. in breadth at the top; the length of the middle section is 132·2 ft. and it is 42·6 ft. in breadth. How many cubic yards of gravel will be dug out of the pit, its mean perpendicular height being 14·4 ft.? (*Ans.* 3,010 c. yds. nearly.)

Earthworms

Darwin estimated the number of earthworms in an acre of garden soil at 53,000, and it has been found that the amount of soil brought up by them and deposited in a fine state amounted to 7·453 lbs. per square yard. What quantity of soil would this represent per acre? (*Ans.* 322 cwt. nearly.)

If the amount of soil brought up by earthworms in ten years is sufficient to cover an acre of ground with a uniform layer 1·4 in. deep, how long would it take to cover the surface to a depth of 1 ft.? (*Ans.* $85\frac{5}{7}$ years.)

Draining

The advantages of draining water-logged soils are very considerable from the point of view of the cultivator. As soon as heavily saturated soils are relieved of excessive moisture the temperature at once rises.

Certain aquatic and semi-aquatic plants take up their abode on wet, undrained land, but after draining these plants soon disappear, and give place to others of a more useful character.

The warmer the soil the earlier will crops mature, a matter of very great importance to market gardeners, as the fact of a certain crop being placed early on the market may have the effect of more than doubling its value.

The operation of drainage is an expensive one, sunk drains necessitating the use of pipes costing considerably more than open drains. The latter, however, have the disadvantage of taking up valuable space that could be more profitably occupied by plants, in addition to making harvest operations more difficult to perform, the risk of breaking machines also being increased.

A drain is an artificial channel either below or on the surface of the ground, for the conveyance of water from marshes, bogs, or other water-logged or low-lying ground, and thereby rendering them adaptable for the cultivation of arable crops.

Drains are made with sloping sides and are almost invariably dug by the cubic yard, hence the necessity of ascertaining their contents with accuracy.

The ordinary method of measuring them is to take the breadths at the top and bottom in different places, and their sum being divided by their number, the quotient is considered as a mean breadth.

Several depths are similarly measured in different places, and their sum divided by their number is taken as a mean depth. Then the length, breadth, and depth being multiplied together, the last product is taken for the content; but it is evident that the process must lead to somewhat erroneous results.

Table showing Cost of Land Drainage per Acre

	Distance of Drains Apart.	Depth of Drains.	Rods per Acre.	Cost per Rod Cutting and Filling.	Cost per Acre Cutting and Filling.	Number 12-inch Drain Pipes required per Acre.	Cost of Drain Pipes at 30s. per 1,000.	Total Cost of Drainage per Acre.
	Feet.	Ft. In.	No.	*d.*	£ *s.* *d.*	No.	£ *s.* *d.*	£ *s.* *d.*
Light gravelly loam	33	3 6	80	10	3 6 8	1,320	1 19 7	5 6 3
Light marly loam	36	3 9	72	9	2 14 0	1,210	1 16 4	4 10 4
Sandy loam	39	4 0	68	7½	2 2 6	1,117	1 13 6	3 16 0
Soft light loam	42	4 0	62	7	1 16 2	1,037	1 11 1	3 7 3
Coarse gravelly sand	60	4 6	44	12	2 4 0	726	1 1 9	3 5 9
Loose gravelly sand	66	4 6	40	10	1 13 4	660	0 19 10	2 13 2
Friable loam	30	3 3	88	7	2 11 4	1,452	2 3 6	4 14 10
Gravelly loam	27	3 3	98	8	3 5 4	1,613	2 8 5	5 13 9
Medium loam	24	3 0	110	6	2 15 0	1,815	2 14 6	5 9 6
Clay loam	21	3 0	125	6	3 2 6	2,074	3 2 4	6 4 10
Free soft clay	21	3 0	125	5	2 12 1	2,074	3 2 4	5 14 5
Friable clay	18	2 9	147	5½	3 7 4	2,420	3 12 7	6 19 11
Stiff adhesive clay	16½	2 6	160	7	4 13 4	2,640	3 19 2	8 12 6
Tenacious gravelly clay	15	2 6	176	8	5 17 4	2,904	4 7 0	10 4 4

Pipe Drains

The underdraining of agricultural land is best and most economically effected by drain pipes. The sizes of the pipes used are governed by the length and depth of the drains, the rate of fall, distance between the drains, porosity of soil, rainfall, and whether the ground contains springs of water.

The great bulk of the water enters the pipes at the joints, which rarely exceed one-tenth of an inch on the whole circumference. With 2-in. pipes this would represent an opening equal to six-tenths of a square inch, so that in 100 yds. length of drain composed of pipes 12 in. long there would be 300 such openings, thereby accounting for a total inlet area of about 200 sq. in.

2-in. pipes are generally used for minor drains not exceeding 12 to 15 ch. in length; while the main drain pipes vary from 3 to 6 in.

The size of the main pipes may, for ordinary drainage, be calculated from the following formula:—

a = number of minor drains.

b = diameter of minor drain pipes.

x = size of main drain pipes.

$$\text{Then } x = \sqrt{a} \times \tfrac{1}{2}b.$$

Ex.—Required the size of a main drain pipe to carry 25 2-in. drains.

Then $a = 25$.
$b = 2$ in.
x = size of main drain pipes.

$$x = \sqrt{a} \times \tfrac{1}{2}b$$
$$= \sqrt{25} \times \tfrac{1}{2} \times 2$$
$$= \sqrt{25}$$
$$= 5 \text{ in. size of main drain pipe.}$$

The relation of the diameter, length, and fall of a drain to the amount of water it is capable of discharging may be computed by the aid of the following formula:—

$$\text{velocity of discharge } v = 48\sqrt{\frac{df}{1+54d}}$$

$$\text{Quantity of discharge } Q = 48a\sqrt{\frac{df}{1+54d}}$$

Where v = velocity of discharge in feet per second.
d = diameter of drain in feet.
f = total fall of drain in feet.
a = area of cross section of drain.
Q = discharge in cubic feet per second.

The formula for calculating the discharge of water in gallons per minute through straight, or nearly straight, long lengths of circular smooth pipes is as follows :—

d = distance of pipes in inches.
y = length in yards.
h = head in feet.

$$\text{Then discharge} = 17{\cdot}03\sqrt{\frac{5dh}{y}}.$$

Ex.—If drains 3 ft. deep, width at top 14 in., width at bottom 3 in., and a mean width of $8\frac{1}{2}$ in. amount in total length to 5,740 ch.; what is the total amount of earth excavated? (*Ans.* 29,816 c. yds. nearly.)

To obtain size of Main Pipes

Multiply the square root of the number of small drains (of fair average length) by the diameter of small pipes; this gives the diameter of main.

Thus, if N = number of small drains.
D = diameter of small pipes.
M = diameter of main.

$$\text{Then } M = \sqrt{N} \times D.$$

Examples

What is the total cost of laying 146 rods of drains, 18 ft. apart and 3 ft. deep, from the following estimate?—

Labour of cutting and filling at 6d. per rod.
Drain pipes at 25s. per 1,000.
Haulage at 3s. per 1,000.
Pipe laying and finishing at 1d. per rod.
Extra for mains, 2s. 6d.
Iron outlet pipes and masonry, 1s. 6d.
Superintendence, 5s.

(*Ans.* £8. 1s. 8d.)

What is the cost per acre of draining a clay soil, the pipes being laid at a depth of 2 ft. 6 in., and 15 ft. apart? (*Ans.* About £14.)

If on loose gravelly soil drains are placed at a depth of 4 ft. 3 in., on friable loam 3 ft. 6 in., on clayey loam 3 ft., and on stiff adhesive clay 2 ft. 6 in., what is the average depth at which these drains are placed? (*Ans.* 3 ft. 4 in. nearly.)

What number of 12-in. drain pipes will be required to drain an acre of ground, the drains being set 24 ft. apart or equal to a total length of 110 rods per acre; and what would be the cost of the pipes at 30s. per 1,000? (*Ans.* 1,815; £2. 14s. 6d.)

Given the following particulars, what will be the cost of draining a 5-ac. field, the subsoil consisting of clayey loam? Distance of drains apart, 21 ft. (equal to 125 rods per acre); depth of drains, 3 ft.; cost per rod of cutting and filling, 6½d.; and cost of pipes, 30s. per 1,000. (*Ans.* £31. 8s. 2d.)

If on loose gravelly soil drains are placed 60 ft. apart, on friable loam 30 ft. apart, on clayey loam 21 ft. apart, and on stiff adhesive clay 16 ft. apart, what is the average distance apart? (*Ans.* 32 ft. nearly.)

Pipe Drains.—Pipes of various shapes and sizes are used, but the cylindrical form is considered best.

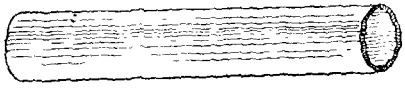


FIG. 37.

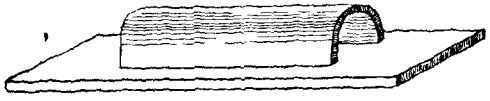


FIG. 38.

In section, the bottom should be just wide enough to receive the pipes. Pipe drains are undoubtedly the most efficient and cheapest form of drain.

In all forms of drains the excavation should be reduced to a minimum. The average dimensions for a depth of 3 ft. are: Width at top 14 in., width at bottom 3 in., and a mean width of $8\frac{1}{2}$ in. These dimensions require 1 to 3 c. yds. of earth to be excavated for each rod of drain.

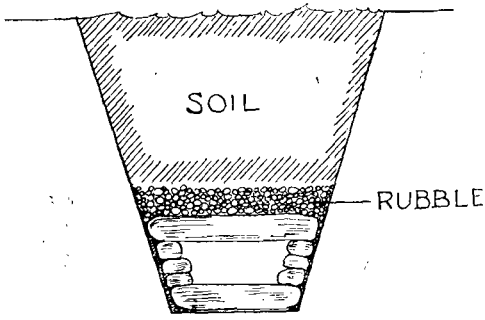


FIG. 39.

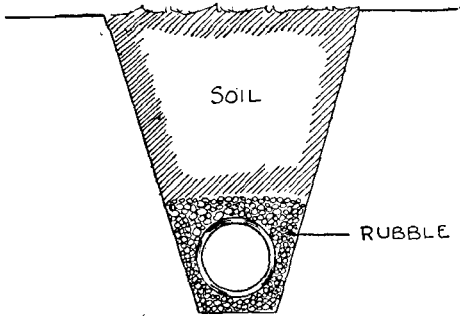


FIG. 40.

The distance apart at which drains are laid varies greatly according to the porosity of the soil. A drain laid in a clay soil will draw from 2 to 3 times its own depth on each side of it, while in a good sandy loam it will draw from 5 to 6 times its own depth. How many feet, therefore, would a drain 2 ft. 6 in. deep in a clay soil draw; and one 3 ft. 6 in. deep, in a good sandy loam?

To obtain the number of small pipes required per acre divide the number of square feet per acre by the distance apart in feet of the drains to be laid; this gives the number of pipes 1 ft. long required per acre.

What number of pipes 14 in. long per acre would be required for drains 18 ft. apart? (*Ans.* 2,075.)

It is estimated that where thorough drainage is practised, tile drains will remove from the soil quite $\frac{1}{4}$ in. of water per day. Allowing nothing for evaporation how many inches of

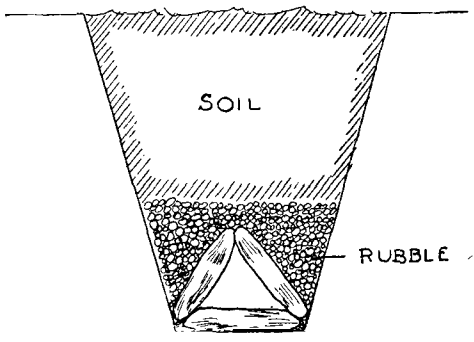


FIG. 41.

water would this represent per month, and what would be the weight of same per acre? (*Ans.* 7 in.; 707·7 tons.)

Table of Rainfall

Inches of Depth.	Cubic Feet per Acre.	Tons per Acre.	Imperial Gallons per Acre.
1	3,630	101·1	22,635
5	18,150	505·5	113,174
10	36,300	1011·0	226,349
12	43,560	1213·2	271,619
24	87,120	2426·4	543,238
28	101,640	2830·8	633,777
34	123,420	3437·4	769,587
38	137,940	3841·8	860,126

Manures

Plant food or manure is required for the growth of all plants, but plants under cultivation usually demand that the soil be enriched by the addition of humus or organic matter, preferably the excrements of the various farm animals. Where the requisite amount of manure from this source is not available, "artificial," or concentrated manures, having an organic or mineral origin, are substituted, preferably in conjunction with farmyard manure.

Root crops will usually admit of intensive cultivation, thereby demanding large applications of manurial ingredients, while, on the other hand, if any attempt is made to overfeed cereal and leguminous crops, considerable harm may be done and the quality and value of the produce seriously affected.

The essential plant foods most deficient in soils, and which crops are continually removing, are nitrogen, phosphoric acid, and potash. The form in which these ingredients are supplied depends largely upon the variety and character of the crop grown, also the chemical and physical property of the soil under consideration.

On p. 139 the quantities of manure ordinarily applied to the various crops are shown.

In arranging for manurial demonstrations in schools for the purpose of demonstrating to students the action of special manures, nothing is more appropriate than the "Eight Plot System" as follows:—

Plot 1. No manure (for comparison).
" 2. 1 cwt. nitrate of soda.
" 3. 5 " superphosphate.
" 4. 3 " kainit.
" 5. 1 " nitrate and 5 cwt. superphosphate.
" 6. 1 " nitrate and 3 cwt. kainit.
" 7. 5 " superphosphate and 3 cwt. kainit.
" 8. 1 " nitrate, 5 cwt. superphosphate, and 3 cwt. kainit.

The quantities mentioned above are at rate per acre. The test may be carried out with any nitrogenous manure (*e.g.*, nitrate of soda or sulphate of ammonia), with any phosphatic manure (*e.g.*, superphosphate or basic slag), and with any potassic manure (*e.g.*, kainit or sulphate of potash).

When the crop is mature the effects of the nitrate may be ascertained as follows:—

Compare plots 1 and 2 for the result of using nitrates alone.

Compare plots 3 and 5 for the result of using nitrates with superphosphate.

Compare plots 4 and 6 for the result of using nitrates with kainit.

Compare plots 7 and 8 for the result of using nitrates with both superphosphate and kainit.

Similar information is found for superphosphate by taking the plots as follows: 1 and 3, 2 and 5, 4 and 7, 6 and 8; and for kainit by taking plots 1 and 4, 2 and 6, 3 and 7, 5 and 8. By omitting three plots (2, 3, 4) and having only five (1, 5, 6, 7, 8) serviceable information will also be obtained for many practical purposes, for the test will show the effect of:—

1st. Using a general mixture (by comparing plots 1 and 8).

2nd. Of omitting nitrogen (by comparing plots 8 and 7).

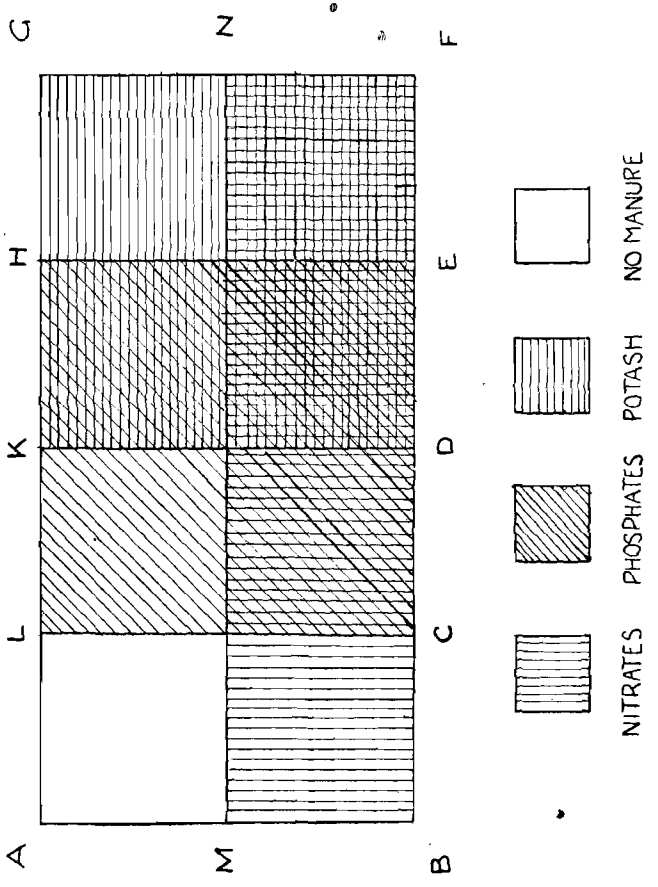
3rd. Of omitting phosphate (by comparing plots 8 and 6).

4th. Of omitting potash (by comparing plots 8 and 5).

The accompanying table gives the various equivalent dressings of manure:—

Quantity of Manure per Acre.	Equivalent Quantity.		
	Per Rood.	Square Rod or Perch.	Square Yard (approximate).
Cwt.	Lbs.	Lbs.	Oz.
1	28	$\frac{3}{4}$	$\frac{3}{8}$
2	56	$1\frac{1}{2}$	$\frac{3}{4}$
4	112	$2\frac{3}{4}$	$1\frac{1}{2}$
6	168	$4\frac{1}{4}$	$2\frac{1}{4}$
8	224	$5\frac{1}{2}$	3

Diagram to illustrate the "Eight Plot System"



The nitrate is sown uniformly over M N F B.
,, phosphate ,, ,, L H E C.
, potash ,, ,, G K D F.

The Valuation of Artificial Manures

The "unit" may be taken to be one per cent. (1 %) or the hundredth part of a ton of the valuable substance in a manure.

RULE.—To find the value of a unit divide the price per ton by the percentage composition of the manure.

NITROGENOUS MANURES

1. Sulphate of ammonia costs, say, £12. 10s. a ton, and contains 25 per cent. of ammonia; therefore the price of a unit of ammonia is - - - - $\frac{\text{£12. 10s.}}{25} = 10\text{s.}$

Or in terms of nitrogen - - - $\frac{\text{£12. 10s.}}{20} = 12\text{s. } 6\text{d.}$

because 17 parts of ammonia contain 14 of nitrogen.

2. Nitrate of soda costs, say, £10. 10s. a ton, and contains 15·5 per cent. of nitrogen; therefore the price of a unit of nitrogen is - - - - - $\frac{\text{£10. 10s.}}{15{\cdot}5} = 13\text{s. } 6\text{d.}$

Or in terms of ammonia - - - $\frac{\text{£10. 10s.}}{18{\cdot}8} = 11\text{s. } 2\text{d.}$

3. Nitrate of lime costs, say, £9. 10s. a ton, and contains about 14 per cent. nitrogen; therefore the price of a unit of nitrogen is - - - - - $\frac{\text{£9. 10s.}}{14} = 13\text{s. } 7\text{d.}$

Or in terms of ammonia - - - $\frac{\text{£9. 10s.}}{17} = 11\text{s. } 2\text{d.}$

4. Calcium cyanamide, or nitrolim, London guaranteed grade, contains 20 per cent. nitrogen, and costs, say, £11. 15s. a ton; therefore the price of a unit of nitrogen $= \frac{\text{£11. 15s.}}{20} = 11\text{s. } 9\text{d.}$

Or in terms of ammonia - - - $\frac{\text{£11. 15s.}}{24{\cdot}3} = 9\text{s. } 8\text{d.}$

PHOSPHATIC MANURES

5. Superphosphate, 35 per cent. soluble phosphate, costs, say, £3. 5s. per ton; therefore the price of a unit of soluble phosphate is - - - - - - $\frac{\text{£3. 5s.}}{35} = 1\text{s. } 10\text{d.}$

6. Bone meal containing 5 per cent. ammonia and 50 per cent. insoluble phosphate costs, say, £5. 10s. per ton. Valuing the ammonia at 10s. per unit, we get 10s. × 5 = £2. 10s.; therefore the value of the insoluble phosphate is the difference between £5. 10s. and £2. 10s. = £3, and the price of a unit of insoluble phosphate - - - - - = $\frac{£3}{50}$ = 1s. 2d.

7. Dissolved bones contain 4 per cent. ammonia × 10s. = £2 0 0
20 per cent. soluble phosphate × 2s. 10d. - - = 2 16 8
and 14 per cent. insoluble phosphate × 1s. 2d. - = 0 16 4

£5 13 0

Dissolved bones should be guaranteed to be "made from raw bones and acid only." The soluble phosphate in dissolved bones is usually valued at 1s. per unit more than in superphosphate, although chemically speaking it is exactly the same thing.

Potash Manures

8. Kainit containing 12·5 per cent. potash costs, say, £2. 5s. a ton; therefore the price of a unit of potash is $\frac{£2.\ 5s.}{12·5}$ = 3s. 7d.

9. Sulphate of potash containing 90 per cent. pure sulphate and 50 per cent. potash costs, say, £10 a ton; therefore the price of a unit of potash - - - - = $\frac{£10}{50}$ = 4s.

Manure Values

The approximate Unit Values of Fertilising Constituents are as follows:—

	Peruvian Guano.			Nitrate of Soda.	Sulphate of Ammonia.	Nitrolim.	Nitrate of Lime.	Bone Meal.	Superphosphate.	Basic Slag.	Bone Compound.	Kainit.	Sulphate of Potash.	Muriate of Potash.	Special Manure.
	Raw or Equalised.	Phosphatic.	Dissolved (soluble).												
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Ammonia, organic, in guano and bones	16 0	12 6	15 0	...	...	...	...	14 6	...	...	15 0	...	...	...	14 0
,, in sulphate of ammonia	...	..	...	...	10 9	...	...	...	...	...	...	...	...	...	12 6
,, calculated from nitrogen	...	...	...	10 0	...	10 0	10 0	...	...	...	...	...	...	...	...
Phosphate, soluble in water	...	...	2 0	...	...	...	...	...	2 0	...	2 0	...	...	...	2 0
,, insoluble, from organic	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...
,, source as in guano, bones, etc.	1 3	1 2	1 3	...	...	...	...	1 3	...	...	1 3	...	...	...	1 3
,, soluble in citric acid	...	...	...	...	...	...	...	...	...	1 7	...	...	...	...	...
,, total in basic slag	...	...	...	...	...	...	...	...	..	1 3	...	...	...	...	...
Potash (pure)	4 0	4 0	4 0	...	...	...	...	.	...	...	...	3 10	4 4	...	4 6

What is the value of sulphate of ammonia containing 19·8 per cent. of ammonia?

What is the value of basic slag containing 30·8 per cent. insoluble phosphate?

What is the value of bone meal containing 4·60 per cent. nitrogen, 44·7 per cent. insoluble phosphate?

What is the value of a special mangel manure containing 3·70 per cent. nitrogen, 12·5 per cent. soluble phosphates, 1·15 per cent. insoluble phosphate?

Answers to Manure Values

Sulphate of ammonia = 19·8 × 10s. 9d. = £10. 13s. nearly.

Basic slag = 30·8 × 1s. 3d. = £1. 18s.

Bone meal = 14·6 × 4s. 6d. + 1s. 3d. × 44·7 = £6. 2s. nearly.

Special manure = 3·7 × 14s. + 12·5 × 2s. + 1·75 × 1s. 3d. = £3. 11s.

The following are estimated to be the manurial constituents per 1,000 parts of the various farmyard manures:—

	Cattle.		Horse.		Sheep.		Pig.	
	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.
Water - -	838·0	938·0	757·0	901·0	675·0	872·0	820·0	967·0
Nitrogen - -	2·9	5·8	4·4	15·5	5·5	19·5	7·0	4·3
Potash - -	1·0	4·9	3·5	15·0	1·3	22·6	2·6	8·3
Phosphoric acid	1·7	...	3·5	...	3·1	...	4·1	0·7

What quantity of each of these constituents is there in 1 ton of each of the different manures?

Food.	Valuation per Ton as Manure.								Compensation Value for each Ton of the Food consumed.	
	Nitrogen.			Phosphoric Acid.			Potash.			
	Per cent. in Food.	Value at 12s. per unit.	Half value to Manure.	Per cent. in Food.	Value at 3s. per unit.	Three-fourths value to Manure.	Per cent. in Food.	Value at 4s. per unit.	Last Year.	Second Year.
		s. d.	s. d.		s. d.	s. d.		s. d.	s. d.	s. d.
Barley	1·65	19 10	9 11	0·75	2 3	1 3	0·55	2 2	13 9	6 10
Beans	4·00	48 0	24 0	1·10	3 4	2 6	1·30	5 2	31 8	15 10
Bran	2·50	30 0	15 0	3·60	10 10	8 2	1·45	5 9	28 11	14 5
Brewers' grains (dried)	3·39	39 7	19 9	1·61	4 10	3 8	0·20	0 10	24 3	12 1
,, ,, (wet)	0·81	9 9	4 11	0·42	1 3	0 11	0·05	0 2	6 0	3 0
Clover hay	2·40	28 10	14 5	0·57	1 9	1 4	1·50	6 0	21 9	10 10
Cocoanut cake	3·40	40 10	20 5	1·40	4 2	3 1	2·00	8 0	31 6	15 9
Cotton cake (undecort.)	3·54	42 6	21 3	2·00	6 0	4 6	2·00	8 0	33 9	16 10
,, ,, (decort.)	6·90	82 10	41 5	3·10	9 4	7 0	2·00	8 0	56 5	28 2
Linseed	3·60	43 2	21 7	1·54	4 7	3 5	1·37	5 6	30 6	15 3
Linseed cake	4·75	57 0	28 6	2·00	6 0	4 6	1·40	5 7	38 7	19 3
Locust beans	1·20	14 5	7 2	0·80	2 5	1 10	0·80	3 2	12 2	6 1
Maize	1·70	20 5	10 2	0·60	1 9	1 4	0·37	1 6	13 0	6 6
Malt	1·82	21 10	10 11	0·80	2 5	1 10	0·60	2 5	15 2	7 7
Malt culms	3·90	46 10	23 5	2·00	6 0	4 6	2·00	8 0	35 11	17 11
Mangels	0·22	2 8	1 4	0·07	0 3	0 2	0·40	1 7	3 1	1 6
Meadow hay	1·50	18 0	9 0	0·40	1 2	0 11	1·60	6 5	16 4	8 2
Oats	2·00	24 0	12 0	0·60	1 10	1 5	0·50	2 0	15 5	7 8
Palm-nut cake	2·50	30 0	15 0	1·20	3 7	2 8	0·50	2 0	19 8	9 10
Peas	3·60	43 2	21 7	0·85	2 7	1 11	0·96	3 10	27 4	13 8
Rape cake	4·90	58 10	29 5	2·50	7 6	5 8	1·30	6 0	41 1	20 6
Rice meal	1·90	22 10	11 5	0·60	1 9	1 4	0·37	1 6	14 3	7 1
Straw—										
Barley	0·40	4 10	2 5	0·18	0 6	0 4	1·00	4 0	6 9	3 4
Oat	0·50	6 0	3 0	0·24	0 9	0 7	1·00	4 0	7 7	7 9
Wheat	0·45	5 5	2 8	0·24	0 9	0 7	0·80	3 2	6 5	3 2
Swedes	0·25	3 0	1 6	0·06	0 2	0 1	0·22	0 11	2 6	1 3
Turnips	0·18	2 2	1 1	0·05	0 2	0 1	0·30	1 2	2 4	1 2
Wheat	1·80	21 7	10 9	0·85	2 7	2 0	0·53	2 1	14 10	7 5

The cost per lb. of the various manurial constituents is approximately as follows :—

Nitrogen	6½d. per lb.
Phosphoric acid	1½d. ,,
Potash	2¼d. ,,

A horse produces 12 tons of manure in the year.

An ox fed in loose box produces from 20 to 30 c. yds. of dung per year, according to the quantity of litter given.

The amount of farmyard manure made during the winter months in the homestead, where there is a fair allowance of litter, will amount to about 6 to 8 tons per head of live stock of all kinds.

A cubic yard of farmyard manure in the heap weighs from 12 to 16 cwt.

1 ton of farmyard manure may contain :—

Nitrogen	9 to 15 lbs.
Potash	9 ,, 15 ,,
Phosphoric acid	4 ,, 9 ,,

Solid and Liquid Manure produced by Stock per Annum

	Solid.	Liquid.
Horse	12,000 lbs.	4,000 lbs.
Cow	20,000 ,,	8,000 ,,
Sheep	760 ,,	380 ,,
Pig	1,800 ,,	1,200 ,,

Heiden found that the average of thirty cattle was 88 lbs. solid and 21 lbs. liquid, total 109 lbs. manure daily.

Weights of Manures per Bushel

Guano	65 lbs.
Bone superphosphate	74 ,,
Mineral ,,	66 ,,
Nitrate of soda	87 ,,
Sulphate of ammonia	60 ,,
Kainit	82 ,,
Slag phosphate	147 ,,
Lime (average)	90 ,,
Gas lime	62 ,,
Nitrate of lime	28 ,,
Calcium cyanamide	58 ,,

Manures to Apply per Acre

Sulphate of ammonia	1 to 1½ cwt.
Nitrate of soda	1 ,, 1½ ,,
Sulphate of potash	1½ ,, 2 ,,
Muriate of potash	1½ ,, 2 ,,
Kainit	3 ,, 5 ,,
Superphosphate	3 ,, 5 ,,
Basic slag	4 ,, 6 ,,
Salt	1 ,, 2 ,,
Soot	30 ,, 40 bus.

