APPLIED
ARITHMETIC FOR PRINTERS

APPLIED ARITHMETIC

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APPLIED ARITHMETIC

A HANDBOOK *of* INSTRUCTION IN PRACTICAL MATHEMATICS FOR PRINTERS' APPRENTICES

BY

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PREFACE

THE original edition of this Applied Arithmetic was prepared in order to have in convenient form, for the apprentices of The Lakeside Press, Chicago, the material necessary for use in their regular work. The aim of the book was to secure the results demanded by actual business. The material was compiled from various sources; much of it being furnished by the heads of departments of The Lakeside Press. The problems were tested in the classes of the Apprentice School and seemed to furnish the necessary foundation for their advanced work in mathematics.

The plan and contents of this Arithmetic appeared to be so well adapted for its purpose that upon request of the Committee on Education of the United Typothetae of America a duplicate set of plates of this enlarged, revised edition, prepared at The Lakeside Press, under the direction of Mr. E. E. Sheldon, was generously contributed for use in this series of textbooks by R. R. Donnelley & Sons Company.

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APPLIED ARITHMETIC

NOTATION AND NUMERATION

Numbers may be expressed in *words*, as, ten pages, twenty-five picas; in *figures*, as, 10 pages, 25 picas; in *Roman numerals*, as, page x, the year MCMIX, Chapter XXIV.

The common system of writing numbers is usually called the *Arabic* system, because the figures which it employs were introduced into Europe by the Arabs. A *figure* is a character used to represent a number. There are ten characters in the Arabic notation.

0	1	2	3	4	5	6	7	8	9
naught	**one**	**two**	**three**	**four**	**five**	**six**	**seven**	**eight**	**nine**

The above figures, expressing values regularly increasing by one from nothing to nine, are used in this system. These figures, taken separately, are called *digits*. The first one, named *naught*, is also called a *cipher* or *zero;* it stands for no number. The remaining ones are called significant figures. All integral numbers are expressed by writing the proper digits in a line. The digit on the right is said to stand in the *first* place, the one preceding this is the *second* place, the next preceding is the *third* place, and so on. This order of arrangement is called the scale of the system. The same digit always indicates the same number of units, but the value of the unit indicated depends on the place it occupies in the scale. If a digit stands in the first place, it expresses simply units, or *ones;* if in the second place it expresses *tens;* if in the third place, it expresses *hundreds;* the *value* of the unit in any place is always ten times that of the unit in the next lower place. Thus the combination 498 stands for 4 *hundreds*, 9 *tens*, and 8 *ones*, or for the number four hundred ninety-eight.

The numbers *one*, *two*, *three*, etc., are called *cardinal* numbers in distinction from *first*, *second*, *third*, etc., which are called *ordinal* numbers.

When expressing in words such compound numbers as 21, 49, and 96 use the hyphen; as, twenty-one, forty-nine, and ninety-six.

Spell 40, f-o-r-t-y, not fourty; 90, n-i-n-e-t-y, not ninty.

Round numbers should be spelled, such as ten million pounds, twelve thousand dollars. As a general rule, any number under one hundred should be spelled. Figures should not begin a sentence; neither should they be divided at the end of a line.

In the Roman method of notation seven letters are used. These letters and the values they express are shown below:

Letter	I	V	X	L	C	D	M
Value	1	5	10	50	100	500	1000

Any other number is expressed by a combination of these letters on the general principle that such a combination represents the sum of the values of its constituent letters, these being arranged from left to right in order of value, and the use of the same letter five times or more being avoided by using letters of greater value; but when, in accordance with the above, the same letter would occur four times, it is customary to employ the sub-principle that whenever a letter precedes one of greater value the value of the two is that of their difference instead of their sum.

The following quantities indicate how the letters are used in representing numbers: III, 3; IV, 4; VIII, 8; XXXIX, 39; XLIX, 49; CDLIX, 459; MDCCCLXXXIX, 1889; MCMIX, 1909.

I......	1	XIV......	14	XC......	90
II......	2	XV......	15	C......	100
III......	3	XVI......	16	CC......	200
IV......	4	XVII......	17	CCC......	300
V......	5	XVIII......	18	CD......	400
VI......	6	XIX......	19	D......	500
VII......	7	XX......	20	DC......	600
VIII......	8	XXX......	30	DCC......	700
IX......	9	XL......	40	DCCC......	800
X......	10	L......	50	CM......	900
XI......	11	LX......	60	M......	1000
XII......	12	LXX......	70	MC......	1100
XIII......	13	LXXX......	80	MD......	1500

Roman numerals are generally used in title-pages and chapter headings; also to specify volumes, parts, or chapters in indexes or tables of contents. When Roman numerals are used to folio introductory matter, lower-case type is used (xviii), setting in small type of the same face as the body of the book. A compositor, when required to put a date in Roman numerals, should prefer the combination that requires the fewer letters; as, MCMIX is better than MDCCCCVIIII.

EXERCISE I

1. Write in figures, two hundred forty-nine million, seven hundred twenty-two thousand, six hundred forty-seven; ninety-seven; three hundred fifty-seven thousand, eight; ten thousand, twenty-eight; four hundred thousand, fifty-five.

2. Write in words, 546; 12,111; 598,584; 2,005,047; 20,092.

3. Write in figures, four hundred thousand, twenty-six; two million, twenty thousand, four hundred eight; sixteen million, twenty-four thousand, forty-nine; twelve thousand, eighty-nine.

4. Write in words, 879; 69; 3,054,096; 729,596; 8796; 560,872.

5. Write in Roman numerals, using lower-case letters, 7, 16, 24, 41.

6. Write in Roman numerals, 19; 79; 129; 328; 428; 1889; 1906; 1492; 1776.

7. Distinguish between number and figure.

8. In expressing numbers, when should a compositor use words? When figures? When Roman numerals?

9. Write the dates when the following events in history occurred: The discovery of America by Columbus; signing of the Declaration of Independence; Battle of Lexington; Battle of Gettysburg; Battle of Manila.

10. Write the following dates, in words, also in