Plant Foods Removed by Crops in Lbs. per Acre

Crop.	Weight of Crop (approximate) Lbs. per Acre.	Quantities removed in Lbs. per Acre.			
		Nitrogen.	Potash.	Phosphoric Acid.	Lime.
Hay	3,300	47	51	12	32
Mangels	67,500	149	300	53	43
Oats	4,800	52	46	19	12
Swedes	36,000	98	80	22	42
Wheat	5,000	50	28	22	9

Analysis of an Average Sample of Fresh Dung

Organic matter	16·58 per cent.
Dry matter	22·49 ,,
Nitrogen, total	·439 ,,
,, insoluble	·317 ,,
,, soluble proteid	·022 ,,
,, ammoniacal	·065 ,,
,, nitrate and amide	·035 ,,
Potash, total	·435 ,,
,, soluble	·330 ,,
Phosphoric acid, total	·271 ,,
,, ,, soluble	·138 ,,

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Muriate of potash	1½ ,, 2 ,,
Kainit	3 ,, 5 ,,
Superphosphate	3 ,, 5 ,,
Basic slag	4 ,, 6 ,,
Salt	1 ,, 2 ,,
Soot	30 ,, 40 bus.

Plant Foods Removed by Crops in Lbs. per Acre

Crop.	Weight of Crop (approximate) Lbs. per Acre.	Quantities removed in Lbs. per Acre.			
		Nitrogen.	Potash.	Phosphoric Acid.	Lime.
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,, soluble	·330 ,,
Phosphoric acid, total	·271 ,,
,, ,, soluble	·138 ,,

Composition of Animal Excreta

	Water.	Organic Matter.	Nitrogen	= Ammonia.	Phosphoric Anhydride	= Tricalcic Phosphate.	Potash.	Lime.	Silica.
Fresh farmyard manure with straw	...	...	...	...	...	...	...	...	...
,, cow ,, ,,	75·5	20·3	0·34	0·41	0·16	0·34	0·40	0·31	0·85
,, horse ,, ,,	71·3	25·4	0·58	0·10	0·28	0·61	0·53	0·21	1·77
,, pig ,, ,,	72·4	25·0	0·45	0·54	0·19	0·41	0·60	0·08	1·08
,, sheep ,, ,,	64·6	31·8	0·83	1·00	0·23	0·50	0·67	0·33	1·47
Mixed farmyard manure, fresh	75·0	21·2	0·39	0·47	0·18	0·39	0·45	0·49	1·08
,, ,, ,, rotted	75·0	19·2	0·50	0·60	0·26	0·56	0·63	0·70	1·68
Peat moss manure	70·9	25·5	0·56	0·68	0·40	0·87	0·54	0·61	1·69
Liquid manure (drainings)	98·2	0·7	0·15	0·18	0·01	0·02	0·49	0·03	0·02
Night soil, solid and liquid	93·5	51·1	0·70	0·85	0·26	0·56	0·21	0·09	0·10
,, dried	11·5	37·4	1·80	2·18	0·24	0·52	1·10	7·20	0·20
Urine of cow	92·0	6·0	0·8	0·97	0·70	1·52	0·60	0·07	0·01
,, horse	89·0	8·0	1·2	1·45	1·20	2·62	0·60	0·04	0·02
,, pig	97·5	1·5	0·3	0·36	1·25	2·72	0·06	0·02	trace
,, sheep	86·5	9·9	1·4	1·70	0·50	1·09	0·60	0·30	trace

Seeds

Seeds possessing, as they do, great variation in size, form, and colour may be put to a variety of purposes in school. Those of larger size such as beans, maize, marrows, etc., may even be made to represent different money values, and so provide younger children with demonstrations in practical arithmetic, including addition, subtraction, multiplication, division, etc.

Seeds, if sound and properly ripened, will germinate when supplied with an adequate amount of heat, air, and moisture, in keeping with their requirements. Seeds, however, often fail to germinate, among the chief reasons being that many are imperfectly developed and matured, or their vitality is weakened owing to improper storage.

The purity of samples is another point deserving attention, as any seeds foreign to the sample—as, for example, weed seeds, seeds of other plants, or varieties different in character to the true type of the seed purchased—must be regarded as an impurity or an adulteration. Impurities may be either useless, such as husks, chaff, and dirt, or worse than useless, as in the case of weed seeds. In any case if the sample contains 5 per cent. of foreign matter in every 100 lbs. the purchaser pays for 5 lbs. of something which is not the true seed he intends to use.

The depth at which seeds germinate will depend largely upon the extent to which moisture and air are retained in contact with the seeds, as should the tilth be composed of large rough particles of soil they cannot possibly germinate, except when showers of rain are continuous from day to day, and even so the seedlings are apt to perish later.

Given volumes of seeds vary in weight according to their individual weights and the density of the whole. Thus rarely is it found that a bushel of seeds of the same variety of plant, grown under varying conditions of soil and climate, are even identical. These remarks may be similarly applied to fruits and potato tubers.

The quantity of seed to sow per acre is also variable for reasons already stated. In districts where birds and field mice abound, or on land infested with wire-worm, heavier

seedings are necessary, while the season at which seeds are sown and the fertility of the soil are also controlling factors.

In the purchase of seeds two important factors have to be considered, purity and germination capacity. Given 100 seeds, 80 of which contain grains and 20 of which are mere husks, then the purity is only 80 per cent. On the other hand, the highest possible germination capacity for such a sample would be 100 per cent., *not* 80 per cent., because the husks are left out of consideration.

Both purity and germination capacity are required to be known before purchasing, and the two together constitute the true value of the seed. To obtain the percentage true value multiply the percentage germination capacity by the percentage purity and divide by 100:—

$$\text{True value} = \frac{G \times P}{100}.$$

Two samples of perennial rye grass seed, called respectively A and B, are offered at 1s. 5d. and 1s. 8d. per lb. respectively. The purity of A was 76 per cent., and its germination capacity 68 per cent. Its real percentage value is therefore $\frac{76 \times 68}{100} = 51{\cdot}6$.

B is of 88 per cent. purity and 83 per cent. germination capacity; its real value being $\frac{88 \times 83}{100} = 73{\cdot}0$.

The prices should be in the proportion of 51·6 to 73·0. This is not so, however, for assuming that 1s. 8d. per lb. is a correct price to pay for sample B, the price of A should be:—

$$\text{1s. 8d.} \times \frac{51{\cdot}6}{73{\cdot}0} = \underline{\text{1s. 2d.}}$$

A farmer purchases 1 lb. of cabbage seed having a germination percentage of 96. On testing a sample of old seed in stock he finds it to have a germination percentage of 32. How much of the latter seed will the farmer have to sow to equal the 1 lb. of better quality seed?

Two samples of clover seed, one Russian and one English, and claimed to be of equal merit, were offered by a seedsman

at 10½d. per lb. The purity of the Russian sample was found to be 87 per cent. and the germination capacity 90 per cent.; the purity of the English sample was 92 per cent. and the germination capacity 79 per cent. Compare the real value of each of the samples. (*Ans.* Russian = 1·08 times English nearly.)

Quantities of Agricultural Seeds required per Statute Acre

Barley	3 bus.
Broom	25 lbs.
Buckwheat	2 bus.
Burnet	40 lbs.
Cabbage, drill	4 to 6 lbs.
,, for transplanting	1 lb.
Carrot	8 lbs.
Chicory	8 lbs.
Clover	16 to 20 lbs.
Fenugreek	30 lbs.
Flax	2 bus.
Furze, for cover	30 lbs.
,, *for fodder*	*40 to 50* lbs.
Grasses and clovers for 1 year's ley	20 lbs.
,, ,, 2 ,,	24 lbs.
,, ,, 3 ,,	32 lbs.
Grass seeds for permanent pasture	40 lbs.
,, ,, temporary pasture	25 to 40 lbs.
Hungarian forage grass	28 to 40 lbs.
Kidney vetch	25 to 30 lbs.
Kohl rabi	4 lbs.
Linseed	2 bus.
Lucerne	20 to 28 lbs.
Lupin	2 bus.
Maize	1 to 1½ bus.
Mangel wurzel	8 to 10 lbs.
Mustard	20 lbs.
Oats	4 bus.
Parsnip	8 lbs.
Peas	2 to 3 bus.
Potatoes	14 cwt.
Rape	6 lbs.
Rye grass	3 bus.
Sainfoin, in husk	5 bus.
,, milled	56 lbs.
Sorghum, drill	15 lbs.
,, broadcast	26 lbs.
Spurrey	15 lbs.
Sugar beet	12 lbs.
Sunflower	8 lbs.
Swede	3 or 4 lbs.
Trifolium incarnatum	24 to 28 lbs.
Turnip, yellow or white	3 or 4 lbs.
Wheat	2½ bus.

Mixture for Permanent Pasture

	Light Soil.	Medium Soil.	Strong Soil.	General Purposes.	Renovating Seeds.
	Lbs. per Acre.	Lbs. per Acre.	Lbs. per Acre.	Lbs. per Acre.	Lbs. per Acre.
Red clover (Trifolium pratense)	1	1	1	1	...
Cowgrass (Trifolium pratense perenne)	1	1	1	1	$\frac{1}{2}$
Cowgrass (late flowering variety)	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$\frac{1}{2}$
White clover (Trifolium repens)	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$1\frac{3}{4}$	1
Alsike (Trifolium hybridum)	1	1	1	1	$\frac{1}{2}$
Trefoil (Medicago lupulina)	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	...
Timothy (Phleum pratense)	$3\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$1\frac{1}{2}$
Italian rye grass (Lolium italicum)	1	1	$1\frac{1}{2}$	1	...
Perennial rye grass (Lolium perenne)	5	6	7	8	2
Cocksfoot (Dactylis glomerata)	7	7	7	7	2
Meadow fescue (Festuca pratensis)	3	3	3	3	2
Tall fescue (Festuca elatior)	3	3	$3\frac{1}{2}$	2	$\frac{1}{2}$
Hard fescue (Festuca duriuscula)	3	3	3	$3\frac{1}{2}$	1
Sheep's fescue (Festuca ovina tenuifolia)	1	$\frac{1}{2}$	...	$\frac{1}{4}$	...
Crested dogstail (Cynosurus cristatus)	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$
Meadow foxtail (Alopecurus pratensis)	3	4	5	3	2
Wood meadow grass (Poa nemoralis)	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	...
Rough-stalked meadow grass (Poa trivialis)	1	$1\frac{1}{4}$	1	$\frac{1}{2}$	$\frac{1}{4}$
Sweet vernal (Anthoxanthum odoratum)	...	...	$\frac{1}{4}$	...	...
Weight of seed per acre	37	39	42	38	14

Crops

The successful cultivation of any particular crop is dependent upon a great variety of circumstances, over many of which the grower has no control.

The quantity of seed necessary to sow per acre depends not only on the germination capacity, but on the fineness of the soil particles at the time of sowing, particularly in the case of small seeds such as those of grasses and legumes.

Yields of produce are largely regulated in keeping with the fertility of the soil and its special adaptability to the growth of certain crops. The mechanical texture of the soil is another important factor, while climate is probably responsible for the greatest variation in yield.

Yield of Crops

Barley—

Average produce per acre = 40 to 48 bus., or 10 to 12 sacks, or 5 to 6 qrs.

Average produce of straw = 13 to 20 cwt.

Proportion of grain to straw in rick = 1 bus. to 21 c. ft.

Cabbages (Drumhead)	25 to 35 tons per acre.
Carrots (Belgian)	12 to 15 tons per acre.
Clovers (as green fodder)	16 to 18 tons per acre per year.
,, (as hay)	2 tons first cut, ¾ ton second cut.
Grass (green)	7 to 14 tons per acre.
,, (hay)	1½ tons per acre.
Italian rye grass (green)	12 to 18 tons per acre.
,, ,, (hay)	1 to 2 tons per acre.
Kohl rabi	10 to 14 tons per acre.
Lucerne	6 to 8 tons per acre each cut.
Mangels	30 to 40 tons per acre.
Sugar beet	20 to 30 tons per acre.

Oats—

Weight per bushel 42 lbs. (ranges from 35 lbs. to 52 lbs.).

Average yield per acre = 60 to 80 bus., or 15 to 20 sacks, or 7½ to 10 qrs.

Average produce of straw = 20 to 30 cwt. per acre.

Proportion of grain to straw = 37 per cent. of grain to 63 per cent. straw and chaff by weight.

Proportion of grain to straw in rick = 1 bus. to 16 c. ft.

Yield of Crops (continued)—

Parsnips	9 to 12 tons per acre.
Potatoes	8 to 15 tons per acre.
Rape (green)	10 to 20 tons per acre.
Rye (cut green)	4 to 5 tons per acre.
Swedes	20 to 30 tons per acre.
Sainfoin (green)	10 to 12 tons per acre.
Turnips	10 to 20 tons per acre.
Vetches (green)	6 to 8 tons per acre.
,, (hay)	2 tons per acre.

Wheat—

Weight per bushel = 60 to 65 lbs.
Average yield per acre = 30 bus.
Average produce of straw = 25 to 35 cwt. per acre.
Proportion of grain to straw in rick = 1 bus. to every 27 c. ft.
Proportion of dressed to tail grain = 10 : 1.

Rye—

Average produce per acre = 25 to 30 bus.
Average produce of straw = 35 to 40 cwt. per acre.

Maize—

Produces 20 to 40 tons of green fodder per acre.

Beans—

Average produce per acre = 25 to 40 bus.
Haulm per acre = 25 to 30 cwt.
Grain in rick = 1 bus. to 35 c. ft.

Peas—

Seed = 2 to 3 bus. per acre, 4 to 6 bus. broad-casted.
Weight = 63 to 65 lbs. per bushel.
Average produce per acre = 30 to 40 bus.
Grain in rick = 1 bus. to 35 c. ft.

Crop.	No. of Lbs. per Cubic Foot.	Cubic Feet per Ton.
Potatoes	34	65
Carrots	31	72
Turnips	31	72
Swedes	34	65
Mangels	35	63
Hay—		
Light		300
Medium		280
Solid		260
Very solid		240

Or divisions for different conditions of compactness may be used :—

	Square Stack.	Round Stack.
If very compact	÷ 6	÷ 8
If well settled	÷ 7	÷ 9
If not well settled	÷ 9	÷ 11

The quotient gives trusses, and the number of trusses divided by 40 gives tons.

The average weights of different kinds of straw after having been stacked for at least a fortnight are approximately as follows :—

Proportion of Grain to Straw

	Cubic Feet per Bushel.	Cubic Feet per Cwt.
Wheat	27	30 to 33
Barley	21 to 22	35 ,, 44
Oats	16 ,, 18	31 ,, 35
Beans	35	47 ,, 50
Peas	35 to 36	44 ,, 48

Distances at which to Plant Fruit Trees Separately in Medium Soils, and Cost of Plants

Kind of Fruit.	Form of Tree.	No of Feet apart.	No. per Acre.	Average Prices of Trees.	
Apple	Standard	21	99	£5 to £10	Per 100
,,	Bush or Pyramid	8	680	£4 ,, £7	,, 100
Currant	Bush	4½	2,151	£3 ,, £5	,, 1,000
Cherry	Standard	24	75	£4 ,, £8	,, 100
Damson	Bush	8	680	£2. 10s. to £5	,, 100
Gooseberry	,,	4½	2,151	£3 to £6	,, 1,000
Pear	Standard	22	90	£5 ,, £10	,, 100
,,	Bush	8	680	£2 ,, £5	,, 100
Plum	Standard	18	134	£5 ,, £10	,, 100
Raspberry	Canes	5-ft. rows, 1 ft. in row	1,742	£1 ,, £2	,, 1,000
Strawberry	Runners	2 ft. 6 in. rows, 1 ft. in row	17,424	5s ,, 10s.	,, 1,000

Crop.	Seed per Acre and per Square Rod.	Time of Sowing.	Weight of Good Seed per Bushel.
Peas	3 bushels per acre. 1½ pints per rod.	Jan. to April.	64 to 66 lbs.
Parsnips	6 to 8 lbs. per acre. ½ to ¾ lb. per rod.	March.	18 to 20 lbs.
Potatoes	10 to 15 cwt. per acre, according to size of tubers. 10 to 12 lbs. per rod.	Feb. to April.	54 to 58 lbs.
Rye	3 bushels per acre. 3 to 4 pints per rod.	Aug. to Sept.	50 to 52 lbs.
Sainfoin	55 lbs. shelled seed per acre. ¼ to ½ lb. per rod.	April to May.	Shelled seed, 60 to 65 lbs.
Tares or vetches	2½ to 3 bushels per acre. 1½ to 2 pints per rod.	Sept. and Oct., also March.	64 to 68 lbs.
Trefoil	12 to 15 lbs. per acre. 1½ oz. per rod.	April to May.	63 to 65 lbs.
Trifolium or crimson clover	15 to 20 lbs. per acre. ¼ lb. (nearly) per rod.	Aug. to Sept.	62 lbs.
Turnips and swedes	3 to 4 lbs. per acre. ¼ to ½ oz. per rod.	Mar. to Aug. according to kind grown and district.	50 lbs.
Wheat	2½ to 3 bushels per acre. 1½ pints per rod.	Sept. to Nov. Spring wheat Dec. to April.	60 to 64 lbs. Spring wheat 66 lbs.

Suitable Soils.	Preceding Crop.	Manures to Apply per Acre.
Medium soils, retentive of moisture.	Barley or oats.	5 cwt. super., 2 cwt. sulphate of potash.
Deep, retentive loams.	After any crop.	2 cwt. sulphate of potash, 3 cwt. basic super.
Friable loams; the deeper the better.	Wheat, oats, clover, or cabbage.	15 tons dung, 5 cwt. basic slag, 3 cwt. guano, and 2 cwt. sulphate of potash.
Medium to heavy loams.	Usually grown as catch crop after potatoes, peas, etc., to provide sheep feed in spring.	12 tons dung, with 3 cwt. super., 2 cwt. kainit in autumn and 1 cwt. nitrate in spring.
Light chalk and loams, never on heavy, clayey land.	Barley or oats.	4 cwt. super. and 1 cwt. sulphate of potash.
Calcareous soils, if not too dry.	Wheat, oats, or barley.	3 cwt. super., 1½ cwt. sulphate of potash at time of sowing.
Light calcareous soils.	Barley, oats, or wheat.	5 cwt. slag, 1 cwt. sulphate of potash.
Calcareous soils; sown on stubbles.	Any straw crop.	5 to 6 cwt. basic slag in autumn, 2 to 3 cwt. guano in spring.
Medium loams, well manured.	Wheat.	25 loads short dung, 5 cwt. dissolved bones, 2 cwt. sulphate of potash.
Heavy, retentive loams.	Clover, roots, or bare fallow.	Plough in 12 tons of short dung together with 3 cwt. super. and 5 cwt. kainit in autumn, 1 cwt. nitrate in spring.

Crop.	Distance between Rows.	Distance between Plants.
Cabbage, garden	18 to 20 inches	15 to 18 inches
,, field	24 ,, 30 ,,	18 ,, 22 ,,
Mangels	18 ,, 20 ,,	12 ,, 15 ,,
Potatoes	22 ,, 24 ,,	9 ,, 12 ,,
Turnips	15 ,, 18 ,,	9 ,, 12 ,,

Examples

If, in Scotland, Potato oats produced 69½ bus. per acre, Berlie 55¾ bus., Hopetoun 52½ bus., Sandy 47¼ bus., Early Angus 47¾ bus., what was the average yield per acre? (*Ans.* 54½ bus.)

If 1 ac. of Potato oats produced 60½ cwt. of straw and 1 ac. of Early Angus produced 54⅖ cwt., what was the average yield of straw per acre? (*Ans.* $57\frac{7}{10}$ cwt.)

If red clover contains 21·9 per cent. of albuminoids when cut young, but only 9·5 per cent. when old, to what extent have the albuminoids depreciated? (*Ans.* 12·4 per cent.)

100 lbs. of good oat straw, cut green, contains 1¼ lbs. oil, 4 lbs. albuminoids, 10 lbs. sugar, gum, and other carbohydrates, and from 20 to 30 lbs. digestible cellulose. What weights of these constituents would there be in 1 ton of such straw? (*Ans.* 28 lbs. oil, 224 lbs. sugar gum, 448 lbs. to 672 lbs. cellulose.)

Of vegetable products gathered as food in their dry state, carbon forms nearly one-half by weight, oxygen rather more than one-third, hydrogen little more than 5 per cent., and nitrogen from ½ to 4 per cent. What quantity of carbon, oxygen, hydrogen, and nitrogen respectively is there in 1 qr. of wheat? (*Ans.* 252 lbs.; 168 lbs.; 25 lbs.; 2½ to 20 lbs.)

If white turnips contain 92·00 per cent. of water, swedes 89·46 per cent., mangels 88 per cent., sugar beet 83·50 per cent., carrots 87·50 per cent., parsnips 85·20 per cent., and potatoes 75·83 per cent., what is the average moisture content of these roots? (*Ans.* 85·93 per cent.)

In estimating the relation between the rainfall without supplemental irrigation and the hay crop in two cuttings the following results were obtained at Wisconsin, U.S.A. :—

Year.	Rainfall, two crops.	Yield per acre.
	In.	Lbs.
1905	13·63	4,028
1906	17·05	4,642
1907	14·92	5,920

What was the average rainfall and yield of hay over this period? (*Ans.* 15·2 in.; 4,863 lbs.)

Supplemental irrigation was found to increase the yield with practically the same average rainfall to 8,746 lbs. per acre. What is the percentage increase of this over the average yield without irrigation and what does it represent in tons per acre? (*Ans.* 80 per cent. nearly; 1·73 tons increase per acre.)

In preparing timber plantations, the poorer the land the closer the plants should be set, while if on good land the sooner a thicket will be formed. What number of plants would be required per acre if planted $3\frac{1}{2}$ ft., 4 ft., $4\frac{1}{2}$ ft., and 5 ft. apart? Compare the cost of planting $3\frac{1}{2}$ ft. apart and 5 ft. apart. (*Ans.* 2 : 1 nearly.)

The cost of soil preparation and plants for plantations, together with cost of planting, will amount to £2. 10s. per acre where the plants are notched, *i.e.*, slipped under spade-cuts in L, T, or H shapes. The cost of notching alone is about 15s. an acre at 3 ft. apart. What is the cost of notching 1,000 plants, and the cost of soil preparation and plants per acre at this distance apart?

The cost of pit-planting with transplants in holes is more expensive. Thus the total cost of plants and planting costs about £3. 10s. per acre. What is the cost of plants per 1,000 if the cost of opening the pits and planting amounts to 8s. 4d. per 1,000 and the plants are planted 4 ft. apart?

CHAPTER VII

LIVESTOCK

PRACTICAL experience in judging, handling, weighing, and slaughtering is the only sure way of acquiring accuracy with regard to the carcass weights of animals.

In many of the Scottish auction marts, and in some of the English markets, fat beasts pass over a weighbridge before entering the sale ring, the weight of the animal, or animals as the case may be, being recorded on a clock-face dial.

While the live weight is thus accurately recorded, the buyer has still to judge as to the carcass weight of the animal, that is, in the case say of a fat steer, whether it is likely to lose 5, 6, or even 7 lbs. of offal out of every 14 lbs. live weight.

Butchers are frequently heard to remark that such and such an animal "will die well," which means that the proportion of carcass to live weight will be considerably above the standard on which live and dead weights are based, namely that out of every 14 lbs. live weight, 8 lbs. are carcass fit for human consumption; the remaining 6 lbs. of offal being made up of hide, head, feet, tail, intestines, etc.

While rarely ever used by practical men, the several methods of ascertaining the dead weights of animals by measurement prove fairly accurate, when a prime quality ox is considered, and so furnish the student with some idea as to the weights of such animals.

Inferior quality animals, those of coarse growth, or cows fattened out for killing, must not be taken as standards for measurement.

To Estimate the Weight of Cattle

1. Measure round the animal close behind the shoulder, then along the back from the fore-part of the shoulder-blade to the bone at the tail. Multiply the square of the girth by 5 times the length, both expressed in feet. Divide the product by 21, and the result is the approximate weight of the four quarters in stones of 14 lbs. Very fat cattle weigh

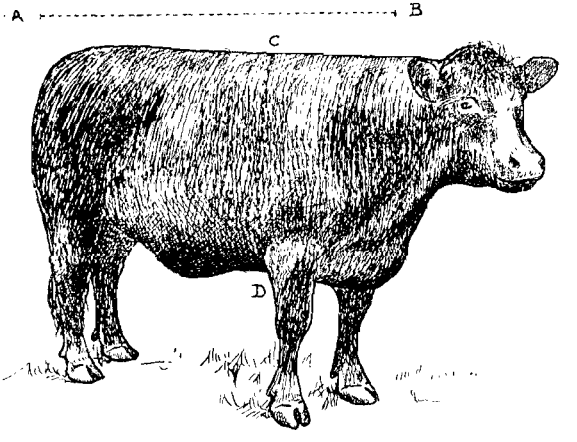

FIG. 13.

about $\frac{1}{15}$ to $\frac{1}{20}$ more, and lean cattle about $\frac{1}{15}$ to $\frac{1}{20}$ less, than the result obtained by the above method. The four quarters are little more than half the weight of the animal when living. The skin weighs about $\frac{1}{18}$ and the tallow about $\frac{1}{12}$ of the whole.

As an example of the method employed, if the girth be 7 ft. and the length 5 ft., then :—

$(7)^2 = 49$
$5 \times 5 = 25$

$4\overline{)4900}$

$21\overline{)1225}$

$58\frac{1}{3}$

Weight $= 58\frac{1}{3}$ st. of 14 lbs.

2. Another method consists in multiplying the length and girth in feet together, then multiply by $2\frac{5}{7}$ and divide by 14. The result is the weight in imperial stones.

Thus :—

$$\frac{\text{Length} \times \text{girth} \times 2\frac{5}{7}}{14} = x \text{ imp. st.}$$

3. The third rule, and one very commonly used, distinguishes between kinds of oxen. The girth is taken and squared, then multiplied by the length, and then multiplied by one of the factors ·23, ·25, ·26, or ·27, as the animal is moderate, fat, prime fat, or very fat. The result divided by 100 is the weight in imperial stones.

This may be represented as follows :—

$$\frac{\text{Girth}^2 \times l \times \text{a factor } (\cdot 23)}{100} = x \text{ imp. st.}$$

The following are particulars of the live weights, dressed carcass weights, and offal of champion animals at Smithfield Show.

Fat Steer—

Live weight	10 cwt. 2 qrs.	18 lbs.
Carcass weight	98 st.	5 ,,
Suet, caul, reed fat		18 ,,
Fat, gut fat, trimmings		20 ,,
Tongue, tail		11 ,,
Head, feet		52 ,,
Heart, liver, lights		31 ,,
Tripe, feck, reed		79 ,,
Hide		83 ,,
Intestines		18 ,,

Fat Sheep (Wether lamb under 12 months)—

Live weight	3 qrs.	27 lbs.
Carcass weight	8 st.	3 ,,
Fat		$4\frac{3}{4}$,,
Pluck		4 ,,
Skin		13 ,,

Fat Pig—

Live weight	3 qrs. 15 lbs.
Carcass weight	9 st. 5 ,,
Pluck	4½ ,,

Ox—

Taken from feeding stall and weighed	12 cwt. 0 qrs. 7 lbs.
Starved for 24 hrs.	11 cwt. 0 qrs. 18 lbs.

Shrinkage = 101 lbs. = 7½ per cent.

Carcass, hot, weighed	805 lbs.
After hanging 24 hrs., weighed	790 lbs.

Shrinkage = 15 lbs. = 2 per cent.

Offal	448 lbs.
Hind quarters	302 ,,
Fore ,,	306 ,,
Bones and trimmings	176 ,,

Carcass Weights of Sheep

Carcass weight of	Cheviots	61·3 per cent. of live weight
,, ,,	Hampshire Downs	58·4 ,, ,, ,,
,, ,,	Kents	56·4 ,, ,, ,,
,, ,,	Mountain breed	63·1 ,, ,, ,,
,, ,,	Southdown	66·0 ,, ,, ,,
,, ,,	Suffolk	61·2 ,, ,, ,,

From this it will be seen that the Kents give the lightest carcass weight and the Southdowns the heaviest.

It is estimated on the average that prime fat beasts will yield a carcass weight of 67 per cent. of the live weight.

It is estimated that 1 acre of very good land will maintain 5 sheep, 1 to 1½ cattle, or 2 horses; 1 acre of good average land will maintain 3 sheep, 1 ox, or 1 horse; 1 acre of poor land will maintain 2 sheep, ½ an ox, or ½ a horse.

Air Space required per Head in Buildings

Cow byre	500 to 600 c. ft. per cow
Stable, open-roofed	1,200 c. ft. per horse
,, with loft above	1,300 ,,

Railway Rates for Livestock

In covered cattle trucks—

	Charge per Mile.
1 animal	3d.
2 animals	5d.
3 ,,	7d.
4 ,,	9d.
5 ,,	11d.
6 ,,	1s. 1d.
For every animal over 6 in the same truck	1d.
Calf, accompanying cow (not above 224 lbs. in weight)	1½d.

Pigs (*under* 224 lbs.), sheep, and goats—

Not exceeding 4 animals	3d.
,, 8 ,,	5d.
,, 12 ,,	7d.
,, 20 ,,	9d.
For every 5 animals (or less) above 20 in same truck	1d.

Pigs (over 224 lbs.), rams, and calves not exceeding 224 lbs.—

Not exceeding 3 animals	3d.
,, 6 ,,	5d.
,, 9 ,,	7d.
,, 12 ,,	9d.
For every 3 animals (or less) above 12 in same truck	2d.

The above are the minimum charges as for 30 miles.

Foods

No hard and fast rules can be laid down with regard to the use of foods, mainly on account of the variation in the animal's constitution and powers of digestion, or, in other words, of extracting the nutrients of any particular food. Further, the digestible ingredients of both manufactured and natural foods are never constant.

The student will be well advised to study carefully any reports that may come to his or her notice containing data

relative to feeding experiments carried out in connection with the different breeds of livestock.

Much of the success attending the feeding of cattle with concentrated foods consists in giving a change of diet, in preventing wasteful and extravagant feeding, and in seeing that each animal clears up the food given, as should stale food be left in the trough fatting animals will soon lose appetite and consequently weight.

To ensure the economical use of concentrated foods, and to reduce the tax thrown upon the digestive and secreting organs of the body an Albuminoid Ratio has been devised, as a means of providing a guide to the proportion of albuminoids or flesh formers, to the non-albuminoids, or sugar, starch, and oil, in rations for animals at various ages whether for producing milk, laying on flesh, or for physical exertion.

While accuracy cannot be attained in a ration, it is nevertheless invaluable to follow the albuminoid ratio as far as is practicable, having regard to the digestibility of the nutrients contained in the respective foods.

Albuminoid Ratio

The albuminoid ratio of a food is the proportion between the digestible albuminoids and the digestible carbohydrates and fats.

It may be expressed thus :—

$$\text{Albuminoid Ratio} = \frac{A}{C + 2\frac{1}{2}F}.$$

Where C = carbohydrates, F = fats, and A = albuminoids.

Ex.—The composition of new milk is as follows :—

Water	87	per cent.
Fat	3·65	,,
Casein	3·45	,,
Albumen	·65	,,
Sugar	4·50	,,
Ash	·75	,,

and therefore contains 4·1 per cent. albuminoids, 3·65 per cent. fat, and 4·5 per cent. carbohydrates.

$$\therefore \text{ Albuminoid Ratio} = \frac{A}{C + 2\frac{1}{2}F}$$

$$= \frac{4{\cdot}1}{4{\cdot}5 + (2\frac{1}{2} \times 3{\cdot}65)}$$

$$= \frac{4{\cdot}1}{4{\cdot}5 + 9{\cdot}125}$$

$$= \frac{1}{3{\cdot}32}$$

$$= 1 : 3{\cdot}32$$

$$4{\cdot}1)13{\cdot}625(3{\cdot}32$$

$$\underline{}$$

$$132$$

$$\underline{}$$

$$95$$

$$\underline{}$$

$$13$$

Milk is nature's food for the calf, and its albuminoid ratio is seen to be 1 : 3·32 or about the same as that of young grass in spring.

The following is a list of albuminoid ratios for different animals under varying conditions :—

	Albuminoids.		Carbohydrates.
Young animals on milk	1	to	3-4
Rapidly growing animals	1	,,	5-7
Oxen at rest	1	,,	14
Sheep at rest	1	,,	12
Fattening oxen	1	,,	9-10
,, sheep	1	,,	8-9
,, pigs	1	,,	7
Horses at work (on maize)	1	,,	9
,, in severe weather	1	,,	4-5
Milking cows	1	,,	6

The average of the figures in the above table works out at about 1 : 6.

The approximate unit costs of the nutritive constituents in feeding cakes and meals are as follows :—

Albuminoids	2s. 8d. to 3s.
Oil and fat	2s. 8d. ,, 3s.
Carbohydrates	1s. 1d. ,, 1s. 2d.

It is agreed that the value of each per cent. or unit of albuminoids and of oil is at least $2\frac{1}{2}$ times that of 1 per cent. or unit of carbohydrates.

Ex.—Find the cost of cotton cake having the following analysis :—

Albuminoids	$22{\cdot}1 \times 2\frac{1}{2} = 55{\cdot}2$
Oil	$5{\cdot}2 \times 2\frac{1}{2} = 13{\cdot}0$
Carbohydrates	$33{\cdot}2 \times 1 = 33{\cdot}2$
Total feeding units	101·4

Composition and Albuminoid Ratio of various Foods

Compiled by Chas. Crowther, M.A., Ph.D., and issued by the University of Leeds.

	Total Dry Matter.	Digestible.				Albuminoid Ratio.
		Albuminoids.		Oil.	Carbohydrates + Fibre.	
		Crude.	True.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
Cotton-seed cake—						
Decorticated	92	35·5	34	8·5	20	1:1·2
Undecorticated Egyptian	88	16·5	15·5	5·3	20	2·1
,, Bombay	88	15	14	4	21	2·2
Linseed cake	88	26·5	25	9·5	32	2·2
Cocoanut cake	89	17·5	17	9·5	39	3·7
Soy bean cake	88	37	34	5·5	22	1·1
,, bean meal, extracted	88	39	36	1·8	24	0·9
,, beans	89	31·5	28·5	15·5	20	2·1
Linseed	91	18	17	34	21	6·1
Locust bean meal	86	4·3	3·5	1	70	21
Maize germ meal	90	12·5	8·5	10·5	55	9·4
Gluten meal	90	35	33	3·5	42	1·6
,, feed	90	23	21	2·5	52	2·8
Rice meal	90	7	6	10	49	10·6
Malt culms or coombs	90	18·5	11·5	1·5	39	4·1
Malt	92	8	6	2	63	11·5
Oatmeal	90	11·5	10	7	48	6·4
Wheat, middlings	88	13	12	3	56	5·3
,, sharps	88	12·5	11	3·5	50	5·4
,, bran, coarse	87	12	10	3	45	5·2
Brewers' grains (wet), fresh	24	4·2	4	1·3	10	3·8
,, ,, (dried)	91	14·7	14	5	35	3·8
Treacle or molasses	78	5·5	...	...	55	...
Meat meal	89	70	67	12·5	...	0·5
Wheat	87	10	9	1·3	65	7·6
Barley	86	7·2	6·7	1·9	64	10·2
Oats	87	10	...	5·3	45	6·3
Rye	87	10	9	1	65	7·6
Maize	89	7·5	7	4·5	68	11·1
Beans	86	22	19	1·2	48	2·8
Peas	86	19·5	17	1	53	3·3
Straw, wheat	86	0·4	0·2	0·4	34	175
,, rye	86	0·6	0·4	0·4	35	90
,, barley	86	1	0·7	0·5	40	59
,, oat	86	1·3	1	0·5	39	40
,, bean	82	4	3·2	0·5	36	11·8
,, pea	86	4·3	3·4	0·7	32	10

Composition and Albuminoid Ratio of various Foods (continued)

	Total Dry Matter.	Digestible.				Albuminoid Ratio.
		Albuminoids.		Oil.	Carbohydrates + Fibre.	
		Crude.	True.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
Meadow hay, medium quality	86	5·5	4	1	41	1:11
Clover hay	84	8·5	5·5	1·5	38	7·9
Pasture grass, young	20	3	2	0·5	10	5·9
,, ,, old	25	2	1·5	0·5	13	9·6
Clover, green	19	2·5	2	0·5	9	5·2
Vetches	16	3·5	2	0·3	7	4·4
Lucerne	24	3	2	0·5	9	5·4
Cabbage	15	2	1·5	0·5	7	5·6
Rape	14	2	1·5	0·5	6	5
Turnip tops	12	1·5	0·5	0·2	5	12·4
Turnips	9·5	0·6	0·2	0·1	6	32·5
Swedes	11·5	1·2	0·3	0·1	8	30
Mangels	12	0·8	0·1	0·1	9	98
Carrots	13	0·8	0·4	0·1	10	26
Sugar beet	25	0·9	0·3	0·1	20	70
Jerusalem artichokes	20	1·0	0·4	0·1	16	41
Potatoes	25	1·1	0·1	0·1	19	200
Milk—cow's whole	12·5	3·3	3·3	3·7	4·7	4·1
,, ,, skimmed	9·5	3·3	3·3	0·7	4·5	6·5
,, ,, separated	9	3·5	3·5	0·1	5	1·5
,, ,, buttermilk	9·5	3·7	3·7	0·7	4·2	1·6
,, ewe's	18	6	6	6·5	4·8	3·4
,, mare's	9·5	2	2	1·3	5·7	4·4
,, sow's	18	6	6	6	5	3.2
Whey (from cow's milk)	7	1	1	0·3	5	5·7

What is the albuminoid ratio of the following ration for feeding milch cows?

Food.		Albuminoids.	Carbohydrates.	Fats.
	Lbs.	Lbs.	Lbs.	Lbs.
Meadow hay	8	0·32	3·28	0·08
Oat straw chaff	8	0·08	2·96	0·04
Mangels	40	0·44	3·60	0·04
Decorticated cotton cake	3	1·08	0·54	0·28
Linseed cake	2	0·48	0·66	0·19
Maize meal	3	0·27	1·56	0·28
	64	2·67	12·60	0·91

Converting the fats into their starch equivalent by multiplying by $2\frac{1}{2}$ (2·27 lbs.), and adding this to the total number of pounds of carbohydrates (12·60 lbs.), we get a total of 14·87 lbs., which, on being divided by the number of pounds of albuminoids (2·67 lbs.), leaves a quotient of $5\frac{1}{2}$. The ration has therefore an albuminoid ratio of $1 : 5\frac{1}{2}$.

Find the albuminoid ratio of the following daily ration of a fattening cow :—

60 lbs. swedes.
12 „ hay.
14 „ oat straw.
4 „ crushed oats.
$4\frac{1}{2}$ „ decorticated cotton cake.

100 lbs. swedes contain—
1·25 lbs. albuminoids; ·1 lb. fat; $9\frac{1}{2}$ lbs. carbohydrates.

∴ 60 lbs. swedes contain—
1·25 × ·6 lb. albs.; ·1 × ·6 lb. fat; 9·5 × ·6 lb. carbo.

Similarly 12 lbs. clover hay contain—
13 × ·12 lb. albs.; 3 × ·12 lb. fat; 36 × ·12 lb. carbo.

14 lbs. oat straw contain—
4 × ·14 lb. albs.; 2 × ·14 lb. fat; 36 × ·14 lb. carbo.

4 lbs. crushed oats contain—
10·4 × ·04 lb. albs.; 5·2 × ·04 lb. fat; 58 × ·04 lb. carbo.

4½ lbs. decorticated cotton cake contain—

$41 \times \cdot045$ lb. albs.; $10 \times \cdot045$ lb. fat; $23 \times \cdot045$ lb. carbo.

$\therefore$ Albuminoids $= \cdot75 + 1\cdot56 + \cdot56 + \cdot416 + 1\cdot845 = 5\cdot131.$

Fat $= \cdot06 + \cdot36 + \cdot28 + \cdot208 + \cdot45 = 1\cdot358.$

Multiplied by 2½ to bring it to terms of carbohydrates

$= 1\cdot358 \times 2\cdot5 = 3\cdot395.$

Carbohydrates $= 5\cdot7 + 4\cdot32 + 5\cdot04 + 2\cdot32 + 1\cdot035 = 18\cdot415.$

Carbohydrates + Fat $\times 2\frac{1}{2} = 18\cdot415 + 3\cdot395 = 21\cdot81.$

$$\text{Albuminoid Ratio} = \frac{5\cdot131}{21\cdot81}$$

$$= \underline{1 : 4\cdot25.}$$

In feeding dairy cows it is estimated that those yielding 2 gals. of milk per day require 2·5 lbs. of albuminoids and 12·5 lbs. of carbohydrates; for those yielding 3 gals. per day add ·6 to the albuminoids and from 1 to 1·5 to the carbohydrates; and for those yielding 4 gals. or more per day add ·75 to the albuminoids and ·75 to the carbohydrates.

Experiments in the feeding of dairy cows go to show that where cows of 1,000 lbs. live weight are stall fed in winter, those yielding 2 gals. of milk per day do not require more than 4 lbs. of concentrated foods; giving an average of 4 gals. of milk, 6 lbs. of concentrated foods; and yielding 6 gals., 8 lbs. of concentrated foods. In fact anything above 8 lbs. of concentrated foods will serve no useful purpose, while of hay, 15 lbs., and of oat straw, 15 lbs., may be given together with 40 lbs. of roots.

Examples

The composition of acorns is approximately: Water, 56 per cent.; nitrogenous matter, 3½ per cent.; fibre, 5 per cent.; fat, 2 per cent.; ash, 1½ per cent. What quantity would have to be fed to a pig per day in order that he may consume 5 lbs. of nitrogenous or flesh-forming matter per week? (*Ans.* 2 lbs.)

What would be the cost of 1 ton of acorns when as much as 1s. 6d. per bushel is obtained, a bushel weighing approximately 56 lbs.? (*Ans.* £3.)

Twenty pigs were sent to a bacon factory; they were fasted 24 hrs. before being dispatched, and weighed on the average 208 lbs. per pig live weight. They were fasted at the factory for another 24 hrs.; and the dressed carcasses were returned as averaging 165 lbs. a-piece. What was the loss per cent. on the live weight? (*Ans.* 20·7 per cent.)

If oats are sold at 40 lbs. per bushel for 18s. a quarter, what is the real price per quarter at their natural weight, which is 36 lbs. per bushel? (*Ans.* 16s. 2½d.)

Farm Rations

The following may be taken as typical rations per 1,000 lbs. (or practically 9 cwt.) live weight:—

For Fattening Cattle—

66 lbs. swedes (or 88 lbs. yellow turnips).
7 „ meadow hay.
14 „ oat straw.
4 „ crushed oats or maize meal.
2 „ undecorticated cotton cake.
2 „ linseed cake.

For Milch Cows—

Yielding 2 gals. per day.

30 lbs. mangels (or swedes).
14 „ oat straw (chaffed).
7 „ meadow hay.
2 „ crushed oats.
3 „ decorticated cotton cake.

Yielding 4 gals. per day and over.

45 lbs. mangels (or swedes).
14 „ oat straw.
7 „ meadow hay.
4 „ crushed oats.
4 „ decorticated cotton cake.

Store Cattle (1½ to 2½ yrs. old)—

56 lbs. mangels (or swedes).
14 „ oat straw.
2-4 „ undecorticated cotton cake.

Horses (at heavy work)—
8-10 lbs. oats.
2-3 „ bran.
15-20 „ straw chaff.
Hay *ad lib.*

Horses (at rest)—
5 lbs. oats.
8 „ oat straw chaff.
6 „ meadow hay.

Sheep (per head per week)—
(fattening)—
120 lbs. swedes.
3 „ hay.
2 „ oat straw chaff.
3 „ maize meal.
3 „ decorticated cotton cake, and linseed cake.

In-lamb Ewes—
120 lbs. swedes.
2 „ hay.
4 „ oat straw chaff.
2 „ oats.
5 „ linseed cake.

Store Sheep—
100 lbs. swedes.
7 „ hay.
2 „ crushed oats.

Pigs—
Fattening, per 100 lbs. live weight
2 lbs. barley meal.
2 „ maize meal.
1 lb. sharps.

Breeding Sows—
3 lbs. sharps.
1 lb. bran.

The following quantities of water are required by animals for every 1 lb. dry matter in food :—

Horse, Sheep	2-3 lbs.
Cow	4-6 ,,
Ox	3-5 ,,
Pig	6-8 ,,

Starch Value

The feeding value of a ration of foodstuff is often for convenience expressed by the weight of digestible starch to which it is equivalent. This is termed its Starch Value or Starch Equivalent.

The following may be taken as the average values of the various food constituents estimated in terms of starch :—

	Starch = 1·00.
Albuminoids	·94
Fat or oil	2·25
Fibre (pulped)	1·02
Starch	1·00
Sugar	·87

When, therefore, the average composition of a feeding-stuff is known its feeding value may be estimated by ascertaining the value of its digestible constituents in terms of starch.

For example, suppose a linseed cake contains 8 per cent. digestible oil, 30 per cent. digestible starch (+fibre), and 20 per cent. digestible albuminoids. Then its Starch Value per 100 lbs. $= (8 \times 2{\cdot}25) + 30 + (20 \times {\cdot}94) = 66{\cdot}8$ lbs.

The actual Starch Value, however, would not be so great as this, owing to the fact that the nourishing ingredients of a food before being used for direct productive purposes have to provide for the labour involved in mastication, digestion, etc., and it is obvious that the less digestible the food the lower will be its availability for productive purposes, or in other words, the lower its Starch Value.

Livestock

The cost of fattening bullocks per 100 lbs. increase in live weight, increases in accordance with the age of the animal.

Thus it is estimated that for every 100 lbs. increase in live weight:—

Bullocks from birth to	6 months	cost	9s.	4d.
,, 6 to	12 months	,,	17s.	1½d.
,, 1 ,,	2 years	,,	22s.	10½d.
,, 2½ ,,	3 years	,,	25s.	8½d.
,, 3½ ,,	4 years	,,	34s.	3d.

Similarly, while lambs can be grown to about 70 lbs. live weight in from ten to twelve weeks, if kept on poorer food they may not put on more than 35 lbs. by the end of six months. Again in the case of pigs it requires two-thirds more food to produce an increase of 100 lbs. with hogs weighing 300 lbs. than with those weighing 40 lbs.

For every 3½ lbs. of organic matter digested by the pig it is estimated that there is a live weight increase of 1 lb. In the case of the ox, on the other hand, 8 lbs. of digestible organic matter are required to produce a similar increase.

CHAPTER VIII

DAIRY FARMING

DAIRY farming has advanced so much on scientific lines during the past few years that whoever intends adopting this branch of agriculture as a means of livelihood must of necessity possess such knowledge as will conduce to accuracy in calculating, measuring, and weighing.

There are few farmers who do not ascertain for themselves the fat percentage of the milk produced on their farms; while all progressive dairy farmers pay special attention to the economical feeding of their cows by regulating the daily ration in keeping with the individual yields of the animals.

The keeping of *milk records*, or in other words, recording the yield of milk of each individual cow, is now generally practised. From this much information is deduced of real value to the farmer, and it proves the only guide in removing from the herd such animals as do not produce a profitable yield of milk containing the requisite amount of butter fat.

A cow producing 600 gals. of milk per annum removes 46 lbs. of ash from the soil, of which 80 per cent. is of manurial value.

Similarly 217 lbs. of albuminoids, containing 35 lbs. of nitrogen, are removed. To return this quantity of nitrogen to the soil it would require 2 cwt. of nitrate of soda.

It is estimated that of 25 lbs. of digestible material required by a milking cow per day, 18 lbs. are necessary for the maintenance of the body, and 7 lbs. for the production of milk and the growth of the calf.

The fat in cream may vary from 15 to 70 per cent. As the Gerber test-bottle only shows 9 per cent. of fat, it is

necessary to dilute the cream with a number of times its volume of water.

Ex.—Take 11 c.c. of cream and place in a flask, and with the same pipette add 33 c.c. of water. Next take 11 c.c. of the mixture and test as with milk. Multiply the percentage of fat shown on the test-bottle by 4, which gives the percentage of fat in the cream.

If $3\frac{1}{3}$ gals. of milk containing 3·0 per cent. of fat make 1 lb. butter—

(*a*) What quantity of butter would $2\frac{7}{8}$ gals. of milk containing 3·5 per cent. fat make?

(*b*) What quantity of milk containing 4 per cent. fat would be required to make 1 lb. of butter?

(*c*) What quantity of milk containing 5 per cent. fat would be required to make 1 lb. of butter?

The acidimeter is used in determining the acidity in milk, whey, and cream. For the purpose of the test the acidity of the milk is considered to be neutralised when it gives a faint pink colour to phenolphthalein.

An alkaline solution (usually $\frac{1}{9}$ normal caustic soda) is used, of such a strength that 1 c.c. will neutralise ·01 g. of lactic acid.

The test is performed by measuring 10 c.c. of the milk into a porcelain dish, into which, after the addition of a few drops of phenolphthalein, the alkaline solution should be titrated from a burette, meanwhile stirring the milk until the desired pinky tinge is produced.

Then the number of cubic centimetres of the alkaline solution used are shown on the graduated burette, *i.e.*, the number of cubic centimetres of $\frac{1}{9}$ normal caustic soda required to neutralise 10 c.c. of milk.

For example:—Supposing 2 c.c. of alkali are required.

Then, since 1 c.c. will neutralise ·01 g. of lactic acid, 10 c.c. of the milk contains ·02 g. lactic acid.

$\therefore$ in 100 c.c. milk there would be ·2 g. lactic acid,
i.e., ·2 per cent. lactic acid.

Examples

3 gals. of shorthorn milk make 1 lb. of butter.
$2\frac{1}{2}\frac{4}{0}$,, Ayrshire ,, ,, ,,
$2\frac{5}{2}\frac{5}{0}$,, Guernsey ,, ,, ,,
$1\frac{1}{2}\frac{8}{0}$,, Jersey ,, ,, ,,

Estimating the value of the milk throughout at 8d. per imperial gallon, and allowing 1d. per gallon for the separated milk, what are the values of the respective butters produced?

If the price of milk, containing 3 per cent. fat and 8·5 per cent. of solids other than fat, is 1d. per pint or 8d. per imperial gallon, and allowing that the solids other than fat and the water in the milk are worth something, the butter fat can be reckoned at 2d. per unit after the first 3 per cent. of fat.

With the above as a basis, what would be the value of the following quality milks:—

Milk containing 3·5 per cent. of fat.
,, ,, 3·8 ,, ,,
,, ,, 4·0 ,, ,,
,, ,, 4·2 ,, ,,
,, ,, 4·5 ,, ,,
,, ,, 4·1 ,, ,,
,, ,, 5·0 ,, ,,

If milk contains 3·1 per cent. fat, 3 per cent. is removed by the separator and 12 per cent. of the milk is removed as cream, what percentage of fat is present in the cream?

In 100 parts of milk—

12 parts of cream contain 3 parts of fat.
1 part ,, ,, $\frac{1}{4}$,,
100 parts ,, ,, $\underline{25}$,,

Butter Ratio

To calculate how much butter would be yielded from milk of known quality, assuming that 100 lbs. of butter contain 85 lbs. of pure butter fat:—

$$\frac{(\%\text{ of fat in milk} - \cdot 2\text{ loss}) \times 100}{85} = \left\{\begin{array}{l}\text{lbs. of butter produced from}\\ 100\text{ lbs. of milk.}\end{array}\right.$$

Ex.—Milk contains 3·4 per cent. of fat. How much butter would 100 lbs. of such milk yield, and what would be the butter ratio?

$$\frac{(3{\cdot}4 - {\cdot}2) \times 100}{85} = \frac{320}{85} = 3\tfrac{5}{17} \text{ lbs. of butter from 100 lbs. of milk,}$$

or

We have 85 lbs. of butter fat in 100 lbs. of butter.
,, ,, 1 lb. ,, ,, $\frac{100}{85}$,, ,,
,, ,, 3·2 lbs. ,, ,, $\frac{320}{85} = 3{\cdot}76$,,

$$\text{Butter Ratio} = \frac{\text{Milk used}}{\text{Butter obtained}} = \frac{100}{3{\cdot}76} = \frac{26{\cdot}5}{1}.$$

The percentage of cream taken from milk in separating varies from 10 to 15 per cent., and must be so regulated that the cream contains 26 to 30 per cent. of fat in summer and autumn, and 30 to 35 per cent. of fat in winter.

To find the percentage of fat in cream, knowing the fat percentage of the milk, and the percentage of cream taken off—

$$\frac{(\%\text{ fat in milk} - {\cdot}1\text{ loss in separating}) \times 100}{\%\text{ of cream taken off}} = \%\text{ of fat in cream.}$$

Ex.—Milk contains 3·5 per cent. of fat, and 12 per cent. cream is abstracted. What percentage of fat would be present in the cream?

$$\frac{(3{\cdot}5 - {\cdot}1) \times 100}{12} = \frac{340}{12} = \underline{28{\cdot}3}\ \%\text{ fat in cream.}$$

To find the percentage of cream taken off knowing both the percentage of fat in the milk and in the cream.

The percentage of cream taken off

$$= \frac{(\%\text{ fat in milk} - \text{loss in separating}) \times 100}{\%\text{ fat in cream}}.$$

Ex.—

$$\frac{(3{\cdot}5 - {\cdot}1) \times 100}{30} = \frac{340}{30} = 11{\cdot}3\ \%.$$

56° F. is a standard temperature for churning, when the atmosphere registers the same temperature. For every 2° F. increase in the temperature of the air, lower the cream 1° F. For every 2° F. decrease in the temperature of the air, raise the cream 1° F.

If the temperature of the dairy is 62° F. at what temperature should cream be churned?

If the temperature of the dairy is 46° F. at what temperature should the cream be churned?

A gallon of milk weighs 10·3 lbs. To turn lbs. into gallons multiply by 10 and divide the product by 103, or simply divide the number of lbs. by 10·3.

Convert 340 lbs. of milk into gallons.

Milk selling according to Quality

A. sends 550 gals. of milk containing 3·3 per cent. fat to a creamery.

B. sends 470 gals. containing 4·2 per cent. fat.

10½d. per lb. is paid for the butter fat in the milk.

How much does each receive?

A. Amount of fat per gallon = ·103 × 3·3 = ·3399 lb.
Value per gallon = 3·399 + ·169 = 3½d. (about).

B. Amount of fat per gallon = ·103 × 4·2 = ·4326 lb.
Value per gallon = 4·326 + ·216 = 4½d. (about).

A. receives 3½d. per gallon—550 gals. at 3½d. = £5. 14s. 7d.

B. ,, 4½d. ,, 470 ,, at 4½d. = £8. 16s. 3d.

Seeing that rich milk is of much greater value for the production of cream, butter, or cheese than poor milk, the majority of creameries and cheese factories now purchase their milk, not at a fixed price per gallon, but according to its butter-fat content.

The following is a table of payments frequently used for this purpose:—

Percentage of Fat in Milk.	Summer Price per 100 lbs.	Winter Price per 100 lbs.
	Pence.	Pence.
3·1	50	...
3·2	51	...
3·3	52	72
3·4	53	73
3·5	54	74
3·6	55	76
3·7	56	77
3·8	57	78
3·9	58	79
4·0	59	80
4·1	60	81
4·2	...	82

A good separator will remove all but ·1 per cent. of fat from milk, and in some instances it has been proved that 9 per cent. more butter was obtained by the use of a separator.

Ex.—If a cow gave 255 lbs. of butter in a year when the milk was separated, how would this yield compare with an equal quantity of milk the cream from which was collected from shallow pans?

If both butters produced are sold at 1s. 2d. per lb., what extra profit is derived by the use of the separator over the period of forty-two weeks that the cow was in milk?

Ex.—If, in testing milk for butter fat, 10 c.c. of sulphuric acid and 1 c.c. of amyl alcohol are placed in a test-bottle together with 11 c.c. of milk, what proportion does the milk bear—

(*a*) To the acid?

(*b*) To the amyl alcohol?

N.B.—Sulphuric acid for testing milk should have a specific gravity of 1·820 or 1·825 at 60° F., and amyl alcohol ·815 or ·816 at 60° F.

Richmond's Milk Scale

A very convenient method of ascertaining the total solids in milk where the specific gravity or lactometer reading and the fat content are known is by means of the Richmond sliding scale. This is made in the form of a ruler with a sliding slip in the centre. At the left top part of the ruler is a scale of

temperatures, and immediately underneath on the sliding slip is a scale of lactometer readings ranging from 22 to 37.

Supposing that the lactometer reading of a sample of milk has been taken, and the temperature noted, the corrected reading to 60° F. may be ascertained by moving the lactometer reading on the sliding slip of the scale in a line with the temperature at which the reading was taken. For example, if the lactometer reading were 33 at 64° F., the 33 on the lactometer scale should be placed in a line with 60° F., when opposite 64° F. will be shown 33·55, the corrected reading. Along the bottom of the ruler is marked a scale giving percentages of total solids, above which on the sliding slip is another scale of specific gravities or lactometer readings, and on the right top part of the ruler itself are marked fat percentages.

When the corrected lactometer reading has been found, all that is necessary to determine the percentage of total solids present in the sample is to move the sliding piece until the arrow on it points to the fat percentage known to be present. Then, opposite the corrected lactometer reading on the lower scale of the sliding piece, will be found the percentage of total solids present. Thus, if a sample, the corrected lactometer reading of which shows 33·55, has a fat percentage of 3·4 per cent., then by placing the arrow against 3·4 per cent. on the column marked fat it will be seen that the lactometer reading 33·55 is in line with 12·6 on the total solids scale, which latter figure denotes the percentage of total solids present.

Formula for Ascertaining Total Solids in Milk

Where T = per cent. total solids.
G = specific gravity or corrected lactometer reading.
F = per cent. fat.

Then,

$$T = \frac{G}{4} + \frac{6F}{5} + \cdot 12,$$

or

$$T = \cdot 25G + 1\cdot 2F + \cdot 12.$$

Solids not fat may be obtained from the following formula :—

$$\text{Percentage solids not fat} = \frac{\text{corrected lactometer reading} + \text{per cent. fat}}{4}.$$

Cost of Milk Production

Winter months (1st Oct. to 31st March)—

Concentrated foods - - - -	1½d. per gal.
Hay - - - - - -	1½d. ,,
Roots - - - - - -	1½d. ,,

Total cost per gallon :—Food, 4½d. ; labour, 3¼d. = 7¾d.

Summer months (1st April to 30th Sept.)—

Concentrated foods - - - -	⅜d. per gal.

It is estimated that every cow producing only 400 gals. of milk or less per year kept in the herd entails the loss of £1 per year, while the profit obtained from every cow yielding 800 gals. or more per year will amount to £8.

Approximate Composition of some Dairy Products

LIQUIDS

	Water.	Fat.	Casein.	Albumin.	Milk Sugar.	Ash.	Specific Gravity.
Milk - - -	87·4	3·7	3·0	0·5	4·65	0·75	1·032
Skimmed milk -	90·1	0·8	3·0	0·5	4·8	0·8	1·034
Separated milk -	90·4	0·1	3·2	0·6	4·9	0·8	1·036
Colostrum - -	71·6	4·1	4·0	15·3	3·4	1·6	1·060
Thick cream (for sale)	45·0	51·3	1·5	0·3	1·5	0·4	1·000
Thin cream (for churning)	64·4	28·0	3·4	0·6	3·0	0·6	1·015
Clotted cream -	33·5	60·0	4·3	0·7	1·0	0·5	1·000
Butter milk - -	90-95	0·5-1	3·0	0·5	4·0	0·7	1·034
Whey - - -	93	0·1-0·4	0·3	0·5	5·0	0·5	1·030
Condensed milk (unsweetened)	64	10-11	10-12	...	14·0	2-2·5	...
Condensed milk (sweetened) containing 30 to 40 per cent. cane sugar	25	8-10	10	...	13-15	2·0	...

SOLIDS

	Water.	Fat.	Casein and Albumin.	Ash.	Containing Salt.
Butter	11-13	83-88	0·3-2·0	0·6-2·2	0·5-2·0
Cream cheese	30-35	55-66	4-5	1-1·2	0·7
Soft cheese	45-50	20-25	15-20	3-4	1-2
Blue-veined cheese	30-35	32-37	25-30	3·5-4·0	2-2·5
Hard-pressed cheese	34	31	29	4·0	2-3

The quantity of salt in butter may vary from ·4 to 10 per cent., but in a well-made sample is usually from 2 to 7 per cent. There is no clear definition of a fresh or salt butter, but as a rule butter containing 1 per cent. or less may be regarded as fresh butter.

If a farmer has 20 ac. of good land he might count upon being able to keep six cows, having five always in milk, the extra cow counting for the dry period of each of the other five. Given that the cows yielded 700 gals. of milk each per year and that their calves realised £1 apiece, what would the farmer's total receipts for a twelvemonth amount to when he:—

(*a*) Retails the whole milk at 4d. per quart?

(*b*) Separates the milk, and churns the cream, obtaining 280 lbs. of butter and 600 gals. of separated milk from each cow per year; and sells the butter at 1s. 2d. per lb. and the separated milk at 1d. per gallon?

(*c*) Makes the milk into cheese, assuming that 700 gals. of milk will produce $6\frac{1}{4}$ cwt. of cheese at 58s. per cwt. and 560 gals. of whey at $\frac{1}{2}$d. per gallon?

To calculate the Quantity of Green Cheese (hard) from whole Milk

The proportion of both casein and fat in milk will influence the yield of cheese, but the quantity of the former constituent is fairly constant, so that the yield may be conveniently estimated from the fat percentage alone. In the

case of rich milk (containing about 4 per cent. fat), the quantity of green cheese produced from 100 lbs. of milk can be found in lbs. by multiplying the fat percentage by 2·7. Similarly with poorer quality milk the percentage of fat should be multiplied by 3 in order to obtain the lbs. of green cheese yielded per 100 lbs. of milk.

The following table by Richmond demonstrates the rate at which cream rises in milk. Milk with a fat content of 3·73 per cent. was well mixed and placed in vessels 24 in. deep :—

Percentage of Fat at Different Depths

	Bottom Inch.	18 in. from Top.	12 in. from Top.	6 in. from Top.	Depth of Cream.	Per cent. Fat in Cream.
					In.	
0 hr. 40 min.	2·80	3·45	3·55	3·60	...	11·0
1 ,, 35 ,,	2·35	2·90	2·98	2·90	2·09	12·6
2 ,, 30 ,,	1·95	2·65	2·72	2·75	2·09	14·2
3 ,, 30 ,,	1·42	2·62	2·72	2·75	2·05	15·2
4 ,, 30 ,,	1·30	2·58	2·62	2·68	1·97	16·2
5 ,, 30 ,,	1·20	2·55	2·58	2·62	1·89	16·8
7 ,, 30 ,,	0·90	2·52	2·53	2·55	1·93	18·2
24 ,, 0 ,,	0·23	1·88	1·90	1·90	1·89	23·5

Given the percentage of fat in milk, ascertained by the Gerber butyrometer, and the specific gravity by the lactometer, the solids not fat can be conveniently estimated by the following formula :—

$$\text{Solids not fat} = \frac{G}{4} + \frac{F}{5} + 0{\cdot}14.$$

Where G = lactometer degrees, F = fat percentage.

The specific gravity of cream may also be ascertained by the lactometer, but it must first be diluted with an equal weight of separated milk, and the specific gravity of the mixture obtained. Then the original specific gravity of the cream before dilution may be arrived at by multiplying the specific gravity of the separated milk by the specific gravity of the mixture, and dividing the result by the difference between twice the gravity of the separated milk and the gravity of the mixture.

Specific Gravity

Specific gravity may be defined as the ratio of the weight of a certain volume of a substance to the weight of an equal volume of pure distilled water, both measured at the same temperature and pressure; the specific gravity of water being taken as 1.

For ascertaining the specific gravity of milk it is usual to employ a "lactometer" which is a modified hydrometer, depending on the principle that the weight of the instrument equals the weight of liquid it displaces. Placed in water at 60° F. it will sink until the 0 of the scale is on a level with the surface of the water, representing a specific gravity of 1·000. Placed in pure new milk at 60° F. it should read from about 28 to 32, *i.e.*, a specific gravity of from 1·028 to 1·032. For temperatures other than 60° F. an allowance of 0·1 lactometer degree must be made for each degree Fahrenheit.

To calculate the Pressure applied to a Cheese by a Screw Cheese Press

Measure length of AB and AC, and DE and DF in inches (see Fig. 44).

Let W = weight in lbs.

$$\text{Then total pressure on cheese} = \frac{(W \times AB)}{AC} \times \frac{DE}{EF}.$$

Thus if W = 20 lbs., AB = 30 in., AC = 2 in., DE = 14 in., and EF = 2 in.

$$\text{Then total pressure on cheese} = \frac{\overset{5}{\cancel{20}} \times 30 \times 14}{\underset{1}{\cancel{2}} \times \underset{1}{\cancel{2}}}$$

$$= \underline{2100 \text{ lbs.}}$$

In order to ascertain whether the use of milking machines tended to make the cows go dry sooner than when hand milked, experiments were conducted between 1st February and 30th September with the following results:—

838 cows milked by machine averaged ·25 lb. strippings, each of 7·7 per cent. fat.

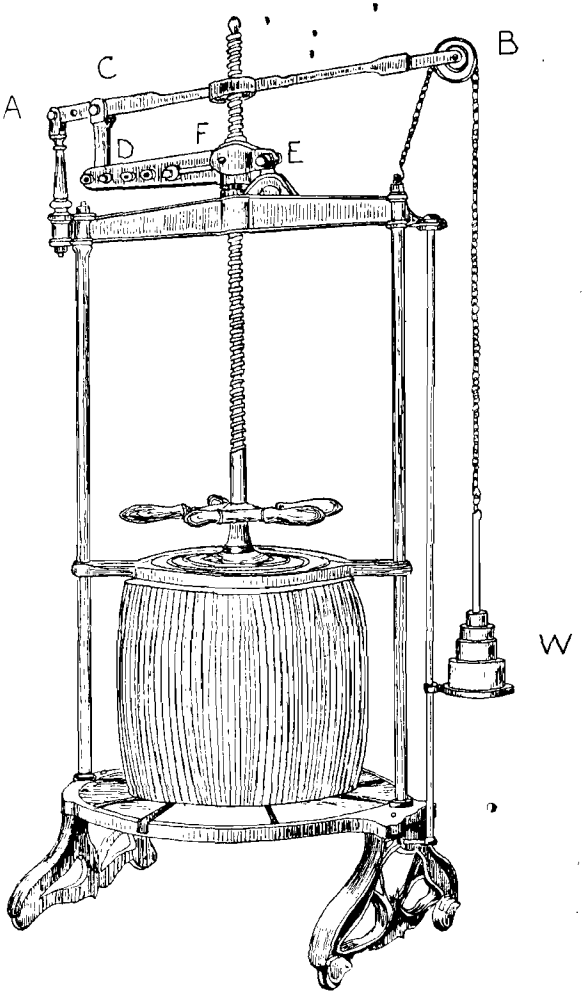

FIG. 44.

2,393 cows milked by hand averaged ·63 lb. strippings, each of 6·8 per cent. fat.

Further experiments, but on different farms, between February and September resulted as follows :—

2,451 full day milkings by machine averaged 26·55 lbs. of 3·70 per cent. of fat per cow.

10,604 full day milkings by hand averaged 26·66 lbs. of 3·62 per cent. of fat per cow.

Which method of milking yielded the richer milk, and by how much more fat?

Composition of some Hard Cheese

Name of Cheese.	Water.	Fat.	Proteins.	Sugar and Extractives.	Salt.	Ash.
Cheddar - - -	33·98	33·15	28·12	0·96	1·15	2·70
Cheshire - -	35·15	29·38	25·38	5·77	1·75	2·57
Derby - - -	35·00	28·00	29·00	4·00	1·15	2·85
Gloucester (single)	27·66	27·12	38·00	3·05	1·26	2·91
,, (double)	33·78	27·19	31·50	3·21	1·55	2·77
Leicester - -	34·05	28·28	28·54	4·94	1·12	3·07

Composition of Rennet

	Liquid.	Tablet.
Water - - - - -	78·86	0·87
Nitrogenous organic matter -	2·00	1·06
Non-nitrogenous organic matter -	0·24	2·06
Ash - - - - - -	18·90	96·01

CHAPTER IX

LABOUR

It is exceedingly difficult to estimate the cost of such labour on the farm as is performed by task or piece work. Much of the following data must therefore be regarded as approximate only. In the earlier ages labour was wholly performed by man with the assistance of the domesticated animals, such as the horse and ox, whereas at the present day machinery has to a very great extent superseded hand and horse labour. Labour-saving machines like the self-binder and the hay-tedder, for example, will do in one day that amount of work the performance of which previously required from fifteen to eighteen men. The fact that some men are possessed of considerably more strength than others, also that horses vary widely in age and breed, and the kind of soil and numerous other conditions influence the performance of similar operations in the field and elsewhere, renders it extremely difficult to attain accuracy in estimating labour.

The allotting of piece or task work has its advantage on large farms, but in order to obtain accuracy of payment the particular kind of work upon which payment is to be made must be tested by timing work actually performed. Thus if an able-bodied man can perform a given quantity of work in, say, two hours, it is then easy to estimate the scale of wages for the completion of such work. This is the case with hoeing and many other farm operations which may extend over many weeks.

A system of labour constants has been arrived at in which 1 represents the ability of 1 man to complete 1 acre or any other unit on which the price is based per day. For example,

if a man can do ½ acre per day the labour constant is arrived at by dividing the day's wages by ·5, so that if 3s. is the current day's wage the cost is 6s. per acre.

Soil Tillages

The cost of various soil operations may be estimated if we take as our standard a pair of horses ploughing 1 acre of medium ground with a 9-in. furrow. Allowance would have to be made for pace, and where the amount of "short" work is exceptional, as the less turning at the end of the furrows the greater will be the acreage completed. Where three or more horses are used an extra man or boy must be employed.

The cost of ploughing depends upon the number and quality of horses required, the amount ploughed per day, and the character of the soil. Easy working land will not require more than a pair of horses, whereas hard ground and stubbles may require three horses, and stiff clayey ground four. The amount of ground turned over in a day varies from ½ acre with two horses to 1½ acres with a pair team. The width of the furrow is an important factor, and may vary from 9 to 12 in.

Ground Work

	Cost per Acre.
Digging—	
To turn over soil with spade 2 to 3 in. without using the foot	12s. to 15s.
To dig 5 or 6 in. deep using the foot	25s. ,, 30s.
To dig 9 to 12 in. deep using the foot	40s. ,, 50s.
From 14 to 21 days are required to dig an acre.	
Double-digging or bastard trenching	£4 to £5.
Trench-digging { Top spit, 3d. per rod / In trench, 5d. per rod }	£5 ,, £7.
Turf-digging	80s.
Ploughing—	
1 man, 1 boy, 3 horses (¾ to 1 acre per day)	15s. to 20s.
1 man and 2 horses	9s. ,, 12s.
Breast-ploughing old sainfoin lea after raftering with double furrow plough	15s. to 20s.
Raising ridges with single plough	2s. 6d.
Splitting ridges with single plough	2s. 6d.

	Cost per Acre
Steam Digger—	
5 to 6 acres per day, 8 to 10 in. deep	12s.
Steam Cultivating—	
1 acre per hour, 9 in. deep, once over	7s. to 10s.
,, ,, ,, twice over	12s. ,, 18s.
Steam Ploughing—	
8 acres per day, 6 to 8 in. deep, two engines	12s.
Steam Drag-harrowing—	
30 to 50 acres per day, once over	4s.
,, ,, twice over	7s.

N.B.—The cost of carting coal and water and cost of coal should be added.

Cultivating—	
3 or 4 horses, cultivator 4 ft. wide, 4 to 6 acres per day	4s. to 5s.
2 horses, 5-tine cultivator, 3 acres per day	3s.
Harrowing—	
Drag—2 horses, 7 to 9 acres per day	1s. 3d. to 1s. 6d.
3 horses, 8 to 10 acres per day	2s. to 3s.
Zig-zag, 2 horses, 10 to 12 acres per day	9d. ,, 1s.
Seed harrows, 1 horse, 12 to 14 acres per day	6d. ,, 8d.
Chain, 1 or 2 horses, 10 to 12 acres per day	6d. ,, 8d.
Rolling—	
Cambridge, 3 horses, 7 to 10 acres per day	1s. 4d.
1-horse roller, 5 ft. wide, 8 acres per day	8d.
2-horse roller, 6 ft. wide, 8 to 12 acres per day	9d. to 1s.

Manuring

Dung—

Carting	1s. per mile per ton
Spreading	2d. per load; 1s. 6d. to 2s. per score loads
Filling	1½d. per load; 2s. per score loads

Filling and spreading, 16 loads per acre.

Turning, 1d. per load, ½d. to ¾d. per cubic yard measured after heap litter, 1s. per score loads.

Sowing artificials (broadcast at rate of 5 cwt. per acre)	2s. 6d. per ton
Sowing soot	¾d. per bushel, 5s. per 100 bus.
Spreading lime	4½d. per ton, 8 tons spread per day

A cart load is about 1 ton, which is sufficient for one horse

to pull, while a waggon yoked to two horses is seldom loaded beyond 3 tons.

Sowing and Planting

	Cost per Acre.
Sowing corn, broadcast, 1½ acres per hour	3d. to 4d.
,, clover, broadcast with barrow	3d. ,, 4d.
,, grass seed, by hand	3d.
,, ,, by barrow	6d. to 8d.
Drilling corn, 2 men, 1 boy, 3 horses, 8 to 12 acres per day	1s. 6d. to 2s.
Drilling turnips, 1 man, 1 horse, 2-rowed drill, 6 to 7 acres per day	9d.
Burning ashes for drill, 1d. per bushel of ashes produced	2s. to 2s. 4d. per cubic yard of 21 bus.
Dibbling beans, according to distance apart	5s. to 8s.
Setting out plants	8d. per 1,000
Planting cabbage, according to distance	8s. to 12s.
Setting plants—1 man, with boy to pull and puddle seedlings, will plant 5,000 to 7,000 per day.	

Hoeing

The cost of hoeing will largely depend upon the condition of the soil and its freedom from weeds of perennial growth, such as couch, knotweed, convolvulus, etc. Retentive soils, and others of a gravelly nature, which become hard and set after heavy rains, render hoeing difficult and expensive.

	Cost per Acre.
Flat-hoeing mangels, first time	6s. 6d. to 12s.
,, swedes, ,,	5s. to 7s. 6d.
,, cabbages, set out	5s. ,, 6s.
,, wheat	4s. ,, 6s.
,, peas	3s. 6d. to 5s.
,, beans	4s. to 5s.
,, mangels, second time	5s. ,, 7s. 6d.
Singling, turnips or swedes	5s. ,, 6s.
,, mangels	6s. ,, 7s. 6d.
Horse-hoeing, 1 man, 1 horse and boy, 3 to 5 acres per day	1s. 6d. to 2s.
Docking and thistleing (extremely variable)	2s. to 3s.

Harvesting and Threshing

	Cost per Acre.
Mowing with machine, meadow grass	1s. to 1s. 6d.
,, by hand, water meadow	7s. ,, 12s.
,, ,, meadow	5s. ,, 6s.
,, ,, light grass crops	4s. ,, 5s.
,, ,, clover or sainfoin	4s. ,, 5s.
,, barley or wheat	3s. ,, 4s.
Cutting round fields (large areas)	2d.
,, and fagging peas in "wads"	6s. to 8s.
,, beans and stooking	7s. ,, 10s.
,, with scythe or hook, and stooking laid wheat or oats	10s. ,, 20s.
,, tying up, stooking, and raking, wheat	9s. ,, 12s.
,, with self-binder, 10 to 12 acres per day, including string	4s. 3d. to 6s.
After reaper, tying up wheat or oats	4s. to 7s. 6d.
Stooking, after binder	10d. ,, 1s.
Pitching and loading	9d. ,, 1s.
Rick-building	10d. ,, 1s.
Thatching ricks	10d. to 1s. per square of 100 sq. ft.
,, ,, when straw is drawn	5d. to 6d. per square
Yelming or drawing straw	¼d. per bundle
Stacking grain	4s. to 5s.
,, hay	3s. ,, 4s.

One man will pitch 5,000 to 6,000 sheaves of corn per day.

Two men with their teams with one binder will cut from 10 to 16 ac. per day, working in alternate shifts.

Estimated Cost of Threshing

	£	s.	d.
Hire of 8 horse-power engine and "drum" with driver and feeder	1	15	0
Coal and oil	0	8	0
Water carting, 1 man and horse	0	7	6
3 men pitching on rick	0	7	6
1 man attending to sacks	0	2	6
1 man and 2 horses removing corn	0	5	10
Use of straw elevator	0	5	0
2 men on straw rick	0	5	0
Labour in removing chaff, 1 man	0	2	6
	3	18	10

If engine and machine are part of the equipment of

the farm, the use and wear and tear can be put down at £1 per day.

Threshing, 1s. 6d. to 2s. 6d. per quarter.

Marketing

Preparing crops for market, contractor finding engine and machine and feeder.

Threshing by contract—wheat	1s. 4d. per qr.
,, ,, barley	1s. 2d. ,,
,, ,, oats	10d. ,,
Winnowing	2d. ,,
Screening	2d. ,,

Cost of delivering corn a distance of 2 miles with 1 waggon, 2 horses, and 2 men, assuming 32 qrs. of wheat, 30 qrs. of barley, or 36 qrs. of oats per day, would amount to 2 horses at 1s. 8d., and 2 men at 2s. 6d. = 8s. 4d.

Raising and Storing Root Crops

	Cost per Acre.
Swede lifting	7s. 6d. to 10s.
Mangel pulling, and throwing on to cart	8s. 6d. ,, 10s.
,, and putting ready for filling	6s. to 9s.
Pulling, cleaning, heaping, and covering swedes	8s. ,, 9s.
Heaping swedes and covering with earth and straw	7s.
Covering triangular heaps, 6 ft. wide at base, with straw and 8 in. of soil	10d. to 1s. per rod in length
Carrots, lifting and filling into cart	20s. to 25s.
Potato raising by hand	30s.
,, by digger	10s.
,, gathering after ploughing	15s.
,, digging, gathering, and filling carts	20s. to 25s.

Miscellaneous

Hedge trimming (two sides)	4d. per chain
,, cleaning	7d. ,,
,, cutting	3d. to 4d. per rod
,, laying	6d. to 8d. per pole, 2s. 6d. per chain
,, trimming of 1 year's growth	2½d. per chain
,, ,, 2 years' ,,	6d. ,,
Setting quicks	1s. 1d. per pole

Scouring hedges	6d. per chain
Stone breaking	9d. to 2s. 6d. per cubic yard
,, dykeing	1s. 6d. per lineal yard
,, picking	3d. per bushel, or 1s. per cubic yard
Gate hanging	5s. each
Gate, or slat hurdle	2s. per doz. to make, sold at 11s. to 12s. per doz.
Faggoting	4s. per 120
Making faggots	6d. per score
Trussing hay, 2 tons daily	4s. per ton
Thatching cottages	4s. per square
Ditching (digging)	5d. per pole
,, (cleaning out)	8d. per chain
Mole catching	1d. to 2d. each.

Draining

Digging 3-ft. drain in uniform clay	1d. per yard run
Laying pipes in trench	½d. per rod
Draining (3 ft.), cutting, and filling	2s. per chain
,, ,, mains	2s. 6d. ,,
,, ,, eyes	6d. each.
,, levelling, and returfing	3d. per chain

Livestock

Stockmen and shepherds are often paid a bonus in addition to their weekly wage, which may also include house, garden, etc.

6d. for each lamb weaned.
9d. to 1s. for every pair of lambs weaned.
1s. for every ram sold (on ram-breeding farms).
3d. for each pig weaned.
1s. for every calf weaned.
5s. for each foal born.
6d. for every couple of fowls marketed.
1d. or 2d. for every score of eggs collected.

Pasturing cow	2s. 6d. to 3s. 6d. per week
To take full charge of cows and find milkers	1s. 6d. per cow per week
Cow attendance in milk	10d. per cow per week
Cow on winter keep in stall	7s. per week for 28 weeks
Pasturing horse	2s. 6d. to 3s. per week
,, sheep	6d. per week
Sheep dipping	1d. each
tending	1d. per head per week

Sheep shearing	-	3s. 6d. per score for stock sheep
,, ,,	-	4s. ,, ,, market ,,
,, ,,	-	special, 4s. 6d. to 5s. per score

A skilled hurdle-maker can make 9 wattle hurdles per day of ten hours, and is paid at the rate of 4s. per dozen.

(*a*) How long would it take him to make 13 doz. of such hurdles?

(*b*) What would be his earnings per week of 6 days?

(*c*) What would the hurdles be sold for at £3. 10s. per load of 10 doz.?

In the manufacture of a gate or slat hurdle, 7 spars or slats are used, together with 2 braces and 3 uprights, the cost of making being 2s. per dozen, and the selling price 11s. per dozen. What number of slats, braces, and uprights would be required for the manufacture of 9 doz. of such hurdles, and what is the cost of making and selling price per hurdle?

If the total cost of erecting a fence for protecting young hedges, and capable of resisting cattle and horses, with galvanised wire, larch stakes and strainers, is £10. 6s. for 250 yds., while a fence needed only against rabbits, hares, or sheep of wire netting 3 ft. high costs £8. 1s. 3d. per 300 yds., compare the cost of each per lineal yard.

A good hoer taking a 5 ft. 6 in. to a 6 ft. stroke will hoe $\frac{3}{4}$ ac. per day of oats and barley on loose land. How long would it take two such hoers to hoe an 8-ac. piece of barley?

In parts of Scotland and elsewhere tenants pay at the rate of 6d. per spade's casting of peats per annum. A spade's casting of peats is 9 ft. lineal of peat bank and 60 yds. lineal of lair of the breadth of 9 ft. How much area, therefore, does one lair cover, and what would be the cost of 9 spades' castings per annum for 7 years?

If there are 30 barrowfuls of peat to a cartload, and each barrowful occupies 1 sq. yd., how many barrowfuls and how many cart-loads of peat would there be in each lair?

If a casting is dug to a depth of 3 peats or about 6 ft., what is the cubic content of a lair of peat?

Table of Wages

	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Per day (6 to week) -	0 0 10	0 1 0	0 1 2	0 1 4	0 1 6	0 1 8	0 1 10
,, week - -	0 5 0	0 6 0	0 7 0	0 8 0	0 9 0	0 10 0	0 11 0
,, annum - -	13 0 0	15 12 0	18 4 0	20 16 0	23 8 0	26 0 0	28 12 0
Per day (6 to week) -	0 2 0	0 2 2	0 2 4	0 2 6	0 2 8	0 2 10	0 3 0
,, week - -	0 12 0	0 13 0	0 14 0	0 15 0	0 16 0	0 17 0	0 18 0
,, annum - -	31 4 0	33 16 0	36 8 0	39 0 0	41 12 0	44 4 0	46 16 0
Per day (6 to week) -	0 3 2	0 3 4	0 3 6	0 3 8	0 3 10	0 4 0	...
,, week - -	0 19 0	1 0 0	1 1 0	1 2 0	1 3 0	1 4 0	...
,, annum - -	49 8 0	52 0 0	54 12 0	57 4 0	59 16 0	62 8 0	...

Implements

Children attending rural schools, and also many agricultural students, have little or no knowledge respecting the prices of ordinary tools and implements used on the farm.

While prices can be ascertained through the medium of trade catalogues, those who do not contemplate the purchase of implements would not be justified in securing catalogues merely for the purpose of providing themselves with this special knowledge; especially when it is known that the cost of publishing many of the more elaborate trade catalogues is a heavy tax on the manufacturer.

The following data, although by no means complete, will be useful to teachers in framing examples, and to students in affording them some idea, if only approximately, of the cost of the commoner agricultural implements.

Cost of Miscellaneous Implements

	£	s.	d.
Beehive, bar frame	1	0	0
Bin	£2 to 2	10	0
Binder	25	0	0
Broadcaster, corn and seed, 9 ft. wide	15	15	0
Bushel measure	0	7	6
Butter paper, good quality, per ream	0	6	9
Butter worker	2	5	0
Cake crusher	3	10	0
Cart, general purposes, to carry 30 cwt., 4-in. by $\frac{5}{8}$-in. tyres	17	10	0
Chaff-cutter, three knives	£10 to 12	0	0
Cheese press, double	7	10	0
,, single	4	5	0
Cheese vat, up to 50 gals. 9d. per gallon, over 50 gals. 8d. per gallon.			
Churn, butter, capacity $2\frac{1}{2}$ gals.	3	10	0
,, railway	1	5	0
Clod crusher, or ring roller, width 8 ft., 22-in. cylinders, weight $16\frac{3}{4}$ cwt.	15	0	0
Cooler, milk, according to capacity, *e.g.*, 40 gals. per hour	2	10	0
Cramming machine, poultry	2	10	0
Cultivator	12	0	0

Cost of Miscellaneous Implements (continued)—	£	s.	d.
Drill, corn and seed, ten rows, 5 ft. 5 in. spread	25	10	0
,, ,, fifteen rows, 8 ft. 1½ in. spread	31	0	0
,, ,, three coulters, and adapted for rows at 16 and 24 in. apart	24	0	0
,, manure and seed, six coulters, wheels 8 ft. wide, for rows 16, 19, and 24 in. apart	31	0	0
,, hand, with box and guide irons	3	0	0
,, turnip and mangel, six rows, width 7 ft.	12	10	0
Elevator	35	0	0
Fork, digging	0	4	6
,, hay	0	2	6
Foster mother, for 60 chicks	2	10	0
,, for 100 chicks	3	0	0
Harness, set of, for cart horse	8	0	0
Hay knife	0	15	0
,, tedder	8	10	0
Harrows for two horses, width 8 ft. 6 in.	4	0	0
,, for three ,, ,, 10 ft. 6 in.	5	5	0
,, light seed zig-zag, 8 ft. 6 in.	3	6	0
,, expanding chain, 8 ft. by 7 ft. 6 in.	3	0	0
,, spike and link, 7½ ft. by 6½ ft.	3	4	0
Hen-coop	0	3	6
Hoe, steerage horse, for three rows turnips, mangels, etc.	8	10	0
,, pony, for light soil for one row, turnips, mangels, etc.	2	15	0
,, expanding horse, with five tines	3	5	0
Honey extractor	£1 to 2	0	0
Incubator, for 50 eggs	2	15	0
,, for 100 eggs	£3. 10s. to 4	10	0
Ladder	9d. per ft.		
Manure distributor, width 9 ft.	18	0	0
Milk recorder	2	0	0
Mower and reaper combined	£16 to 18	0	0
Pails, milk, 4 gals.	0	7	0
Petrol engine (horizontal), 1 H.P.	16	0	0
,, (vertical), 2½ H.P.	26	0	0
Plough, general purpose, two wheels, for light or heavy soil	5	0	0
,, ,, one wheel, for light or heavy soil	4	17	6
,, swing	4	10	0

Cost of Miscellaneous Implements (continued)—

	£	s.	d.
Pulper, root, hand - - - - £2. 10s. to	3	10	0
Presser, land, two wheels, 36-in. diameter - -	7	10	0
,, three wheels, 42-in. - -	9	10	0
Rake, two-horse, manual delivery - - -	15	10	0
,, hay, single horse - - - - £8 to	10	0	0
Raves, curved harvest - - - -	2	0	0
Roller, flat, three cylinders, width 7½ ft., cylinder diameter 18 in., weight 10½ cwt. - - -	10	15	0
Sacks, each - - - - - - 1s. to	0	1	6
Sack barrow - - - - - -	1	10	0
,, lifter - - - - - -	2	10	0
Seed barrow for clover and grass seeds, 12 ft. wide, single box - - - - - -	3	15	0
Scotch hands - - - - - -	0	2	6
Separator, 44 gals. per hour - - - -	12	0	0
Scythe - - - - - - - 5s. to	0	7	6
Spade - - - - - - -	0	4	6
Swath turner - - - - - -	12	0	0
Scarifiers, wrought-iron, 13 tines, width of cut 6 ft. 8 in. - - - - - - -	10	0	0
Waggon, farm - - - - - -	35	0	0
Water barrow, capacity 30 gals. - - -	1	18	0
Winnowing machine, width 24 in. - - -	6	15	0

CHAPTER X

VALUATION

FARM valuations may be regarded as of two kinds, namely, that made for the purpose of ascertaining the interest in the farm of an outgoing tenant, or in other words Tenant Right Valuation, and that made annually by the farmer himself for the purpose of accurately determining, in conjunction with a properly drawn up balance-sheet, his exact financial position at the end of the year. The system of valuation varies greatly in different counties, doubtless due to the different and long-standing customs, also systems of farming in vogue through the variation in soil and climatic conditions. It is never an easy matter for a valuer to make an accurate valuation outside his own county, or the district with which he is familiar.

Tenant right or outgoing valuation is a very complicated business, but the following values may afford some guide although variations in price are sometimes considerable, caused by the scarcity or prevalence of various crops, etc., in different counties.

Cultivations.—Details of the acreage of the fields and the labour employed are usually supplied by the outgoing tenant. The approximate cost of the various soil operations will be found on p. 173, and the value of the cultivations for the different crops may be estimated accordingly. For example, taking a crop of 5 ac. of swedes, this might be valued somewhat as follows :—

Ac.	R.		Swedes :—	£	*s.*	*d.*
£0	12	0	1 Ploughing (3 horses)			
0	5	0	2 Cultivates			
0	1	3	1 Dragging			
0	5	0	Collecting weeds			
0	2	0	2 Heavy harrowings			
0	1	6	2 Light ,,			
0	2	6	2 Rollings			
0	2	6	Drilled			
0	3	0	Seed			
0	12	0	Artificial manure			
0	4	0	2 *Horse hoeings*			
0	14	0	Singling and hand hoeing			
0	16	0	Rent, rates, taxes, etc.			
£4	0	9		20	3	9
				20	3	9

Hay and Straw.—Where this produce constitutes part of the tenant right, the usual and most convenient method of assessing the value is at consuming or feeding price, although in some districts it is taken at a market price. Consuming price in the case of hay is generally accepted as two-thirds of the market price. With straw, consuming price may be taken at from one-third to two-thirds of the market price according to the locality, but more often a price is fixed per acre for an average crop of the different straws, as follows :—

Wheat straw varies from 7s. to 16s., average 11s. per acre.
Oat ,, ,, 8s. to 9s., sometimes more.
Barley ,, ,, 5s. to 8s.
Bean or pea haulm, if valued, is 5s. per acre at the most.

Farmyard Manure.—When the manure is taken over by the new tenant at full market value, the price per load varies from 3s. 6d. to 5s., including cost of labour, or an average of 4s. 6d., while the dung that has been applied to the land is valued per acre at not more than £5. If the manure is assessed at consuming price it is usual to estimate it at two-thirds of the market price plus cost of carting and spreading. An average price is 3s. 6d. per load, or 75s. per acre, together with cost of turning at, say, 3d. per load, and spreading at

about 3s. per acre. The size of a load is taken as 1 c. yd. but it may vary up to as much as 40 c. ft.

Artificial Manures and Feeding Stuffs.—The allowance made for artificial manure depends upon the kind of manure and to what extent it is exhausted by the crop. Where root or green crops are valued at either market or consuming price no valuation is made of the manure, while where the crop is valued at cost of tillages and seed, the whole value of the manure is estimated. If artificial manure is applied to a corn crop in the last year of the tenancy it is considered to be entirely exhausted, the only exception being undissolved bones which are estimated on a three or four years' principle. With manures applied to pastures, two years is generally allowed, or from three to five years in the case of dissolved bones, and from six to ten in the case of undissolved bones. Very soluble manures, *e.g.*, nitrate of soda and sulphate of ammonia, are excepted, owing to their easy solubility. The allowance for the manurial value of the various concentrated foods fed on the farm is usually one-third of the cost of linseed and cotton cake, rape cake, meal and malt culm fed in the last year of the tenancy, and one-sixth of the cost of that of the year previous. Corn, whether purchased or home grown, and if fed to other beasts than horses regularly employed on the farm, is estimated at one-sixth of the cost of that fed in the last year and one-twelfth of the preceding year.

Land Improvements.—Of these draining is undoubtedly one of the most important, but the basis of compensation for this work naturally varies greatly according to the number of years over which it is likely to prove of service. Where the most beneficial results accrue it is estimated to last for thirty five years, or where less benefit is received twenty-five years, and lastly fifteen years. The amount, therefore, annually deducted for exhausted value will be $\frac{1}{35}$, $\frac{1}{25}$, and $\frac{1}{15}$ respectively. In the case of improvement by chalking the cost of carting and spreading with pit close at hand is 1s. 6d. per load or 2s. 6d. to 3s. if carted for some distance, and another

1s. may have to be added per load for cost of chalk, so that 70s. may be regarded as the average cost per acre. The period over which the benefit extends, whether on pasture or arable land, varies from six to twenty years and the compensation therefore varies accordingly. Twelve years may be taken as a general average, and the full value should be allowed for the first three years, as very little benefit ensues until the chalk has been applied some time. Liming will cost £4 per acre and remuneration will extend over three, eight, ten or even more years according to the character of the soil.

Annual Valuation.—This valuation or stock-taking is usually made at the end of the year although some prefer to take it at the anniversary of the commencement of their tenancy each year.

Livestock are usually taken at the current market value, or in some cases it is preferable to place a definite value on the usual working and breeding stock of the holding each year, and value the selling stock only at market price.

Machinery, implements, harness, etc., will all require an annual deduction of from 5 to 10 per cent. from the valuation made in detail at the commencement of the tenancy to set off depreciation caused by wear and tear. Thus the usual amounts to deduct annually are as follows:—

Waggons, carts, etc., in general use	8 to 10 per cent.
Harvest and other carts occasionally used	5 ,,
Ploughs, cultivators, drags, harrows, etc.	5 to 10 ,,
Threshing and winnowing machines	5 to 7½ ,,
Machine belting	15 to 20 ,,

Hay and straw is taken at market value or at consuming value, namely, two-thirds of market value.

Corn, either threshed or in rick, at current market prices.

Growing crops at cost of production as for Tenant Right Valuation (see *ante*, p. 184).

Tillages for succeeding crops at cost price (see p. 173).

Dung, if included in tenant right, should be also included in the annual valuation accordingly. Otherwise the labour on the same is only taken into account.

Feeding Stuffs, Manures, etc., in stock are valued at cost price. If applied, unexhausted value should be estimated as in the case of Tenant Right Valuation.

A properly drawn up balance-sheet should be prepared showing in addition to the valuation all assets from other sources and the total liabilities, to which latter should be added any allowance for which the tenant may be liable in respect of dilapidations.

In valuations it is usual to value hay in the stack-yard at market price, less manurial value. This would vary from £2. 10s. to £4 per ton. Similarly, straw may be valued at from 20s. to 30s. per ton; corn in the stack or in the granary at its market value. Mangels in clamp at 8s. per ton, as these could not be taken at selling price, but only at their feeding value. What, therefore, would be the value of the following, taking an average from the above prices?

18 tons meadow hay.
15 tons wheat straw.
8 tons oat straw.
30 qrs. wheat at 35s.
40 qrs. oats at 21s.
125 tons mangels.

Building Repairs

Farm buildings are continually undergoing repair, and very often it is necessary for a farmer to have some elementary knowledge of building construction. With regard to the ordinary everyday repairs much information is contained under other headings, such as that of Labour, Drainage, Measurement of Timber, etc. It is very useful to be able to form an accurate estimate of repairs, or failing this, to be able to state somewhat accurately the amount and nature of the materials required to complete such repairs as are necessary.

The cost of maintaining all the buildings on a farm in good condition will, of course, depend on their age, the care with which they have been formerly treated, and the materials and method of construction. For those in good condition the cost

may be estimated, at about 10 per cent. of the farm rental, while for those of only a temporary character, or in a dilapidated condition, 16 to 20 per cent. should be allowed.

Tenants from year to year are generally liable only for dilapidations resulting from accident, carelessness, negligence, wilful and other damage that may arise from neglect. The following particulars give the average cost of labour and materials respectively, in order to render them applicable where the tenant is liable for the former and the landlord the latter:—

	Labour.			Materials.			Total Cost.		
*Bricklayer—	£	s.	d.	£	s.	d.	£	s.	d.
Brickwalling, 14 in., worked fair both sides, ¾ place bricks and ¼ stocks per rod	3	10	0	8	10	0	12	0	0
All stocks	3	10	0	10	0	0	13	10	0
Brick-nogged partitions, flat (including timber), per yard super.	0	1	3	0	2	3	0	3	6
Brick-nogged partitions, on edge, per yard super.	0	0	11	0	1	7	0	2	6
Raking out and pointing flat joint in mortar, per yard super.	0	1	2	0	0	6	0	1	8
Taking down old brick-work, cleaning and stacking bricks and finding scaffolding, per rod	2	8	0		...		2	8	0
Taking down, cleaning, and stacking only, per rod	1	4	0		...		1	4	0
Paving of floors of cottages and outhouses with hard stock bricks laid flat in sand and grouted in mortar, per yard super.	0	0	8	0	2	10	0	3	6
Do., on edge, per yard super.	0	1	6	0	3	0	0	4	6
Mason—									
Taking down old masonry, cleaning and stacking the stone, per yard cube	0	2	0		...		0	2	0
Building 18-in. rough random walling, including scaffolding, per yard super.	0	1	6	0	6	0	0	7	6

* From Bright's "Agricultural Surveyor's Handbook."

	Labour.			Materials.			Total Cost.		
Mason (*continued*)—	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
Building random coursed worked walling, per yard super.	0	2	0	0	7	0	0	9	0
Flat pointing, per yard super.		...			...		0	0	9
Tuck pointing, per yard super.		...			...		0	1	3
York stone step, 3 ft. 6 in. × 9 in. × 6 in. each		...			...		0	13	0
Do., coping, 13 in. × 2½ in. per foot run		...			...		0	2	0
Bath stone window sill, 4 ft. × 8 in. × 3 in. tooled, weathered, and throated, each		...			...		0	5	0
York stone sink, 3 ft. 6 in. × 2 ft. × 6 in., each		...			...		0	15	0
2-in. tooled York paving, jointed in cement, per yard super.	0	1	0	0	6	0	0	7	0
3-in. do. do.	0	1	0	0	7	0	0	8	0
Taking up and relaying, per yard super.	0	2	0	0	0	6	0	2	6
Pebble paving, 4 in. deep, laid in screened gravel, per yard super.		...			...		0	7	0
Tar paving, on 4-in. concrete, per yard super.		...			...		0	6	0
Asphalt paving, ¾ in. thick, on concrete, per yard super.		...			...		0	5	0
Drains—Excavating, laying, and filling in with—									
Glazed socket 3-in. pipes with cement joints, per yard lineal	0	0	4	0	1	6	0	1	10
Do., 4-in. do. do.	0	0	5	0	1	10	0	2	3
Do., 6-in. do. do.	0	0	6	0	2	6	0	3	0
Do., 9-in. do. do.	0	0	7	0	3	0	0	3	7
Carpenter—									
Common lean-to roofs, per square	0	4	0	1	0	0	1	4	0
Common span roofs, with purlins, per square	0	6	0	1	8	0	1	14	0
Framed roofs, with purlins and rafters, per square	0	12	0	1	8	0	2	0	0
Joists and 1-in. board floors, wrought folding, per square	0	11	0	1	9	0	2	0	0
Ceiling joists, per square	0	5	0	0	6	0	0	11	0
Barn floor, 2-in. oak plank, listed and dowelled, per square	0	16	0	4	4	0	5	0	0
4-in. partitions, framed and braced, and lathed and plastered on both sides, per square	0	15	0	1	10	0	2	5	0

	Labour.			Materials.			Total Cost.		
Carpenter (*continued*)—	£	s.	d.	£	s.	d.	£	s.	d.
Weather boarding, rough, per square	0	4	0	0	17	0	1	1	0
Do., splayed edges, per square	0	5	0	1	0	0	1	5	0
Doors, ledged—									
1¼-in. rough edges, shot, per foot super.	0	0	3	0	0	6	0	0	9
Do., ploughed and tongued, per foot super.	0	0	4	0	0	6	0	0	10
Do., braced, per foot super.	0	0	4½	0	0	6	0	0	10½
Do. do., and hung folding, per foot super.	0	0	5	0	0	6	0	0	11
Refacing old doors, per foot super.		...			...		0	0	6
Ordinary door frames, and fixing, each	0	6	6	0	6	0	0	12	6
Deal mangers, 1½-in. wrought, rabbeted and round capping, 3 in. × 2 in., per foot run	0	0	9	0	0	6	0	1	3
Oak mangers, 1½-in. wrought, rabbeted and round capping, 3 in. × 2 in., per foot run	0	0	11	0	0	7	0	1	6
Feeding trough, per foot run	0	0	9	0	0	6	0	1	3
Slater and Tiler—									
Slates laid with 2½-in. lap, with copper nails, per square	0	7	0	1	6	0	1	13	0
Do., strip and relay, per square	0	8	0		...		0	8	0
Pantiles laid dry, per square	0	4	0	0	18	0	1	2	0
Do., pointed inside, per square	0	8	0	1	2	0	1	10	0
Do., pointed outside, per square	0	7	0	1	2	0	1	9	0
Do., pointing old work outside, per square	0	3	6		...		0	3	6
Do., pointing old work inside, per square	0	6	6		...		0	6	6
Old pantiling, stripped, new lathed, and relaid dry, allowing 20 new tiles to the square, per square	0	12	0	0	8	0	1	0	0
Plain tiling, laid to a 4-in. gauge, and fir laths, per square	0	7	0	1	13	0	2	0	0
Do., laid to a 3½-in. gauge, and fir laths, per square	0	9	0	1	16	0	2	5	0
Do., laid to a 3-in. gauge, and fir laths, per square	0	10	6	1	19	0	2	9	6
If with oak laths add 3s. per square									

	Labour.			Materials.			Total Cost.		
Slater and Tiler (*continued*)—	£	s.	d.	£	s.	d.	£	s.	d.
Old plain tiling, stripped off, new double fir laths, and retiling, allowing 100 new tiles to the square, per square	0	18	0	0	10	0	1	8	0
Thatch, laying new coat of thatch on old materials, per square	0	4	0	0	16	0	1	0	0
Sundries—									
Lime-whiting walls, per yard super., each coat	...			...			0	0	1½
Do., ceilings, per yard super., each coat	...			...			0	0	2
Wash, stop, and whiten, per yard super., each coat	...			...			0	0	3½
Render, float, and set walls, per yard super., each coat	0	0	8	0	0	4	0	1	0
Sizing and preparing walls and hanging paper, per piece, 8d. to 1s.									
Setting small grates, each - -	...			...			0	5	0
Do., cottage ranges, each - -	...			...			1	0	0
Glass, 21 oz., including glazing, per foot super.	...			...			0	0	6

Painting

The surface which a given weight of paint will cover varies with the density and viscidity of the mixture, also with the nature of the material to which it is applied. For estimates it may be assumed that, approximately:—

1 lb. of white paint mixed with oil, etc., will cover on wood about $4\frac{1}{2}$ yds. super. the first coat, $6\frac{1}{2}$ yds. the second, and $6\frac{3}{4}$ yds. each additional coat.

1 lb. of red-lead paint, mixed and applied as a first coat on iron, will cover about 5 yds. super. The cost will be about $4\frac{1}{2}d.$ per yard for the first coat, and $2\frac{1}{2}d.$ per yard for the second coat.

	Labour.			Materials.			Total Cost.		
Gates and Fences—	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
9-ft. field gates, oak, sawn, each	0	4	0	0	11	0	0	15	0
Do., cleft, sawn, each - -	0	5	0	0	15	0	1	0	0
Do., larch, sawn, each - -	0	2	6	0	7	6	0	10	0
Do., red deal, sawn, each -	0	2	0	0	5	6	0	7	6
Hanging post, oak, 8 ft. × 8 in. × 7 in., and fixing, each	0	2	6	0	9	0	0	11	6
Catch post, 7 ft. × 6 in. × 6 in., and fixing, each	0	2	0	0	6	6	0	8	6
Ironwork, per set - - -		...		0	3	6	0	3	6
Fixing posts and hanging gate, per set	0	5	0		...		0	5	0
4-ft. oak wicket gates, each -	0	2	0	0	7	0	0	9	0
Oak posts, per pair - - -		...			...		0	8	0
Fixing posts and hanging gate, per set	0	3	0		...		0	3	0
Stiles, with 2 oak posts, 6 ft. × 5 in. × 5 in., and 4 rails, 6 ft. × 4 in. × 2½ in., per set	0	3	0	0	11	0	0	14	0
Fixing do., per set - -	0	2	6		...		0	2	6
Fencing, oak posts, 9 ft. apart, mortised for 4 larch or elm rails, with intermediate upright, per yard run	0	0	6	0	2	6	0	3	0
Oak park pale fencing, with 2 arris rails and oak posts 9 ft. apart—									
3 ft. high, per yard run - -		...			...		0	4	0
4 ft. ,, ,, ,, - -		...			...		0	4	6
5 ft. ,, ,, ,, - -		...			...		0	6	0
6 ft. ,, ,, ,, - -		...			...		0	7	6
Trimming thorn hedges, per chain		...			...		1d. to 3d.		
Filling up gaps in hedges, per perch		...			...		9d. ,, 1s.		
Cutting, laying, and making good fence, per perch		...			...		1s. to 1s. 6d.		
Cleaning out shallow ditches, per perch		...			...		1d. to 2d.		
Wiring old thin fence, 1 wire, per perch		...			...		8d.		
Do., 2 wire, per perch - -		...			...		1s. 2d.		

Walls

Rubble stone walls should be one-third thicker than those constructed of brick; a minimum thickness of 18 to 20 in. being generally adopted for outside and 12 to 15 in. for interior walls.

One ton of ordinary rag or limestone for rubble work will form about 23 c. ft. in bulk.

Rubble masonry when built in courses requires per cubic yard about 35 c. ft. of stone, including waste, and $6\frac{1}{2}$ c. ft. of mortar; but in random and common uncoursed rubble-work 33 c. ft. of stone and 9 c. ft. of mortar are required.

Twenty-two bushels of rough flint, with 1 bus. of split flints to every yard superficial of face, and 8 c. ft. of mortar will build 1 c. yd. of flint walling.

The cost per square of external partitions built on brick or stone foundations and covered with weather boarding will be approximately as follows:—

	s.	*d.*
Partitions framed and braced	17	6
Weather boarding, rough	9	0
Nails and fixing	3	6
Two coats gas tar	2	6
Proportion of cost of foundations	20	0
	52	6

or about 4s. 9d. per yard super.

The outside walls of farm buildings when constructed of brick may be of a minimum thickness of 9 in. for one story erections, if strengthened with 14-in. pillars, 10 ft. apart, to carry roof trusses.

For buildings of two stories the walls should be 14 in. thick.

In the neighbourhood of London, brickwork is measured by the rod of $16\frac{1}{2}$ ft. sq., and reduced to the standard of $1\frac{1}{2}$ bricks in thickness. In other parts of England the cubic yard is generally used as a standard of measurement.

One rod of brickwork = $16\frac{1}{2}$ ft. × $16\frac{1}{2}$ ft. × $1\frac{1}{2}$ ft. = 306·2812 c. ft. = 11·34375 c. yds.

One rod of brickwork = 272 super. ft., of the standard thickness of $1\frac{1}{2}$ bricks.

The cost of mortar is usually about 11s. per cubic yard, estimated as follows :—

3 yds. of sand at 5s.	15s.
1 yd. stone-lime at 10s.	10s.
Carriage and mixing (about)	8s.
Cost of 3 c. yds.	33s.

Cost per cubic yard = 11s.

In calculating the cubic content of buildings, the height is taken from the footings to half the height of the roof and multiplied by the length and width of the walls of the structure.

A good concrete can be made of clean gravel, broken hard brick or ballast, or similarly hard material, well mixed with freshly burnt ground Blue Lias stone-lime or Portland cement, in the proportion of 1 of lime to 6, and 1 of cement to 8, of the other material.

A cubic yard, or 27 c. ft., of ordinary concrete requires 34 ft. of gravel, sand, and lime. Therefore, in the proportion of 6 to 1, a cubic yard of concrete will require 1·1 yds. of gravel and sand to 3 bus. of lime, without taking into consideration any decrease of bulk (usually one-sixth) for ramming.

Assuming the cost of lime to be 9d. per bushel, Portland cement 2s. per bushel, and gravel 5s. per yard cube, the expenditure on concrete would be as follows :—

Lime Concrete—

1·1 yds. gravel at 5s.	5s. 6d.
3 bus. Blue Lias ground lime at 9d.	2s. 3d.
Mixing, wheeling, depositing, and ramming	1s. 3d.
Cost per yard cube	9s. 0d.

Concrete if under 1 ft. thick, is usually charged by the

yard super.; and if over 1 ft. thick by the yard cube, according to the nature of the materials.

Concrete Cement—

1·1 yds. gravel at 5s.	5s. 6d.
3 bus. Portland cement at 2s.	6s. 0d.
Mixing, wheeling, depositing, and ramming	1s. 3d.
	12s. 9d.

or per yard super., 12 in. thick, 4s. 3d.
,, ,, 6 ,, 2s. 1½d.
,, ,, 4 ,, 1s. 5d.

CHAPTER XI

AGRICULTURAL ENGINEERING

Engineering Formulæ.—Almost every standard calculation concerned in different branches of engineering is effected by the aid of formulæ; the reason being that to ascertain mathematical values of any material, structure, engineering structure, or appliance, laboratory research, together with expensive apparatus and expert men, are necessary. For instance, if it is required to ascertain the strength of an iron bar, say 1 in. in diameter, when subject to tension, compression, or "bend" (more correctly described as "bending moment"), this particular bar must be placed in very heavy testing machines, so accurately constructed that not only may the bar be tested to destruction, but the actual effort which produces this effect be recorded in lbs. or tons. The work is done by experts who formulate their results in various ways, and practical engineers requiring to know quickly and accurately the strength or other quality of a material, structure, or arrangement, use these formulated results, or formulæ as they are called, to work from, thus avoiding the necessity of testing to destruction.

An agriculturist, on seeing a formula which could supply him with the result to a problem he wished to work out, might very well feel that it was too scientific and intricate, whereas this should not be the case, provided the simple rules of arithmetic are understood together with the meaning of the terms and expressions used in formulæ.

For convenience, in complicated formulæ, letters are used as well as figures, and after the general problem has been worked out and a formula obtained, values can be given to

these letters to obtain results in special cases. Thus, a result of $\frac{2a+3b}{c}$ might be arrived at. The values of these letters are known for special cases, and for the sake of clearness may be taken in this case as $a=2$, $b=4$, $c=6$; the result will be:—

$$\begin{aligned}&\frac{2a+3b}{c}\\ =&\frac{2\times 2+3\times 4}{6}\\ =&\frac{4+12}{6}\\ =&\frac{16}{6}\\ =&2\tfrac{2}{3}.\end{aligned}$$

Animal Power

The unit of power is that required to raise a definite weight a definite height in a definite time, or 1 lb. 1 ft. high in 1 minute.

A Watt's standard horse-power will raise 33,000 lbs. 1 ft. high in 1 minute, or do 33,000 units of work (foot-pounds per minute).

	Units.
Horse - - - -	22,000
Ox - - - -	16,930
Ass - - - -	5,030
Mule - - - -	11,720
Man, pumping or turning crank	2,600

Wind Power

The actual or effective power of a windmill may be expressed by the following formula:—

$$\text{Actual horse-power}=\frac{A\times V^3}{1{,}080{,}000}.$$

Where A = area of the sails of the wheel in square feet,
and V = velocity of the wind in feet per second.

To Find the Indicated Horse-Power of a Steam Engine

Let P = pressure of steam in lbs. per square inch in cylinder.
L = length of stroke in feet.
A = area of piston in square inches.
N = number of revolutions per minute.

$$\text{Then} \quad \text{I.H.P.} = \frac{\text{PLAN}}{33000}.$$

To Find Effective or Brake Horse-Power

The previous formula described the method of ascertaining the theoretical horse-power, but the figure more usually required is the effective or brake horse-power. This is the actual effort exerted by the engine at the flywheel, and in order to find it pass a double rope held in position by wood blocks round the flywheel; attach one end to a spring balance and suspend a load of say W pounds from the other.

Then let P = pull on the balance in lbs.
R = radius to centre of rope.
W = load in lbs.

The frictional resistance overcome by engine = W − P lbs.
Work performed per revolution = $(W - P)2\pi R$ ft.-lbs.,

$$\text{and B.H.P.} = \frac{2\pi R(W - P)n}{33000}$$

Where n = number of revolutions of flywheel per minute.

Power required to Raise Water

To find the capacity of pump per stroke.

Let n = number of strokes per minute.
B = bore in feet.
s = stroke in feet.
$\pi = \frac{22}{7}$.

Then capacity of pump in cubic feet per minute

$$=\left(\frac{B}{2}\right)^2 \times \pi \times s \times n.$$

The weight of a cubic foot of water = 10 lbs. Therefore the above result multiplied by 10 will give the weight in lbs. of water lifted per minute.

It is next required to measure the height through which the water has to be lifted.

Let W = lbs. of water lifted per minute.
H = height in feet.

$$\text{Then } \frac{W \times H}{33000} = \text{theoretical power required.}$$

To allow, however, for friction in the pump the result should be doubled when deciding the size of engine required.

Method of ascertaining Capacity of Tanks

The rule used for finding the cubical content of tanks should first be applied thus (see p. 96):—

Let L = internal length in feet.
W = ,, width ,,
D = ,, depth ,,

Then L × W × D = capacity of tank in cubic feet.

To convert cubic feet to gallons multiply by 6·227 thus: x c. ft. of water × 6·227 = y gals. of water.

To convert cubic feet to lbs. multiply by 62·28 thus: x c. ft. of water × 62·28 = y lbs. of water.

Leather Belting

Power transmitted by Belting (Richardson)

The following formula gives the power transmitted by any belt—

$$H = \frac{(T-t)v}{33000}.$$

Where H = actual horse-power transmitted.
T = strain in lbs. on the pulling side of the belt.
t = strain in lbs. on the slack side of the belt.
v = speed of belt in feet per minute.

When a belt is doing its full work, T will be the greatest safe working strain that the belt will stand; this is about 90 lbs. per inch of width for singles (more accurately 60 lbs. to 120 lbs. according to the thickness of the leather), and about 150 lbs. for doubles (135 lbs. for light and 160 lbs. for heavy doubles). In order that the belt shall do as much as possible, t must bear such a ratio to T that the belt just does not slip over the pulleys. In practice t varies from $\frac{1}{3}$ to $\frac{2}{3}$ of T, depending on the character of the surfaces of the belt and pulley, and on the fraction of the circumference of the pulley embraced by the belt; $\frac{1}{2}$ of T will be a safe average value for t. Hence $T - t$ will be on the average 45 lbs. for singles and 75 lbs. for doubles for every inch of width.

Hence the following rule for finding the power that any *given belt should transmit*:—

Multiply the width of the belt in inches by 45 if single, by 75 if double; multiply this again by the speed in feet per minute, and divide by 33,000; the quotient will be the number of actual horse-power the belt will transmit.

Ex. 1.—Required the horse-power which a 5-in. single belt, running at 1,000 ft. per minute, will transmit.

$$\frac{5 \times 45 \times 1000}{33000} = 7 \text{ H.P. nearly.}$$

Ex. 2.—What power can be transmitted by a 12-in. double, running at 1,500 ft. per minute?

$$\frac{12 \times 75 \times 1500}{33000} = 41 \text{ H.P. nearly.}$$

Ex. 3.—An example of the reverse kind: What width must a belt be to transmit 20 H.P., the belt running at a speed of 2,500 ft. per minute?

$$\frac{20 \times 33000}{2500 \times 45} = 6 \text{ in. nearly, if single.}$$

$$\frac{20 \times 33000}{2500 \times 75} = 3\tfrac{1}{2} \text{ in., about, if double.}$$

Then $\frac{N \times r}{n} = R.$

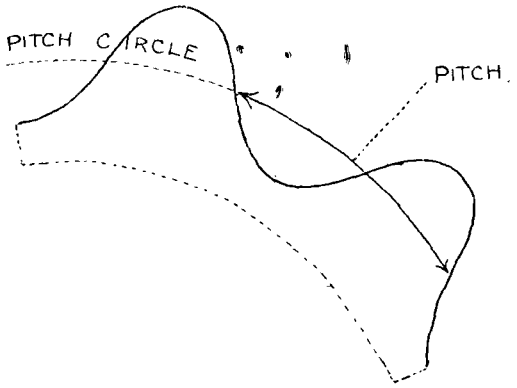

FIG. 45.

Ex.—A pair of gears run together, the pinion or driver has 20 teeth, the driven has 60 teeth. The speed of the pinion is 100 revolutions per minute, what is the speed of the driven shaft?

$$R = \frac{N \times r}{n}$$
$$= \frac{20 \times 100}{60}$$
$$= 33{\cdot}3 \text{ revs. per minute.}$$

This formula, like all others, may be changed to give different values thus:—

$$R = \frac{N \times r}{n},$$
$$\text{or} \quad N = \frac{R \times n}{r},$$
$$\text{or} \quad r = \frac{R \times n}{N},$$
$$\text{or} \quad n = \frac{N \times r}{R}.$$

When a train of gears is running and it is required to find the speed of the last driven, knowing the speed of the driver

or first pinion, the most easily understood method is to take the first pair and find the speed of the second or driven; then calling this second wheel the driver, work out the speed of the third, and so on to the end. But for rapidity and ease the multiple of the teeth of the drivers into the multiple of the teeth of the driven, multiplied by the number of revolutions of the pinion, will give the speed of the last wheel, thus:—

$$R = \frac{N \times N_2 \times N_3 \times N_4, etc.}{n \times n_2 \times n_3 \times n_4, \text{ etc.}} \times r.$$

This formula may similarly be changed to give different values as before:—

$$N_2 = \frac{R \times n \times n_2 \times n_3 \times n_4, \text{ etc.}}{r \times N \times N_3 \times N_4 \text{ etc.}},$$

$$\text{or} \quad r = R \times \frac{n \times n_2 \times n_3 \times n_4, \text{ etc.}}{N \times N_2 \times N_3 \times N_4, \text{ etc.}},$$

$$\text{or} \quad n_3 = \frac{N \times N_2 \times N_3 \times N_4, \text{ etc.}}{R \times n \times n_2 \times n_4, \text{ etc.}} \times r.$$

Ex.—A train of gears is composed of three drivers and three driven wheels. The three drivers have respectively 10, 15, and 20 teeth, whilst the three driven have respectively 25, 35, 25 teeth. To find the speed of the last driven wheel, assuming the speed of the first driven to be 100 revs. per minute, we have:—

$$R = \frac{10 \times 15 \times 20 \times 100}{25 \times 35 \times 25}$$

$$= 13{\cdot}7 \text{ revs. per minute.}$$

Formulæ

To Convert Centigrade to Fahrenheit

The following are the corresponding fixed points on the above thermometer scales:—

	Fahr. °.	Cent. °.
Freezing point	32	0
Boiling point	212	100
No. of degrees between the freezing and boiling points	180	100

The ratio between them is 9 : 5.

Thus to convert Centigrade to Fahrenheit multiply by 9, divide by 5, and add 32.

Formula for converting C. ° to F. °—

$$\tfrac{9}{5}\text{C.}^\circ + 32.$$

Ex.—Convert 40° C. to F. °—

$$\tfrac{9}{\cancel{5}} \text{ of } \cancel{40}^{8} + 32$$

$$= 72 + 32$$

$$= \underline{104^\circ \text{ F.}}$$

To Convert Fahrenheit to Centigrade

Subtract 32, multiply the remainder by 5, and divide by 9.

Formula for converting F.° to C.°—

$$(\text{F} - 32) \times \tfrac{5}{9}.$$

Ex.—Convert 149° F. to C. °—

$$(149 - 32) \times \tfrac{5}{9}$$

$$= \cancel{117}^{13} \times \tfrac{5}{\cancel{9}}$$

$$= \underline{65^\circ \text{ C.}}$$

Revolutions per Minute of Separator Bowl

The simplest method of finding the number of revolutions the bowl of a separator makes per minute is to stick a piece of adhesive paper on the bowl, and move the handle of the separator through one complete turn, noting the number of times the bowl revolves during that time. Then this multiplied by the number of revolutions the handle makes per minute will give the number of revolutions of the bowl per minute. Thus, if the number of times the bowl revolves during one complete turn of the handle be 100, and the handle is turned at a speed of 60 revs. per minute, then the speed of the bowl is $60 \times 100 = 6{,}000$ revs. per minute.

The speed may also be ascertained by any of the foregoing formula for finding the speed of toothed gearing, although this necessitates counting the number of teeth on the various gear wheels.

Lighting

Petrol gas is one of the cheapest illuminants for use on the farm, and may be made by one of two systems—the Safety Light or the Mitchelite. In the former the cost will average about £50 for installing 40 lights and the petrol required to produce 1,000 c. ft. of gas will cost 1s. 8d. By the Mitchelite process the cost of plant for 50 lights amounts to £40 and the cost of petrol per 1,000 c. ft. of gas is about 1s. 3d. Compare the costs of installation and petrol per 1,000 c. ft. of gas for a farmstead requiring 25 lights.

CHAPTER XII

INSURANCE

An insurance is a contract to pay a certain sum of money, or to indemnify the insurer against loss, in the event of some particular thing happening, in consideration of which the insurer pays a certain sum beforehand. The amount paid for the insurance is called the Premium, and the contract on which the conditions are set out is called the Policy.

Agriculturists generally insure against loss from fire and against claims arising under the Workmen's Compensation Acts. They may also insure their lives, that is, that a certain sum of money shall be paid to their heirs at their death. They may insure certain payments in case of accident to themselves (personal accident) or against loss from accidents happening to other people through their servants, horses, etc. (third party insurances), or against loss from the death of their livestock.

Most of the large insurance companies have entered into an agreement amongst themselves to charge certain definite rates for particular insurances, so as to avoid competition. A list of these rates is called a tariff, and the companies entering into the agreement are known as tariff companies. The companies that have not entered into the agreement are known as non-tariff companies and each can fix its own rates for any particular class of insurance.

Each separate and distinct item in an insurance is spoken of as "a risk." For example, a farmhouse and buildings, if adjoining, would be one risk, but if the farmhouse were one side of the road and the buildings the other, each would be a separate risk. The same rule applies to stacks, if close to the

buildings or if far apart, and to workmen, the ordinary farm labourers being one risk and men travelling with a threshing machine another.

Risks are spoken of as good or bad, according to their liability to catch fire, meet with accidents, etc.

The tariff rates in England and Wales for insurance against loss from fire are as follows :—

Hay, corn, and straw stacks	7s. 6d. per £100.
Agricultural produce in or about buildings	7s. 6d. ,,
Implements and other dead stock	7s. 6d. ,,
Livestock against death from fire or lightning	3s. 0d. ,,
Household furniture in brick or stone house roofed with slates or tiles	2s. 0d. ,,
Farm buildings, brick or stone, roofed with slates or tiles	1s. 6d. ,,

Wooden and thatched buildings, and the furniture in these, are charged at higher rates, varying with the risk.

The tariff rate for insurance against claims arising out of accidents occurring to ordinary farm workmen under the Workmen's Compensation Acts and common law (legal liability) is 15s. per £100 of wages paid during the year. The rates for other classes of workmen are usually higher than for agricultural labourers, and depend on the liability to accident, the rate for men travelling with an engine and threshing machine being as much as 35s. per £100 of wages. It is important, therefore, when making out a list of workmen, that each class of workmen be mentioned separately, because, if a man, insured as an agricultural labourer, were injured while carting stones for the highway or felling a tree, there might be some difficulty in obtaining the compensation. A farmer insuring all his men is, however, allowed to send a man to the station with milk, or when carting corn or coal, and to use his men when threshing on the farm without extra payment.

Every agriculturist employing any labour should note that the risk of loss through the Workmen's Compensation Acts

is even more serious than the risk of loss from fire. An uninsured farmer may lose practically the whole of his capital by a fire, but he can start life again free from debt. On the other hand an uninsured farmer who has the misfortune to have one of his men permanently disabled by accident has to pay that man half his wages as long as he lives, and nothing will release him from the liability but the man's death. Even then, if the man leaves any dependants, the employer is liable for compensation to them, and further it must be remembered that the employer's death does not stop the liability, which will have to be met by his heirs.

Livestock insurance is not nearly so common as insurance against loss from fire or accidents to workmen, although a good many farmers insure their mares against foaling risks, and owners of valuable pedigree animals commonly insure them to cover death from any cause.

The rates for the insurance of livestock are fairly heavy, running from 5 per cent. to $12\frac{1}{2}$ per cent. of the insured value of the animals. The insured value is usually two-thirds of the estimated market value, that is, an animal estimated to be worth £60 is insured for £40, and the premium payable is so much per cent. on the £40. Note that whereas the premiums payable on fire or workmen's compensation insurances are usually so many shillings per cent. (per £100), the premiums on livestock are pounds (per £100). The premium on a mare worth £60, to insure £60 —the full market value—payable on her death from fire or lightning under the fire insurance policy at 3s. per cent. would be 2s., whereas the premium payable on the same mare to insure against the loss of the mare from foaling might be £3 which is £$7\frac{1}{2}$ per £100, reckoned on £40 as two-thirds of her market value.

It is probably owing to these high premiums that so little livestock insurance is done in this country, but there is also the fact that ordinarily the deaths of the animals take place singly and do not represent any serious loss of capital at any one time in the case of a farmer in a fairly large way

of business. It is different with a small farmer—the loss of one cow worth £20 out of three or four may mean 20 per cent. of his capital, but to the farmer with thirty or forty cows the loss of one is a comparatively small matter.

Insurance of Horses

The most important risk with horses to cover is the breeding risk. The premium for insuring a mare for £50 is usually about £1. 15s., while for the mare and foal (£50 for the mare and £6 for the foal) the premium is usually about £3. 2s. 6d. This also covers abortion, and death from any cause (except fire and lightning).

Extra premiums at the rate of 1 per cent. of the total amount insured are charged in the event of any of the following circumstances: If it is proposed to insure only one mare under four years of age and in foal for the first time; on all mares over ten years of age in foal for the first time; on all mares which have had two or more unsatisfactory foalings.

The company usually require notice of foaling to be forwarded to them within twelve hours.

With regard to insurance against death from accident or disease, a classification of the different horses is usually made, with the following rates per annum:—

Private, saddle, trap, and farm horses, two or more horses	4	per cent.
single horses	5	,,
Horses for light trade purposes in two-wheeled vehicles	5	,,
Horses for light trade purposes in four-wheeled vehicles, also hunters	6¼	,,
Polo ponies, posting horses, or those let on hire	7½	,,
Heavy draught horses, used for timber, coal, carting, etc., and by builders, etc.	8¾	,,
Railroad, canal, cab, and omnibus horses	10	,,

It is usual for the owner to carry part of the risk himself at about one-third of the market value.

Stallions are insured against death from accident or disease at the rate of £5. 10s. per annum or for periods of six, four, or three months at £4, £3, and £2. 10s. respectively.

Rates for Castration Risks :—

One to three years old	£4. 4s. per cent.
Over three years old	£1. extra per cent. for each year.

Insuring Poultry Appliances

There is considerable danger of fire whenever incubators and brooders are running, especially when lamps are filled too full, and not cleaned or trimmed properly. Even when carefully attended to, there is still a great amount of risk, and it therefore behoves the owner to insure as well as possible in order to receive at least some compensation in the event of accidents of this nature.

The fowls themselves may even be insured against loss by burglary, fire, and storm. These risks, however, necessarily require a heavy premium, which may amount to about £3. 10s. per cent.

If the sum insured on agricultural property is less than three-fourths of the value of all the property insured at the breaking out of a fire, then the amount recoverable is proportionate to the amount of the property insured by the company, the insurer having to bear the remainder of the loss himself.

Ex.—What amount can be recovered under an insurance policy where farm property was insured for £500, while the value at the time of the fire was £800, and damage to the extent of £750 is done?

If farm property of the value of £850 be insured for £510, and damage is done through fire to the extent of £300, what amount can the farmer recover from the company, bearing the remainder of the loss himself?

CHAPTER XIII

MEASUREMENTS OF RICKS AND TIMBER

Rick Measuring

THE only accurate method of weighing is by the use of platform scales.

The number of tons may be nearly determined by ascertaining the number of cubic feet or yards in the rick, and obtaining the weight per cubic foot by actual weighing.

The number of yards per ton will depend on the solidity of settlement of the rick.

If a good-sized rick, say, of 20 tons, has well settled, about 12 c. yds. to a ton will be a fair estimate.

The majority of hay buyers, with perhaps the exception of a few of the most expert who merely glance at the rick and sample the hay for quality and solidity, adopt the following means of measurement: The length and breadth of the rick are measured with the tape, then the height to the eaves, and the perpendicular height from the eaves to the top.

The volume is then calculated as follows:—

To the height from the ground to the eaves, add one-third of the height from the eaves to the top; multiply this sum by the breadth, and that product by the length. This will give the contents in feet, which divide by 27 (cubic feet in a yard). The quotient will be in yards. Divide this by 10 to bring it to tons.

An average made rick of meadow hay will cut out 270 c. ft. to the ton. In the case of clover and sainfoin or other coarse-grown hays, a content of 300 c. ft. to the ton is the average.

Any ricks that are brown through heat require a greater density to be allowed for, such as 250 c. ft. to the ton in

meadow hay, and 270 c. ft. to the ton in field grasses. If the hay is more than brown a still greater density may be allowed, but this must be a matter of judgment entirely.

Allowance must be made if the hay has taken rain in the making, as this causes it to lose its virtue and consequently weigh lightly.

After a rick has stood one winter, 2 tons or more of rough hay must be allowed for.

Hay

In estimating the contents of square or oblong haystacks, the mean length, l, and width, w, are taken in feet and inches at a point about midway between the upper part of the stack-bed and the eaves, an allowance (from 3 in. in trimmed stacks to 8 in. in others) being made in each measurement for the loose outsides. The height, h, is usually taken from the upper part of the stack-bed to the height of the first thatching rope, or the following proportions of the roof are added to the height of the stack from upper part of stack-bed to eaves line:—

Stacks with gable ends one-third of perpendicular height of roof.

Stacks with hipped ends one-fifth of perpendicular height of roof.

Then—

$$\frac{l\ w\ h}{27} = \text{cubic yards.}$$

$$\frac{l\ w\ h}{\text{No. of feet per truss}} = \text{trusses.}$$

$$\frac{l\ w\ h \times \text{lbs. per foot}}{112 \times 20} = \text{tons and cwts.}$$

For circular stacks the mean circumference and perpendicular height are taken between the upper part of stack-bed and eaves, and to the latter is added one-third of the perpendicular height of the roof. The contents in cubic feet may then be obtained by multiplying the area equivalent to the circumference by the height.

A simpler method by which the approximate contents may be found is to multiply one-half of the square of two-fifths of the circumference by the height for the cubic contents in feet, *e.g.*, a stack having a circumference of 50 ft., height from stack-bed to eaves 10 ft., and eaves to top 6 ft., will give the following results :—

$$\text{Height} = 10 + \tfrac{6}{3} = 12 \text{ ft.}$$

Then—

50 ft. circumference = 199 ft. area nearly, and height, 12 ft. : vol. = 2388 c. ft.

$$\text{or } \frac{50 \times 2}{5} = 20, \text{ and } \frac{20^2}{2} = 200.$$

$$\therefore \text{ contents} = 200 \times 12 = 2400 \text{ c. ft.}$$

The number of cubicyards, trusses, or tons may then be found by the same methods as those already described for square or oblong stacks.

The contents of haystacks are found in order to ascertain their weights, which vary according to the density of the hay. For example, in some stacks the hay will not weigh more than 8 or 10 st. per cubic yard, while in others it may weigh anything up to 16 st. per cubic yard.

To measure a circular stack as in Fig. 46.

Multiply the square of the circumference at the bottom by ·07958, or for general practice by ·08. The product will be the area of the base. Find the area of a section at the eaves DE in the same manner. To the sum of these areas add the square root of their product. Multiply this by the perpendicular height HI = CD, and one-third of the product will be the solidity of the frustum ABED.

Multiply the area of the section at the eaves by the perpendicular height IG = DF, and one-third of the product will be the solidity of the cone DEG.

To the solidity of the frustum add that of the cone, and the sum will be the contents of the rick ADGEB.

Ex.—The circumference at the base of AB is 65 ft., the circumference at the eaves DE 82 ft.; the perpendicular

height HI = CD 18 ft., and IG = DF 19 ft. How many solid yards does the rick contain?

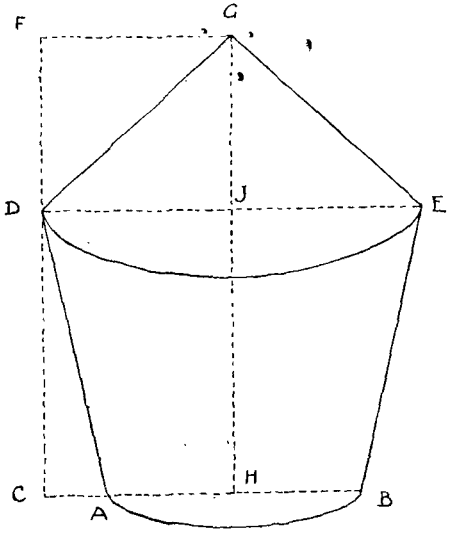

FIG. 46.

The circumference of the base of a hayrick is 53 ft. 9 in., the circumference at the eaves 72 ft. 6 in., the perpendicular height of the lower part 16 ft. 9 in., and that of the upper part 18 ft. 3 in. How many tons are contained in the stack, a cubic yard having been found to weigh 14 stones?

Find the contents of a haystack, Fig. 47, which is bulged from the bottom to the top, from the following dimensions: Girth at the bottom, AB = 38 ft.; CD 57 ft.; EF 68 ft.; GH 58 ft.; IJ 32 ft. The perpendicular distance between each section is 5 ft., and the perpendicular height of the conical part IKJ 4 ft. 6 in.

To measure a haystack having a rectangular base.

When the stack is straight from the bottom to the eaves, and from the eaves to the top, as in Fig. 48, the lower part

can be taken as a prismoid, and the upper part as a triangular prism.

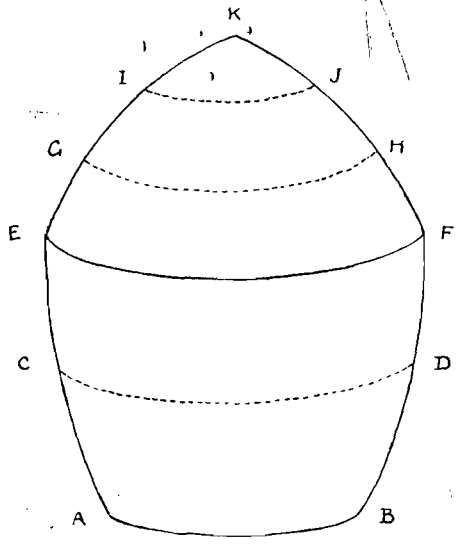

FIG. 47.

Rule.—Multiply the mean length at the bottom by the mean breadth, and the product will be the area of the bottom. Proceed to find the area of a section at the eaves in the same manner. Multiply half the sum of the length of the bottom and eaves by half the sum of the breadths, and the product will be the area of a section equally distant from the bottom and eaves.

To the area of the bottom add the area of the section at the eaves, and four times the area of the middle section; multiply this sum by the perpendicular height, from the bottom of the eaves, and one-sixth of the product will be the solidity of the lower part.

Next multiply the breadth at the eaves by the perpendicular height from the eaves to the top, and half the product

will be the area of the end, which, being multiplied by the mean length, will give the solidity of the upper part.

Finally add these two solidities together, and the sum will give the content of the whole rick.

Ex.—In the accompanying *diagram of a hayrick*, the mean length at the bottom is 40 ft. 6 in., and the mean breadth 18 ft. 9 in.; the mean length at the eaves 46 ft.

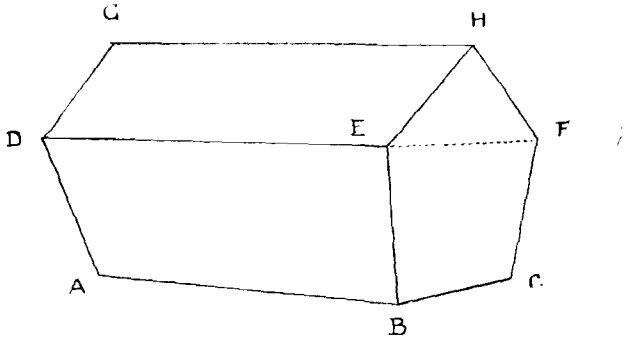

FIG. 48.

3 in., and the mean breadth 26 ft. 6 in. The perpendicular height from the bottom to the eaves is 18 ft. 9 in., and from the eaves to the top 16 ft. 6 in. How many cubic yards does the rick contain, the mean length of the upper part being 44 ft. 9 in.?

Hay and Straw Weight

36 lbs. avoirdupois of straw				= ½ truss.
56 ,,	,,	of old hay		= 1 truss.
60 ,,	,,	of new hay		= 1 truss.
36 trusses				= 1 load.

Hay is called old after the commencement of September, when it has had time to settle and get thoroughly dry. A load of *old hay should weigh* 18 cwt.; a load of new hay 19 cwt. 32 lbs.

A load of straw weighs 11 cwt. 64 lbs.

The weight of hay per cubic yard in the stack depends on the nature of the hay, its age, the size of the stack, and the part of the stack taken. It varies from 112 lbs. to 300 lbs. per cubic yard. 196 lbs. is an average adopted in the North; but in the South 224 lbs. to the cubic yard is considered a good average.

For different conditions of hay and stacks the number of cubic yards to a ton will approximately vary as follows:—

Condition of Stack.	Square Stacks.	Round Stacks.
	Cubic Yards.	Cubic Yards.
If not well settled - - -	12	13
If fairly well settled - - -	10	11
If very compact - - - -	8	9

In estimating the weight of hay in a stack it is usual to multiply the length of the stack by its breadth, and multiply the result by its height, all in feet; divide the total by 27, which will give the number of cubic yards; divide the number of cubic yards by 8, 10, or 12, according to the condition of the stack, as per above table, and the result will be the weight in tons. In measuring the height, deduct two-thirds of the number of feet from the eaves to the top. For example, a stack 20 ft. long and 10 ft. broad thus multiplied is 200 ft., say, the height to the eaves 10 ft., from the eaves to the top 6 ft.; two-thirds of the last-named figure is 4 ft., leaving 2 ft. to be added to the 10 = 12, multiply 200 by 12 = 2,400; then divide 2,400 by 27, which gives nearly 90 c. yds., and 90 divided by 12 (12 c. yds. = 1 ton, as per above table) = 7½ tons.

Weight of Hay

Cubic Feet per Truss.	Cubic Feet per Ton.	Weight per Cubic Yard.			Remarks.
		Cwt.	Qrs.	Lbs.	
5	200	2	2	22	Exceptionally solid.
6	240	2	1	0	Very solid.
$6\frac{1}{2}$	260	2	0	8	Solid.
7	280	1	3	20	Medium.
$7\frac{1}{2}$	300	1	3	8	Light.
8	320	1	2	21	Very light.

Measurement of Timber

Before valuation the trees are usually blazed and numbered in white paint, or razed with a distinctive cross-like mark, by the vendor's agents or foresters. The first step is to ascertain the height of the tree. For this purpose it is customary to use a pole, the upper part, from 8 ft. or so up, being marked off in 1-ft. or 2-ft. lengths. The usual length of the pole is 14 ft., for in the case of tall trees the woodman can hold the pole up against the trunk 6 ft. from the ground, and so an even length of 20 ft. is obtained. Any unmeasured length beyond the top of the pole must, of course, be judged by the eye. The end of the tree or its first length is that point at which a sudden break in its uniformity of size and taper occurs. With trees of more than one main length this termination is called a "stop." The lengths beyond this stop must of necessity be calculated by sight only, bearing in mind that the greater their distance from the ground the less will their length *appear*. Thus a length of 12 ft. 35 ft. from the ground will look much shorter than one the same length only 15 ft. up.

The quarter girth of the tree is next obtained at the mean between the point and the base. In practice, however, it is usual to girth the tree standing at from 5 ft. to 6 ft. from the ground, which gives the medium girth of the lower 12 ft. Then compute by sight the upper part of the tree, which

is fairly accurately obtained by practice. The method of measuring is by means of a strap on which are stitched the inches, each "inch" really representing 4 in. of actual measure. Two kinds of straps are in general use, one of which gives the actual quarter girth of the tree, leaving the measurer to make his own deduction for bark, usually 1 in. to the foot in the case of oak and elm, and $\frac{1}{2}$ in. to the foot in the case of ash, larch, and the thinner barked trees. In the other case the allowance for bark is deducted from the inches on the strap. This, however, is somewhat mechanical, and does not permit that latitude of discrimination between thick and thin barks, not only necessary for different species of wood, but even for trees of the same kind. Given the quarter girth, the cubical contents are simply obtained by squaring it and multiplying the length. As with length, so with quarter girth in the case of second or further "stops," the measurer must trust to his eye. The limbs of the tree, unless exceptional in size and growth, are generally disregarded, the custom being to take account of the spire, *i.e.*, the main tree, and one top, as, even with the most careful felling, extensive breaking of the limbs is inevitable.

While there are many aids to obtaining quickly the cubical contents from given lengths and quarter girths, such as the slide rule and stoppers tables, the majority of practical valuers rarely use them, but depend on certain "rule of thumb" yet accurate mental tables for promptly arriving at the desired measurements, such as the following :—

Quarter Girth. In.	Cubic Contents.
6	$\frac{1}{4}$ of *length in feet.*
7	$\frac{1}{3}$,, ,,
$8\frac{1}{2}$	$\frac{1}{2}$,, ,,
10	$\frac{2}{3}$,, ,,
$10\frac{1}{2}$	$\frac{3}{4}$,, ,,
11	$\frac{5}{6}$,, ,,
$11\frac{1}{2}$	$1\frac{1}{12}$,, ,,
12	*length in feet.*
$12\frac{1}{2}$	,, $+\frac{1}{12}$
13	,, $+\frac{1}{6}$

Quarter Girth. In.	Cubic Contents.
$13\frac{1}{2}$	length $+\frac{1}{4}$
14	,, $+\frac{1}{3}$
$14\frac{1}{2}$	,, + not quite $\frac{1}{2}$.
15	,, + just over $\frac{1}{2}$.
$15\frac{1}{2}$	,, $+\frac{2}{3}$
16	,, $+\frac{3}{4}$
17	double the length.
18	$2\frac{1}{4}$ times the length.
19	$2\frac{1}{2}$,, ,,
20	$2\frac{3}{4}$,, ,,
21	3 ,, ,,
24	4 ,, ,,
27	5 ,, ,,

The above results can easily be tested by means of a slide rule.

Measuring Fallen Timber

The measurement of felled timber is carried out on similar lines to those above mentioned, with the difference that the actual lengths and mean girths can be obtained instead of estimated only.

The cubical contents are calculated from the following formula:—

Let G = ¼ girth of tree at middle in feet.
g = ,, at one end.
g_1 = ,, at other end.
L = length of log in feet.
c = cubic contents of log in feet.

Then—

$$c = \mathrm{L}\left(\frac{\mathrm{G}+g+g_1}{3}\right)^2$$

Allowance is made for bark by deducting from each quarter girth.

No part of a tree is considered timber unless it measures 24 in. in circumference, *i.e.*, 6 in. quarter girth.

In London the sectional area of square timber is measured by means of the Customs or Queen's calipers, but in Dublin, Glasgow, and other home and American ports, by string

measurement, that is, by girthing the centre of the baulk with a piece of string, and squaring one-fourth of the length of the string. Of course this method can only be applied with accuracy to square timber; but in string measuring round timber, the trade custom is the same as if it were squared, the log being girthed at two or three points, and one-fourth of its mean girth, less three times the average thickness of the bark, squared for the sectional area.

For finding the true content of a round log stripped of bark, one-fifth of its mean circumference squared, multiplied by twice its length, gives within ½ per cent. of the truth :—

$$\text{Content} = (\tfrac{1}{5}\ \text{girth})^2 \times 2\ \text{length}.$$

Square timber is sold in London by the load of 50 c. ft.; or by the 50-ft. run, also certain standard percentages over 12 in. square, according to its quality.

Quarter Girth Measurement

In measuring the cubic contents of timber in the log an allowance of about 20 per cent. is made to cover wastage in sawing, etc. Instead, therefore, of estimating the contents in the usual way, the mean girth is taken midway between the ends of the log, and the contents reckoned as equal to the length multiplied by the square of the mean quarter girth.

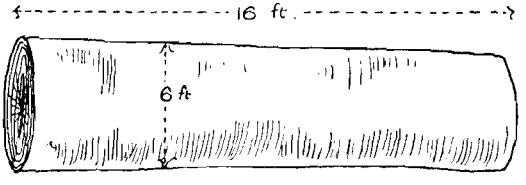

FIG. 49.

Thus, a log 16 ft. long and 6 ft. in mean girth would by quarter-girth measurement contain—

$$16 \times \left(\frac{6}{4}\right)^2 = 36\ \text{c. ft.},$$

whereas the actual cubic contents would be

$$16 \times \frac{6^2}{4\pi} = \frac{576}{12{\cdot}566} = 45 \text{ c. ft. (nearly).}$$

An allowance is also usually made for the bark, and nothing is paid for tops and branches below the recognised timber size of the district.

Prices of Timber

Oak under 10 ft.	-	55s. to 65s. per load of 50 c. ft.
,, 10 and under 20 ft.		65s. to 75s. ,, ,,
,, 20 ,, 30 ,,		75s. to 85s. ,, ,,
,, 30 ft. and upwards		85s. to 100s. ,, ,,
Elm under 20 ft.	-	6d. to 8d. per cubic foot.
,, 20 to 40 ft. -	-	8d. to 9d. ,,
,, 40 ft. and upwards		9d. to 1s. (the latter for only very fine trees).

	Per cubic foot.		Per cubic foot.
Acacia -	1s. to 1s. 6d.	Larch -	9d. to 1s.
Alder -	1s.	Lime -	9d. to 1s. 2d.
Ash -	1s. 3d. to 2s. 6d.	Maple -	6d. to 1s. 6d.
Beech -	8d. to 1s.	Plane -	1s.
Birch -	1s.	Poplar, abele or aspen -	6d. to 1s.
Box -	3s. to 5s.	Scotch and Spruce Fir -	4d. to 8d.
Cedar -	2s.	Sycamore	1s. 6d. to 2s. 6d.
Cherry -	8d. to 1s.	Walnut	2s. to 3s.
Chestnut (horse)	1s. 6d. to 2s.	Willow	1s. 6d.
,, Spanish	1s. to 1s. 6d.	Yew -	2s.
Holly -	2s. to 4s.		
Hornbeam	2s.		

The following may be regarded as the most useful sizes of wood for the farm, together with price per foot run:—

2 × 4 at	1d. to 1½d. per ft. run.
2 × 6 at	1½d. to 1¾d. ,,
2 × 7 at	2¼d. to 2½d. ,,
2½ × 7 at	2½d. to 3d. ,,
3 × 4 at	2d. to 2½d. ,,
3 × 7 at	3d. to 3½d. ,,
3 × 9 at	4d. to 6½d. ,,

The 2 × 4 and 3 × 7 sizes are usually termed "battens," and 3 × 9 "deals," while 3 × 4 and similar sizes are often

described as "quartering." 2 × 4 is one of the most useful sizes.

The usual sizes of weather board, which is generally lapped about $\frac{3}{4}$ to 1 in., are as follows :—

$\frac{3}{4} \times \frac{1}{2} \times 6$ or 7 in. at 8s. to 9s. per square.
$1 \times \frac{1}{2} \times 7$ at 10s. 6d. to 12s. ,,

Weather board is generally treated with gas tar, creosote, or some other preservative.

Flooring—

1 in. × 6 or 7 in. at 13s. to 15s. per square.
$\frac{3}{4}$ in. × 6 or 7 in. at 11s. to 13s. ,,

Matching—

1 in. × 6 or 7 in. at 13s. 6d. to 16s. per square.
$\frac{3}{4}$ in. × 6 or 7 in. at 11s. 6d. to 13s. 6d. per square.
$\frac{5}{8}$ in. × 6 or 7 in. at 10s. to 11s. 6d. ,,

Slate battens—

$\left.\begin{matrix} \frac{3}{4} \times 2 \\ \frac{3}{4} \times 2\frac{1}{2} \end{matrix}\right\}$ at 2s. to 2s. 6d. per 100-ft. run.

Tile battens—

$\left.\begin{matrix} \frac{3}{4} \times 1 \\ \frac{3}{4} \times 1\frac{1}{4} \end{matrix}\right\}$ at 1s. to 1s. 3d. per 100-ft. run.

Post and rail fencing (usually of larch)—

6 ft. - - - 6 × 3 larch posts at 1s. 9d. to 2s. each.
10 ft. - - 4 × 1½ larch rails at 10d. to 1s. ,,
6 ft. - - - 4 × 1½ centre stays at 5d. to 6d. ,,

Oak and larch slabs are also very useful for repairs, and are usually purchased by the load ; a good waggon load being generally procurable for about 30s.

Log.—A felled tree with its top and branches cut off.

Baulk.—A log roughly hewn to an octagonal shape. Foreign timber comes over in this shape as it is less costly in freight and the useless sap wood is got rid of.

Flitch.—Half a baulk or any piece of timber more than 6 in. thick. These are sold at so much per foot cube.

Planks.—Timber not less than 11 in. wide, 3 to 4 in. thick.
Deals.—Timber not less than 9 in. ,, 3 to 4 in. ,,
Battens.—Timber from 4 in. to 7 in. ,, 2 to 3 in. ,,
These are all sold at so much per foot run.

A "square" of wood is a 100-ft. run 12 in. wide. The number of running feet is determined according to whether the wood is more or less than 12 in. wide, thus :—

100-ft. run 12 in. = 1 square.
200-ft. run 6 in. = 1 ,,
300-ft. run 4 in. = 1 ,,
80-ft. run 15 in. = 1 ,,

and so on.

Examples

How many squares of flooring material will it take to lay three rooms of the following dimensions: 14 ft. by 13 ft., 12 ft. by 12 ft., and 18 ft. by 9 ft. 6 in.?

How many feet run of boarding 7 in. wide is there in a square?

How many squares of 7-in. match-boarding will it take to cover the walls of a room 16 ft. long, and 14 ft. wide, and 10 ft. high, allowing for a window 6 ft. by 4 ft., a door 3 ft. by 7 ft., and a fireplace 4 ft. 6 in. by 3 ft. 9 in.?

Note.—7-in. matchboard only covers $6\frac{1}{2}$ in. because of the tongue and groove.

The sides of a barn, 80 ft. by 18 ft., require weather-boarding. How many squares and how many feet run of 7-in. boarding will it take, allowing for a lap of $\frac{3}{4}$ in.?

CHAPTER XIV

WORKED EXAMPLES

WHAT is the cost of 25 tons of hay at £4. 17s. 6d. per ton?

£4. 17s. 6d. = £5 − 2s. 6d.

The cost at 2s. 6d. = $\frac{1}{8}$ the cost at £1.

£	s.	d.		£	s.	d.	
25	0	0	= cost at	1	0	0	per ton.
		5					
125	0	0	= ,,	5	0	0	,,
3	2	6	= ,,	0	2	6	,,
121	17	6	= ,,	4	17	6	per ton.

What is the cost of 30 tons of mangels at 12s. 6d. per ton?

Cost at 10s. per ton	= £15 0 0
Cost at 2s. 6d. or $\frac{1}{4}$ of 10s.	= 3 15 0
	£18 15 0 = cost at 12s. 6d. per ton.

Wheat top-dressed in spring with $1\frac{1}{2}$ cwt. of nitrate of soda was found to give an increase of 7 cwt. of straw per acre. What would be the increase from a field 5 ac. 3 r. 20 sq. po. in area, at the same rate of increase?

Increase for 5 ac.	= 5 × 7	= 35 cwt.
,, ,, 3 r.	= $\frac{3}{4}$ × 7	= $5\frac{1}{4}$,,
,, ,, 20 sq. po.	= $\frac{1}{8}$ × 7	= $\frac{7}{8}$,,
Total increase =		$41\frac{1}{2}$ cwt.

Express 17 tons 13 cwt. in tons?

20 cwt. = 1 ton.

∴ 13 cwt. = $\frac{13}{20}$ ton.

∴ 17 tons 13 cwt. = $17\frac{13}{20}$ tons = 17·65 tons.

Express 13 qrs. 5 bus. in quarters.

13 qrs. 5 bus. $= 13\frac{5}{8} =$ 13·625 qrs., for 8 bus. = 1 qr.

$\therefore$ 5 bus. $= \frac{5}{8}$ qr. = ·625 qr.

What is the cost of a 56-lb. Cheddar cheese at 52s. per cwt.?

56 lbs. $= \frac{56}{112}$ cwt. $= \frac{1}{2}$ cwt.

$\therefore$ Cost of 56 lbs. $= \frac{1}{2}$ cost of 112 lbs., or 1 cwt.

$= \frac{52}{2}$s. = £1. 6s. 0d.

What is the cost of 100 tons of hay at £3. 17s. 6d. per ton?

£3. 17s. 6d. = £4 − 2s. 6d. Cost at 2s. 6d. $= \frac{1}{8}$ cost at £1.

£100 0 0 = cost at £1 0 0 per ton.

4

£400	0	0	=	,,	4	0	0	,,
12	10	0	=	,,	0	2	6	,,
£387	10	0	=	,,	£3	17	6	per ton.

If in 3 hours rain fell to a depth of ·285 in., what was the rate of fall per hour?

$$\text{Fall per hour} = \frac{\cdot 285}{3} = \cdot 095 \text{ in.}$$

The rent of an upland farm is 12s. per acre, while the rent of a woodland farm is 26s. per acre. Compare the former with the latter.

$$\text{Rent of the upland farm} = \frac{12}{26} \text{ of the woodland farm}$$

$$= \frac{6}{13} \text{ of the woodland farm.}$$

The work of a farm horse is valued at 3s. 6d. per day. What is the value of the work of 6 horses per day?

Value of 1 horse per day = 3s. 6d.

$\therefore$ Value of 6 horses per day = 1 × 6 = 3s. 6d. × 6

= £1. 1s.

26 cwt. of hay cost £4. 5s., what is the cost of 14 cwt.?

$$14 \text{ cwt.} = \frac{\overset{7}{\cancel{14}}}{\underset{13}{\cancel{26}}} \text{ of } 26 \text{ cwt.}$$

$$\therefore \quad \text{Cost of } 14 \text{ cwt.} = \tfrac{7}{13} \text{ of } \tfrac{85}{1} = \tfrac{595}{13}$$
$$= \underline{\text{£2. 5s. } 9\tfrac{4}{13}\text{d.}}$$

If 7 qrs. 2 bus. of wheat cost £10. 3s., what was the price per quarter?

$$7 \text{ qrs. } 2 \text{ bus.} = 7\tfrac{2}{8} = 7\tfrac{1}{4} \text{ qrs.}$$

$$\text{Price per quarter} = \text{£}10 \quad 3 \quad 0 \div 7\tfrac{1}{4} = \text{£}10. \ 3\text{s.} \div \tfrac{29}{4}$$

$$\begin{array}{r} \text{£}10 \quad 3 \quad 0 \\ \qquad\qquad 4 \\ \hline 29)40 \quad 12 \quad 0 \\ \hline \underline{\text{£}1 \quad 8 \quad 0} \end{array}$$

How many drain pipes $1\frac{2}{3}$ ft. in length are required to drain a length of ground $47\frac{1}{2}$ ft. long?

$$\text{Number of pipes} = 47\tfrac{1}{2} \div 1\tfrac{2}{3}$$
$$= \frac{95}{2} \div \frac{5}{3} = \frac{\overset{19}{\cancel{95}}}{2} \times \frac{3}{\underset{1}{\cancel{5}}}$$
$$= \frac{57}{2} = \underline{28\tfrac{1}{2}.}$$

£17. 10s. was paid for $2\frac{1}{2}$ cwt. of factory butter. What was the price per cwt.?

$$\text{Price per cwt.} = \text{£}17. \ 10\text{s.} \div 2\tfrac{1}{2}$$
$$= 17\tfrac{1}{2} \div 2\tfrac{1}{2}$$
$$= \frac{\overset{7}{\cancel{35}}}{\underset{1}{\cancel{2}}} \times \frac{2}{\underset{1}{\cancel{5}}}$$
$$= \underline{\text{£}7.}$$

What is the cost of 24 cows at £21. 10s. each?

$$\text{£}21. \ 10\text{/} = \text{£}21\tfrac{1}{2}. \qquad \therefore \ \text{Cost} = \text{£}21\tfrac{1}{2} \times 24 = \frac{43}{\underset{1}{\cancel{2}}} \times \overset{12}{\cancel{24}}$$
$$= \underline{\text{£}516.}$$

What does a cheesemonger pay for 7 cwt. 82 lbs. of cheddar cheese at £2. 16s. per cwt.?

$$7 \text{ cwt. } 82 \text{ lbs.} = 7\frac{82}{112} = 7\frac{41}{56} \text{ cwt.}$$

$$£2.\ 16s. = £2\frac{16}{20} = £2\frac{8}{10}.$$

$$\therefore \text{ Cost} = £2\frac{8}{10} \times 7\frac{41}{56} = \frac{28}{10} \times \frac{433}{56}$$

$$= £21.\ 13s.$$

A bacon hog weighed 9 st. 7 lbs. (dressed carcass weight). What was its cost at 7s. 6d. per stone of 14 lbs.?

Cost of 7 lbs. = ½ cost of 1 st.

£	s.	d.		st.	lbs.
0	7	6	= cost of	1	0
		9			
3	*7*	*6*	= ,,	*9*	*0*
0	3	9	= ,,	0	7
£3	11	3	= ,,	9	7

A porker weighed 5 score and 6 lbs. (live weight), and when killed lost 3 lbs. out of every 14 lbs. live weight. What was its cost at 12s. 6d. per score lbs.?

Difference between live weight and dead weight of porker

$$= \frac{3 \times 106}{14} \text{ lbs.} = \frac{159}{7} = 23 \text{ lbs. (approx.).}$$

$\therefore$ Dead weight of porker = 106 lbs. − 23 lbs. = 83 lbs.
= 4 score 3 lbs.

£	s.	d.		score	lbs.
0	12	6	= cost of	1	0
		4			
2	10	0	= ,,	4	0
0	1	3	= ,,	0	2
		7½	= ,,	0	1
2	11	10½	= ,,	4	3

Cost of 2 lbs. = $\frac{1}{10}$ cost of 1 score

What is the price of a shorthorn bullock weighing 63 st. (dead weight) at 8s. 1d. per stone of 14 lbs.?

	£	s.	d.		s.	d.	
Cost at 1d. = $\frac{1}{12}$ cost at 1s. =	3	3	0	= cost at	1	0	per stone.
			8				
	25	4	0	= ,,	8	0	,,
	0	5	3	= ,,	0	1	,,
	£25	9	3	= ,,	8	1	per stone.

What is the cost of 28 lbs. of Danish butter at £4. 15s. per cwt.?

$$28 \text{ lbs.} = \frac{28}{112} = \frac{1}{4} \text{ cwt.}$$

$\therefore$ Cost of 28 lbs. = $\frac{1}{4}$ cost of 1 cwt.

$$= \frac{£4.\ 15s.}{4} = £1.\ 3s.\ 9d.$$

What is the cost of a fat cow weighing 8 cwt. 8 qr. 8 lbs. (dead weight) at $6\frac{1}{2}$d. per lb.?

8 cwt. at 1d. per lb.	= 9s. 4d. × 8	=	£3	14	8
3 qrs. ,, ,,	= 2s. 4d. × 3	=	0	7	0
8 lbs. ,, ,,		=	0	0	8
$\therefore$ 8 cwt. 3 qrs. 8 lbs. at 1d. per lb.		=	£4	2	4
					6
,, ,, ,,	at 6d. per lb.	=	£24	14	0
,, ,, ,,	at $\frac{1}{2}$d. ,,	=	2	1	2
,, ,, ,,	at $6\frac{1}{2}$d. ,,	=	£26	15	2

Cream contains 33·5 per cent. of butter fat. How many lbs. of butter fat are there in 45 lbs. 10 oz. of cream?

Butter fat = $\frac{33{\cdot}5}{100}$ of 45 lbs. 10 oz.

= ·335 of 45 lbs. + ·335 of 10 oz.

45	10
13·40	oz. 3·35
1·675	
lbs. 15·075	
16	
·75	
·450	
3·35	
oz. 4·55	

Answer 15 lbs. 4·55 oz.

A bullock weighing 7 cwt. 2 qrs. 14 lbs. was fattened and then weighed 12 cwt. 1 qr. 8 lbs. Compare the fat weight with the initial weight.

$$7 \text{ cwt. } 2 \text{ qrs. } 14 \text{ lbs.} = 854\tfrac{1}{2} \text{ lbs.}$$
$$12 \text{ cwt. } 1 \text{ qr. } 8 \text{ lbs.} = 1380 \text{ lbs.}$$
$$\text{Fat weight} = \frac{1380}{854} \text{ of initial weight.}$$
$$\text{Fat weight} = 1{\cdot}615 \text{ of initial weight.}$$

In an experiment with potatoes, Up-to-dates yielded 14 tons 8 cwt. per acre, while Farmer's Glory produced 10 tons 12 cwt. Compare the produce per acre of Up-to-dates and Farmer's Glory.

$$\text{Up-to-dates} = 248 \text{ cwt.}$$
$$\text{Farmer's Glory} = 132 \text{ cwt.}$$
$$\text{Up-to-dates} = \frac{132}{248} = {\cdot}532 \text{ produce of Farmer's Glory.}$$

A farmer purchases some sheep for £180 and borrows the money to pay for them at 5 per cent. interest. He completes paying the interest at the end of six months.

(*a*) How much interest has he to pay?

(*b*) What is the whole sum he pays to the bank?

$$\text{Interest on £180 at 5 per cent. for 1 year} = \frac{5}{100} \text{ of £180} = \text{£9.}$$

(*a*) Interest on £180 for six months = £4. 10s.

(*b*) Total amount paid = £180 + £4. 10s. = £184. 10s.

If wheat is quoted at 28s. 6d. per quarter, what is the price per bushel?

$$\text{Price per bushel} = \frac{28\text{s. } 6\text{d.}}{8}$$
$$= 3\text{s. } 6\tfrac{3}{4}\text{d.}$$

What is the cost of 6 tons 16 cwt. 3 qrs. of hay at £3. 10s. per ton?

	£	s.	d.		Tons	cwt.	qrs.
	3	10	0	= cost of 1	0	0	
			6				
	21	0	0	= ,,	6	0	0
Cost of 10 cwt. = ½ cost of 1 ton	1	15	0	= ,,	0	10	0
,, 5 cwt. = ½ ,, 10 cwt.	0	17	6	= ,,	0	5	0
,, 1 cwt. = ⅕ ,, 5 cwt	0	3	6	= ,,	0	1	0
,, 2 qrs. = ½ ,, 1 cwt.	0	1	9	= ,,	0	0	2
,, 1 qr. = ½ ,, 2 qrs.	0	10	0½	= ,,	0	0	1
	23	18	7½	=	6	16	3

What would be the cost of four quarters of beef, the combined weight of which is 14 cwt. 16 lbs., when beef is selling at £2. 15s. 6d. per cwt.?

	£	s.	d.		Cwt.	lbs.
	2	15	6	= cost of 1	0	
			7			
	19	8	6	= ,, 7	0	
			2			
	38	17	0	= ,, 14	0	
Cost of 16 lbs. = ⅐ of 1 cwt.	0	7	11⅐	= ,, 0	16	
	39	4	11⅐			
=	39	4	11	cost of 14 cwt. 16 lbs.		

A cow gave an average daily yield of $3\frac{1}{4}$ gals. of milk for 2 weeks. What was the value of the milk when sold wholesale at 9d. per gallon?

Number of days $= 42 \times 7 = 294$.
Number of gallons $= 294 \times 3\frac{1}{4} = 882 + 73\frac{1}{2} = 955\frac{1}{2}$.
Value of milk $= 955\frac{1}{2} \times 9$d. $= 8599\frac{1}{2}$d. $= 716$s. $7\frac{1}{2}$d.
$=$ £35. 16s. $7\frac{1}{2}$d.

One acre of ground is sown with yellow globe mangolds, in drills 20 in. apart, and later the plants are thinned out to a distance of 10 in. from plant to plant, the roots are found to average $2\frac{3}{4}$ lbs. in weight. State total weight of roots per acre.

Area occupied by each plant $= 10 \times 20$ sq. in.

Number of plants in the acre $= \frac{4840 \times 9 \times 144}{10 \times 20}$

$= 31363.$

$\therefore$ Weight $= 31363 \times 2\frac{3}{4}$ lbs.

$= 38$ tons 10 cwt. $8\frac{1}{4}$ lbs.

$4)31363 \times 2 = 62726$

$7840\frac{3}{4} \times 3 = 23522\frac{1}{4}$

$28 \left\{ \begin{array}{l} 4 \overline{)86248\frac{1}{4}} \\ 7 \overline{)21562} \\ 4 \overline{)3080 + 2} \\ 20 \overline{)770} \end{array} \right\}$ lbs. 8

38 tons 10 cwt.

A stall-fed dairy cow received the following daily ration: 66 lbs. of sliced mangels at 8s. per ton; 14 lbs. of loose meadow hay at 65s. per ton; 20 lbs. chaffed oat straw at 35s. per ton; 5 lbs. decorticated cotton cake at £8. 5s. per ton. What is the cost of keeping the cow for 1 week?

Weekly Bill

		s.	*d.*
Mangels	462 lbs. $= \frac{1}{5}$ ton (nearly) at 8s. per ton	$= 1$	8
Hay	98 lbs. $= \frac{7}{8}$ cwt. at 3s. 3d. per cwt.	$= 2$	10
Straw	140 lbs. $= 1\frac{1}{4}$ cwt. at 1s. 9d. per cwt.	$= 2$	2
Cake	35 lbs. $= 1\frac{1}{4}$ qr. at 2s. 1d. per qr.	$= 2$	7
		9	3

Use your common sense in working. 462 lbs. is not quite $\frac{1}{5}$ ton, but it is near enough for all practical purposes. In everyday life we do not bother about unwieldy fractions of a penny. Quite recently we saw in an examination paper a coal bill to be worked to the nearest farthing—what need is there of words?

Miscellaneous

1. A man digging ordinary garden soil 1 spit deep is paid at the rate of $2\frac{1}{2}$d. per square rod, while another man trenching heavy loam 2 spits deep, is paid 1s. 1d. per square rod. How many square rods of the lighter soil must be dug to equal the cost of trenching 1 square rod of the heavy soil?

2. If in removing soil with a wheel-barrow a man can wheel and tip a load, and return empty a distance of 30 yds. on a level plank, or 20 yds. up a ramp or steeply inclined plank, in 1 minute, how long would it take to remove 153 c. yds. of earth, a barrow-load of which is estimated one-ninth of a cubic yard?

3. In removing earth or other loose material, a horse and cart takes an hour to go and return a distance of 1 mile, removing $\frac{3}{4}$ of a cubic yard each journey. How many cubic yards will be removed by the horse and cart in 7 hrs.?

4. The analysis of a sample of skimmed or separated milk gave the following parts by weight: Water 928·75, cheese with a trace of butter = 28·00, sugar of milk 35·00, muriate of potash 1·70, phosphate of potash 0·25, lactic acid, with acetate of potash 6·00, earthy phosphate 0·30. What is the total of these amounts?

5. If a man ploughing with a foot-width furrow turns over $1\frac{1}{2}$ ac. in a day, while another ploughman, working on stiffer land, with a 9-in. furrow ploughs $\frac{3}{4}$ ac. per day, how much more land will be ploughed by the former than by the latter at the end of 6 days?

6. If the cost of keeping 2 horses is estimated at 3s. 6d. per day, and the ploughman's wages at 2s. 6d., what will be the cost per acre when $\frac{1}{2}$ ac. of heavy land, $\frac{3}{4}$ ac. of loam, and $1\frac{1}{2}$ ac. of light chalky land are ploughed per day?

7. If a farm horse, costing £45 at 6 years of age, depreciates at the rate of £2 per annum, what will be the value of the horse at 16 years of age?

8. A rich heavy loam produced 48 tons 4 cwt. $2\frac{1}{2}$ qrs. of mangels per acre, whereas a light sandy loam, deficient in plant food, yielded 27 tons 13 cwt. 1 qr. per acre.

Find: (*a*) The total yield from the 2 ac. of land.
(*b*) The difference in weight between the 2 yields.

9. What is the weight of 7 qrs. 6 sacks 56 lbs. of wheat in lbs.? (1 bus. = 60 lbs.)

10. 6 Devon steers 1 year 10 months old received the following ration commencing 10th December: 4 lbs. linseed cake; 4 lbs. barley meal; 60 lbs. swedes; 12 lbs. oat straw. After 10th January this ration was increased. What was the total weight of each food consumed over this period? Also find the respective cost of each lot of food consumed, the prices being:—

Linseed cake	£8. 15s. per ton.
Barley meal	£7. 15s. ,,
Oat straw	£1. 15s. ,,
Swedes	8s. ,,

11. A farm horse receives per week: 1 truss of old hay (56 lbs.) at 70s. per ton; 1 truss of oat straw (36 lbs.) at 30s. per ton; 2 bus. old oats at 20s. per quarter (1 qr. = 8 bus. = 2 sacks). What is the cost of keeping the horse for 3 months?

12. A farmer purchases some sheep for £180, and borrows the money to pay for them at 5 per cent. per annum interest. He completes paying the interest at the end of 6 months.

(*a*) How much interest has he to pay?
(*b*) What is the whole sum he pays to the bank?

13. If the weight of a live pig be $1\frac{5}{14}$ as much as the weight of a dead pig, what is the dead weight of a bacon hog, the live weight of which is 240 lbs. (12 score lbs.)?

14. A Galloway heifer weighed 7 cwt. 2 qrs. when put up for fattening, and continued to lay on an average weight of $1\frac{1}{2}$ lbs. per day. What was her weight at the end of 14 weeks?

15. A dairyman, in examining his dairy record, finds that one of his cows yielded 670 gals. of milk in the year, of which milk 350 gals. were made into butter, it requiring $2\frac{1}{3}$ gals. to make 1 lb. of butter; while the remainder of the milk was retailed at 4d. per quart, the butter being retailed at 1s. 4d. per lb. Compare the respective returns from butter and milk.

16. A farmer had 20 ac. of clover ley, half of which he manured for wheat with 3 cwt. of superphosphate of lime, the remainder being unmanured. The unmanured ground yielded 7 sacks of grain per acre, while the manured yielded $9\frac{1}{2}$ sacks per acre. How much more grain was obtained from the manured ground?

17. The autumn ploughing of heavy land costs 18s. 6d. per acre, while the spring or second ploughing costs 12s. 6d. What was the cost of the two ploughings in a field of 35 ac.?

18. The cost of flat-hoeing 17 ac. of mangels on a light, clean, loamy soil was 6s. 6d. per acre, while in a field of the same size on a stiff, retentive, gravelly soil, foul with weeds, the cost was 17s. per acre. What was the difference in the cost of hoeing the two fields?

19. During lambing time a farmer lost 1 lamb out of every 14 born. If 377 lived, how many died?

20. If 560 sticks of celery are tied up in market bunches of 12 to the bunch, how many stems or sticks will remain over?

An ordinary corn sack holds 4 bus. leaving ample room for tying. In the corn trade an allowance of 4 lbs. is expected per sack. Thus, if barley is sold at 30s. per quarter, and weighed off at 54 lbs. to the bushel, each sack with its contents will weigh 220 lbs.

N.B.—In the seed trade a 5-bus. sack is ordinarily used, and an allowance of 5 lbs. is expected, and is claimed if a 4-bus. sack is used.

21. What quantity of nitrate of soda will be required to dress a crop of oats covering 7 ac. 3 r. 35 sq. po. at the rate of 2 cwt. per acre?

22. If 1 gal. of milk and $1\frac{1}{4}$ lbs. of cane sugar produce $2\frac{1}{2}$ pts. of condensed milk, how much milk and sugar respectively will be required to produce 1 gal. of condensed milk?

23. A condimental food for cattle is made up as follows, at a cost of 18s. :—

	Lbs.
Locust bean meal	28
Maize meal	56
Linseed cake meal	20
Sulphur	2
Saltpetre	2
Common salt	$1\frac{1}{2}$
Fenugreek	1
Gentian	$\frac{1}{2}$
Sulphate of iron	$\frac{1}{2}$
Aniseed	$\frac{1}{4}$
Ground ginger	$\frac{1}{4}$

If fed to an adult animal at the rate of 2 oz. per day, how long will this amount last, and what will be the cost per day?

24. A calf weighed 75 lbs. at birth, and when killed at the end of 335 days showed a daily average increase of 2·8 lbs. What was its weight?

25. If 85 per cent. of a fat pig is meat with bone, of which 80 per cent. is available as food, what percentage is unconsumable as food?

26. It is estimated that 1,000 lbs. of barley straw will on an average remove from the soil $5\frac{1}{2}$ lbs. of nitrogen and 50 lbs. of mineral matter, the latter including about 25 lbs. of silica, 12 lbs. of potash, $3\frac{1}{2}$ lbs. of lime, 2 lbs. of phosphoric acid, and 1 lb. of magnesia. This being so, what quantity of these respective ingredients will be removed from an acre of ground the yield of straw from which amounts to 1 ton?

27. Which contains more nitrogen, 10 tons of guano containing 17·36 units of nitrogen per ton, or 9·5 tons of sulphate of ammonia containing 19·7 units of nitrogen per ton? (One unit weighs 22·4 lbs., and 1 ton = 2,240 lbs.)

28. A farmer threshes 5 ricks each containing 1,570 c. ft. of barley grain, and he gets altogether 1,756 bus. of grain. How many bushels did he obtain per cubic foot of barley?

29. Kainit contains 12·5 parts of potash to the ton, and sulphate of potash contains 50 parts of potash to the ton. How many tons of sulphate of potash will contain the same amount of potash as 30 tons of kainit?

30. If small round ricks such as are commonly seen in Scotland contain the produce from ·5 of an acre, how many ricks will be required to contain the produce from $13\frac{3}{4}$ ac.?

31. If linseed cake contains 28·3 parts of albuminoids, 10·0 parts of oil, and 7·9 parts of ash, how many parts of other ingredients will there be in 100 parts of the cake?

32. A farm of 729·7 ac. contains 72·6 ac. of wheat, 29·7 ac. of roots, 67·1 ac. of barley, 34·8 ac. of oats, 37·5 ac. of clover ley, 320 ac. of dry pasture. The remainder of the land is as water meadow. Find its area.

33. If 5 cows cost £97. 11s. 3d., and the best one is worth £23. 10s. 6d., what is the value of each of the others, supposing each to be worth the same amount?

34. If a cow eats 28 lbs. of hay in a day, how many days can a cow be kept on 27,468 lbs. of hay?

35. If a cow costs 6s. $9\frac{1}{2}$d. to keep for 1 week, how much will it cost to keep 7 cows for 3 weeks?

36. Give the weight of hay in cwt. qrs. and lbs. which 19 cows will consume in 74 days if each cow eats 28 lbs.

37. A barn gallon of milk is reckoned as 17 pints; what is the value of 98 barn gallons at $1\frac{1}{2}$d. per pint?

38. If 17s. 6d. per week is charged to pasture 7 cows, how many cows can be kept for £4. 2s. 6d. per week?

39. If 231 tons of mangels be pulled from a field of 7 ac., what yield should be expected from a field of $14\frac{1}{2}$ ac.?

40. Calculate my yearly income from 15 cows if each cow produces 483 gals. of milk which I retail at $3\frac{1}{2}$d. per quart.

41. $3\frac{3}{4}$ gals. of milk produce $1\frac{1}{2}$ lbs. of butter. How much butter can be produced from 120 pints of milk?

42. If a good scytheman can mow a field of $5\frac{1}{2}$ ac. in 3 days, while a less skilful man requires 4 days, how long will it take the two men working together to mow a meadow of 17 ac.?

43. If 1 gal. of milk weighs 10·32 lbs., how many gallons of milk are there in a churn whose contents weigh 2 cwt. 3 qrs. 6·76 lbs.?

44. What do I receive for the produce of 3 ac. 3 r. of potatoes, if I get $7\frac{1}{2}$ tons per acre and sell them at 4s. 9d. per cwt.?

45. If 4 per cent. of milk is butter fat what weight of butter fat is there in 17 gals. of milk, reckoning the weight of 1 gal. of milk as 10·32 lbs.?

46. What weight of corn may I expect from a rick containing 1,620 c. ft., if each cubic yard produces a bushel of corn and each bushel weighs 62·5 lbs.?

47. If 87 per cent. of milk is in the form of water, what weight of solid is there in 97 gals. of milk (10·32 lbs. to the gallon)?

48. If in covering a roof with pantiles every square (100 sq. ft.) requires 1 bundle of 12 oak laths 10 ft. × $1\frac{1}{4}$ in. × $\frac{1}{4}$ in., 150 nails, and 1 peck of tile pins, what amount of each material will be required in tiling the roof of a cowshed having a total area of 360 sq. ft.?

49. If 20 sheaves of wheaten straw weighing 28 lbs. each are required to cover a square (100 sq. ft.) of thatched roof, what number of trusses weighing 36 lbs. each will be required to cover 360 sq. ft.?

50. A manure heap is 33 ft. by 12 ft., and its average thickness $4\frac{1}{2}$ ft. A cubic yard, weighing 12 cwt., forms a load.

(*a*) How many loads are there in the heap?

(*b*) What is the total weight of manure in the heap?

51. A cow is allowed 800 c. ft. of air space. A span roof cow-house is 90 ft. long and 15 ft. wide, the height to the eaves being 9 ft. and from the ground to apex of roof 15 ft. What number of cows can be accommodated?

N.B.—It requires about two-thirds more food to produce 100 lbs. of gain with heavy bacon hogs weighing 12 score lbs. and upwards, than with porkers weighing from 3 to 6 score lbs.

52. If a pig weighing 80 lbs. consumes 3·62 lbs. of fo per day in order to make a gain of ·79 lb., what quanti of food will be consumed by a bacon pig weighing 280 lbs and what will be the gain per day?

53. A plain roof tile is $10\frac{1}{2}$ in. $\times 6\frac{1}{4}$ in. $\times \frac{5}{8}$ in. and weigh $2\frac{1}{4}$ lbs. What is the area of a tile and what number of tile would there be in 1 cwt.?

54. If 1 c. ft. of manure weighs 56 lbs., find the weight of 24 loads each containing 45 c. ft.

55. The cost of wintering a six months old Shorthorn steer for 180 days amounts to £2. 10s., while in the case of sheep 10s. per head for ewes and 7s. per head for hoggs is not unusual. What would be the total cost of wintering 30 head of steers, 300 hoggs, and a breeding flock of 200 ewes?

56. A greasy wool is bought at 12d. per lb. and on the impurities being removed is found to lose 40 per cent. Without taking the cost of scouring into consideration, what is the cost of the clean wool per lb.; and what would be the cost per lb. if it lost 50 per cent.?

57. Assuming the normal temperature of the horse to be 100·5° F., of the cow 102° F., of the sheep 103·5° F., of the pig 103·2° F., and of the fowl 100·8° F., convert these temperatures into degrees Centigrade.

58. A 12-ton crop of sound potatoes consists of 9 tons of marketable tubers, 1 ton 18 cwt. of tubers of seed size, and the remainder small tubers or chats. What is the percentage of each kind of tuber?

59. Three Aberdeen-Angus steers under 2 yrs. weighed respectively 12 cwt. 20 lbs., 13 cwt. 47 lbs., and 14 cwt. 3 lbs.; while three others under 3 yrs. weighed 16 cwt. 110 lbs., 17 cwt. 1 lbs. and 18 cwt. 3 lbs. What was their average weight?

60. An acre-inch represents the amount of water necessary to cover an acre 1 in. deep. Given that 1 gal. of water contains 277·274 c. in., what quantity of water does 1 ac.-in. represent in gallons per acre?

An acre-foot is the amount of water which would cover an acre 1 ft. deep and is therefore equal to 12 ac.-in.

61. A good road can be made for 1s. to 1s. 3d. per square yard, while a first class road with pitch bottom 7 to 10 in. deep and 4 to 6 in. of metal over it will cost 4s. to 7s. per square yard. What would be the cost of making a road 300 yds. long and 16 ft. wide in each case?

62. If a raspberry grower is £56 per acre out of pocket up to the third year when his plantation is in full bearing, and the cost of cultivation for each succeeding year is £6. 10s. per acre, what will be his profit or loss at the end of the sixth year, provided the crop gives an average yield of 3 tons per acre at £21 per ton?

63. The limit of butter fat in margarine is restricted to 10 per cent., and of water to 16 per cent. What excess per cent. of these standards would a sample contain having an analysis of 13 per cent. butter fat and 20 per cent. water?

64. The total cost of marling a farm of 800 ac., applying 117 yds. to the acre, amounted to £9. 18s. per acre. What was the total cost?

65. If, in consequence of marling, the annual rental value of the land rose from 5s. per acre to £1. 12s. 6d., how long would it be before the extra rent received covered the capital expended in marling?

66. If the work of a pair of horses be estimated at 5s. per day and a man at 3s. per day when harrowing, what is the cost per acre, assuming that 16 ac. can be harrowed in one day?

Note.—Mangel clamps or heaps are usually from 6 to 8 ft. wide at the base, according to the size and condition of the roots, and taper in triangular fashion to a height of about 5 or 6 ft. The average weight of a cubic foot of mangels in clamp is estimated to be 35 lbs.

67. What weight of roots is there in a mangel clamp 7 ft. wide at the base, 6 ft. high, and 30 yds. long?

68. In the square system of planting cabbage for cattle the plants are planted 30 in. by 30 in., in order that the crop may be horse hoed each way as often as required, while "market" cabbage plants may be planted 2 ft. by 2 ft.

What number of each of these kinds of plants would be required to plant an acre?

69. Find the volume of a heap of stones 12 ft. by 10 ft. at the base, 8 ft. by 6 ft. at the top, $3\frac{1}{2}$ ft. high.

70. For the proper home-curing of bacon it is necessary to maintain a temperature of from 40° to 42° F. What are these temperatures in degrees Centigrade?

71. The temperature of a store for butter is from 6° below zero to 2° C. Convert these to degrees Fahrenheit.

72. If the thinnings of a timber plantation of, say, 2,000 trees (larch and Scotch fir poles) at the end of 20 years are worth £30, what will be the amount of this sum in 20 years at 3 per cent. simple interest? What is the area of the plantation if the trees were planted 4 ft. apart?

73. The following are the average costs of different kinds of fencing: Wood uprights and 3 rails, 9d. per yard; iron uprights and wire, 2s. per yard; iron uprights and 4 lines barbed wire, 1s. 6d. per yard; oak palings, 4 ft. or 6 ft. high, 7s. 6d. or 9s. per yard respectively; wall of brick, 6 ft. high, 30s. per yard. Find the cost of fencing round a field 273 ft. long and 94 ft. wide in each case.

74. If 1 sq. ft. of English sheet-glass weighs 15 oz. and costs 12s. per 100 sq. ft., what will be the number of sheets, weight and cost per sheet, 8 in. by 6 in. in size, of glass in a crate of sheets measuring in all 300 sq. ft.?

75. Estimate the cost of glazing the roof of a greenhouse, 40 ft. long and 14 ft. wide, at 4d. per square foot. Allow 5 per cent. for the overlapping of the glass and consider that the wooden bars take up 20 sq. ft.

76. The small round baskets used for black currants, strawberries, and raspberries will hold on an average about 13 lbs. of fruit. How many baskets would be required for a crop of 3 cwt.?

77. The typical bushel basket used for all kinds of vegetables and some of the rougher and inferior fruits is made of osiers and costs about 21s. per dozen. It measures 11 in. in diameter inside the rim and has a depth of about

10 in. What is its content as compared with the half sieve which is $14\frac{1}{2}$ in. in diameter inside the rim and 7 in. deep?

78. If a market salesman obtains 5 per cent. commission on consignments in the sender's boxes or baskets, and $8\frac{1}{2}$ per cent. using his own baskets, what is his commission in each case if he effects sales to the value of £18. 10s.?

79. What number of days in an ordinary year are there for the following legal seasons for killing game, etc.: Grouse or moor fowl, 12th August to 10th December; partridge, 1st September to 1st February; pheasant, 1st October to 1st February; wild fowl, 1st August to 1st March.

80. It is estimated that a bushel of wheat weighing 63 lbs. contains 865,710 seeds, a bushel of oats weighing 42 lbs. contains 469,952 seeds, and a bushel of barley weighing 57 lbs. contains 665,442 seeds. What number of seeds are there in 1 lb. of each kind of grain?

81. If the average quantity of wheat produced per acre is $7\frac{1}{2}$ qrs. and the quantity of seed sown is 3 bus., what part of the produce must be returned again to the ground as seed?

82. The fire insurance rates on farm property are usually as follows: Farm buildings, 3s. per cent.; livestock, 3s. per cent.; agricultural produce and utensils, 7s. 6d. per cent. What is the value of the buildings, livestock, and produce and utensils of a farm, if the premiums paid for one year amount to 15s., 10s., and £3. 15s. respectively?

83. For marketing many vegetables there is nothing to equal bags made of Hessian canvas. This is sold in widths of 6 ft. at about 7d. per yard run, and the largest size bags require 6 sq. ft. of canvas and about $\frac{1}{4}$d. worth of string for sewing. What is the cost of making a score of such bags?

84. If a farmer employs 9 men, for each of whom he has to pay 7d. per week under the Insurance Act, and 1 maid, for whom he pays 6d. per week, what are his total payments per year under the Act, provided that 4d. each per week of the men's and 3d. per week of the maid's contribution is recoverable?

85. If two good pitchers at 5s. per day clear 100 ac. in 8 days at a cost of £4, what would the same men earn in clearing a field of 32 ac.?

86. If a scythe, cutting as it does closer to the ground than a machine, accounts for a saving of 2½ cwt. of hay per acre, what would be the saving of hay in a 20-ac. field, hay being valued at 48s. per ton?

87. If a farm horse is worth £40 at six years old, and £18 at seventeen, at what average rate has he depreciated?

88. If the food of a farm horse in summer is estimated at 7s. 6d. per week, in autumn at 9s. per week, in winter at 6s. 6d. per week, and in spring at 10s. per week, what is the cost of his food for one year?

89. If a farmer pays 35s. per acre for labour on 300 ac. of light soil and 45s. per acre on 150 ac. of medium soil, what is his total cost of labour for the year?

90. During seven winter months from October to April inclusive the actual cost of hay and all artificial foods for a herd of 30 Holstein cattle, yielding from 800 to 1,000 gals. of milk per year, averaged £5 per head. What was the cost of feeding the herd per week, and the cost per head per week?

91. An unscrupulous butter factor purchased margarine at 6¾d. per lb. and put it up in round 1 lb. pats which he sold at 1s. per lb. wholesale. What profit did he realise if he purchased and sold 1,143 lbs. of margarine in this manner?

92. In an experiment with regard to the cost of rearing chickens the following results were obtained:—

Cost of egg	-	1·43d. per chicken.
,, working incubator	-	0·2 ,,
,, working brooder	-	0·2 ,,
Food cost, 4 weeks	-	1·01 ,,

What, therefore, would be the cost of rearing 25 such chickens?

ANSWERS

EXAMPLES I

Addition and Subtraction

1. 30° F.
2. 22·4° F.
3. £4. 4s.
4. £12. 17s. 6d.
5. £6. 12s.
6. 3 yds. 1 ft. 9 in.
7. 33 sq. po. 3½ sq. yds.
8. 668 sq. yds.
9. 165 ac.
10. 11 tons 19 cwt. 3 qrs. 2 lbs.
11. £7. 3s.
12. 813 yds.
13. 55 ac. 3 r. 1 sq. ch. 2 sq. rods 8¾ sq. yds.

EXAMPLES II

Multiplication

1. 900 bus.
2. 40 tons 12½ cwt.
3. £1,259. 5s.
4. 9,000 sq. yds. = 1 ac. 3 r. 17 po. 15¾ yds.
5. 34,900 c. ft.
6. 11s. 8d.
7. 195 cwt.
8. 34 sq. po. 21½ sq. yds.
9. 716 yds. 2 ft.
10. £218. 15s.
11. £2. 2s.
12. 1 mile 175 yds.
13. 29 hrs. 36 mins.
14. 4,160 tons
15. 5 tons 0 cwt. 3 qrs. 26 lbs.
16. 5 tons 14 cwt. 2 qrs. 16 lbs.
17. 12 tons 17 cwt. 18 lbs.
18. 22 tons 5 cwt. 2 qrs. 24 lbs.
19. £3. 1s. 9d.
20. £2. 3s.
21. 2 tons 6 cwt. 2 qrs. 17 lbs.
22. £72. 10s.
23. 18¾ tons
24. £39. 4s. 11d.
25. £18. 5s.
26. £25
27. £3. 11s. 3d.
28. £3. 6s. 3d. live; £2. 12s. 1d. dead
29. £121. 17s. 6d.
30. £18. 15s.
31. £7. 4s.
32. 3×10^6
33. £5. 8s. 0¾d.
34. £2. 8s.
35. £2. 13s. 1½d.
36. £20. 12s. 6d.
37. £9
38. £1. 13s. 4d.; £5. 6s. 8d.; £7. 6s. 8d.
39. 560 cwt.
40. £1. 3s. 9d.
41. £26. 13s. 6d.
42. 16 cwt. 2 qrs. 27 lbs.
43. 2,512 sacks 2 bus.
44. 69½ cwt.
45. 450 score lbs.
46. 15,065 gals.
47. £171
48. £2. 19s. 5d.
49. 600 tons
50. 100 lbs.
51. 40 lbs.; 1 cwt. 2 qrs. 26 lbs.
52. £233. 10s.
53. 4,032; 2,592
54. £20. 19s. 9d.
55. £22. 2s. 10d.
56. £18. 6s. 8d.
57. £266. 1s.

EXAMPLES III

1. 45 tons
2. 320 cwt.
3. 72 pigs
4. 151 lbs.
5. 4s. 6d.; 7s. 10½d.
6. 7¼d.; 4s. 10d.; 8s. 5½d.
7. 7¼d.; 8s. 5½d.; 67s. 8d.
8. 5s.
9. 42 tons
10. 6½d. nearly
11. 9½d. nearly
12. 1½d.; 3d.; 4½d.; 7½d.; 9d.
13. 18
14. £41. 5s.
15. 72 bus.; 18 times
16. 360 bus.; 2,429 bus.
17. 28 bus.
18. 95 bus.
19. 7 ac. 2 r.
20. £22. 14s.
21. 72 lots
22. 12 cwt. 1 qr. 13 lbs. nearly
23. 7½ lbs.
24. 1s. 7d. nearly
25. 314 ac. nearly
26. £1. 11s. 5d.
27. 5s.
28. 1 ton 4 cwt. 1 qr. 23 lbs.
29. 526⅔ gals.

EXAMPLES IV

1. 40⅗ sq. r.; 13s. 10d.
2. 57½ bus.
3. £3. 6s.; 17s. 6d.
4. 4,477 sq. yds.
5. 17·50142 ac.
6. 800 sq. yds.; 24,200 sq. yds. 50 sq. ch.
7. 3,630 sq. yds.
8. 928 sq. ch.
9. £11
10. 3s. 6¾d.
11. 86¼ lbs.
12. 194 qrs. 2 bus. 1 pk.
13. ⅜ sack over; 249 sacks
14. 85 gals. 2 qts.; £5. 14s.
15. 19s. 9d.; 4s. 11¼d.
16. 11 cwt. 3 qr. 1 st. 12 lbs.
17. 69 yds. 1 ft. 8 in. nearly

EXAMPLES V

1. 25·05 in.
2. 12·53 lbs. solid; 87·47 lbs. water
3. 136·442 ac.
4. 30⅛ ac.
5. 515 times; 120 links over
6. 29
7. 2 r. 4 po. nearly
8. ·75; ·227; ·005; ·06; ·003; ·005
9. ·095 in.
10. 5 cwt. 3 qrs. 24 lbs.
11. 189·66 lbs.
12. 5 tons 14 cwt. 3·9 qrs.
13. 18⅛; 49½; 37·2; $8\frac{21}{40}$; $35\frac{5}{6}$; 7·7
14. £5. 18s.
15. Hay ·43, oats ·27, beans ·13, maize ·11, bran ·06

EXAMPLES VI

1. $\frac{17}{50}$ ch.
2. $\frac{57}{1760}$
3. $\frac{88}{100}$
4. $1\frac{3}{8}$ gals.
5. $13\frac{1}{2}$ tons
6. $2\frac{2}{5}$ tons
7. 175 gals.
8. $19\frac{14}{15}$ gals.
9. $10\frac{19}{40}$ gals.
10. $10\frac{2}{35}$ cwt.
11. 325 times; $\frac{1}{48}$ gal. left
12. 94
13. 787½ tons
14. 1·4375
15. $\frac{27}{40}$
16. $\frac{23}{44}$

EXAMPLES VII

1. 50 lbs. 5 oz.
2. 240½ lbs. nearly
3. 8½d. nearly
4. 4 days
5. 16 hrs.
6. 51⅓ days
7. 70 doz.
8. 920⅘ lbs.

9. £326. 7s. nearly
10. 4s. 2d.; 7s. 4d.
11. 8s. 5½d.
12. 3¼½ cwt.
13. 220 lbs.
14. £21. 7s. 10½d.
15. 234⅔ lbs.
16. 20 lbs.; 160 lbs.
17. 57½½ lbs.
18. 337,500
19. 228¼ days
20. 183 lbs. nearly
21. 117½½ ac.
22. 708⅓ lbs.
23. 1⅕ days
24. 15 cwt. 1 qr. 25 lbs. nearly
25. 2,784 tons
26. 168 gals.

EXAMPLES VIII

. 6 : 13 or 1 : 2 nearly
. 20 : 11 or $1\frac{9}{11}$: 1
1·529 : 1; 6·25 : 1; 2·963 : 1; 3·5 : 1; 1·686 : 1
1·36 : 1
1·16 : 1

EXAMPLES IX

Percentages

7½ cwt.
10. 10s.
9·7 gals.
5. 5s.
5 per cent.
per cent.

lbs. 4½ oz.
per cent. nearly
9½d.; 65s.; 10s. 5d.
lbs. starch; 4½ lbs. albumen; 2¼ lbs. oil
tons
lbs. starch; 1⅗ lbs. gluten; oil
lbs. starch; 2¼ lbs. nearly
bumen

15. 1·4 gals. nearly
16. 3·03 per cent.
17. 18·8; 36·7; 44·5
18. 4 st. 7½ lbs.; 4½ lbs.; 4·9 lbs.
19. 10 cwt. 0 qr. 2 lbs.; 3 qrs. 7½ lbs.; 1 cwt. 3 qrs. 2 lbs.
20. 10½ oz.
21. 5¾ oz. boric acid; 3⅗ lbs. salt.
22. 166¼ grs.
23. 88·5 per cent.
24. 2·25 per cent.
25. 38 per cent. hay, 10 per cent. beans, 24 per cent. oats, 28 per cent. maize; 9·9 lbs. hay, 2·4 lbs. beans, 6·3 lbs. oats, 7·5 lbs. maize
26. 87·36; 50·4; 8·4; 21·84
27. 219 nearly; £7. 19s. 8d.
28. 3¾ cwt. silica, 1⅛ cwt. potash, $2\frac{1}{10}$ qrs. lime, 1 qr. 6 lbs. phosphoric acid, 21 lbs. magnesia
29. 907·2 lbs.; 648 lbs.; 648 lbs.; 220·32 lbs.; 64·8 lbs.
30. 150 gals.
31. 3 lbs. nearly
32. 1·9 qrs.
33. ·275 lb.; 3·02 lbs.; 11·545 lbs.
34. 21 cwt.; 52·2 cwt.
35. 4·7 lbs. nearly
36. 43·7 gals.; 40·6 gals.; 43·4 gals.
37. 1·04 tons; 1·365 tons
38. 3·9 cwt.

EXAMPLES X

1. £18. 16s. 8d.
2. 1 ton 6¼ cwt.
3. 19·84 lbs.
4. 26 ac.
5. 13½ ac.
6. 3 ft. 3 in.; 32½ ft.

EXAMPLES XI

1. £16; £65. 4s.; £3. 12s.
2. £25. 6s. 3d. £77. 17s. 2d. £41. 5s. 10d.

EXAMPLES XII

1. 64
2. 23
3. 376
4. 507
5. $5\frac{7}{45}$
6. 74·21

EXAMPLES XIII

1. 7,195
2. 15,840
3. $241\frac{4}{5}$; £6. 0s. 8d.
4. $187\frac{1}{2}$ bus
5. 18 times the floor surface
6. 7,920
7. 284
8. 75
9. 193
0. £59. 10s. 5d.
1. 2,250 lbs.
2. 1,462
3. £600; £240; £150
4. £13. 4s.
5. 936; 2,940
6. 3
7. 26 in. ; 23 in. ; 14 in.
8. 88 ft.
9. £5. 16s. 4d.
0. The second by $4\frac{1}{2}$ sq. ft.
1. 2 yds.
2. 187 times
3. 256

EXAMPLES XIV

1. $3\frac{1}{3}$ c. yds.
2. ,196 gals.
3.),794 gals.
4. c. ft.
5. $\frac{3}{4}$ gals.
6. $\frac{3}{4}$ c. yds. ; $33\frac{1}{3}$ tons
7. n.
8. 7. 5s.
9. c. ft.
0. $\times 9\frac{1}{4}$ in. $\times 7\frac{1}{8}$ in.
1. yds.
2. 11s. 1d.
3. yds. 51 c. ft.
4. 129 c. yds. 17 c. ft. ; 18 c. yds 14 c. ft. ; 37 c. yds. 1 c. ft.
5. 1 c. yd. $8\frac{1}{16}$ c. ft.
6. $1\frac{7}{8}$ c. ft.
7. $51\frac{1}{24}$ c. ft.
8. $2{,}581\frac{7}{8}\frac{7}{8}$; 2,582 c. yds. nearly
9. Top soil, £23. 3s. ; excavating, £13. 18s. ; turf, £16. 13s. 4d.

MISCELLANEOUS EXAMPLES

1. $5\frac{1}{3}$ sq. rods.
2. $22\frac{1}{2}$ bus.
3. $5\frac{1}{4}$ c. yds.
4. 1,000
5. $4\frac{1}{2}$ ac.
6. 2s. 2d.
7. £25
8. 75 tons 17 cwt. $3\frac{1}{2}$ qrs. ; 20 tons 11 cwt. $1\frac{1}{2}$ qrs.
9. 2 tons 3 cwt. 1 qr. 12 lbs.
10. 128 lbs. cake, 10s. ; 128 lbs. meal, 9s. ; 1,920 lbs. swedes, 7s. ; 384 lbs. straw, 6s.
11. £4. 6s.
12. £4. 10s. ; £184. 10s.
13. 177 lbs. nearly
14. 8 cwt. 3 qrs. 7 lbs.
15. Milk, £21. 6s. 8d. ; butter, £10 ; 2 : 1 nearly
16. 25 sacks
17. £54. 5s.
18. £8. 18s. 6d.
19. 29
20. 8
21. 15 cwt. 3 qrs. 21 lbs.
22. $3\frac{1}{3}$ gals. milk ; 4 lbs. sugar
23. 896 days ; $\frac{1}{4}$d. nearly
24. 9 cwt. 5 lbs.
25. 32 per cent.
26. 13·32 lbs. nitrogen, 56·00 lbs. silica, 26·88 lbs. potash, 7·84 lbs. lime, 4·48 lbs. phosphoric acid, 2·24 lbs. magnesia
27. Sulphate, 304·47 lbs. more
28. 25 nearly
29. $7\frac{1}{2}$ tons
30. 271

31. 61·3 ; 21·6 ; 17·1
32. 168 ac.
33. £18. 10s. 2d.
34. 981
35. £7. 2s. 7½d.
36. 351 cwt. 2 qrs.
37. £10. 8s. 3d.
38. 33
39. 487½ tons
40. £422. 12s. 6d.
41. 6 lbs.
42. $5\frac{2}{7}\frac{3}{7}$ days
43. 30½ gals.
44. £133. 11s. 10½d.
45. 7·0176 lbs. = 7 lbs. ¼ oz. nearly
46. 6 tons 13 cwt. 26 lbs.
47. 119·8152 lbs.
48. $\frac{9}{4\,3}$ c. ft. = 324 c. in. oak, 540 nails, 3·6 pks. pins
49. 56 trusses
50. 66 loads ; 39 tons 12 cwt.
51. 20 cows
52. 6·03 lbs.
53. $65\frac{5}{8}$ sq. in. ; 50 tiles
54. 5 cwt.
55. £280
56. 1s. 8d. per lb. ; 2s. per lb.
57. 38° C. ; 38·9° C. ; 39·7° C. ; 39·6° C. ; 38·2° C.
58. 75 per cent. ; 16 per cent. ; 9 per cent.
59. 15 cwt. 37 lbs.
60. 22,622 gals. nearly
61. £80 to £100 ; £320 to £560
62. £113. 10s.
63. 30 per cent. ; **25 per cent.**
64. £7,920
65. $7\frac{1}{5}$ yrs.
66. 6d.
67. 29 tons 10 cwt. 2 qrs. **14** lbs.
68. 6,969 ; 10,890
69. 280 c. ft.
70. 4·4° C. ; 5·5° C.
71. 21·2° F. ; 35·6° F.
72. £48 ; $3{,}555\frac{5}{9}$ sq. yds. = $\frac{3}{4}$ ac. nearly
73. £9. 3s. 6d. ; £24. 9s. 6d. ; £18. 7s. ; £91. 15s. ; £110. 2s. ; £367
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76. 155
77. 2 : 1 nearly
78. 18s. 6d. ; 31s. 5d.
79. 120 ; 153 ; 123 ; 212
80. 13,741 ; 11,189 ; 11,674
81. $\frac{1}{2\,0}$ lb.
82. £500 ; £333. 6s. 8d. ; £1,000
83. 4s. 4d.
84. £6. 10s.
85. £1. 5s. 7d.
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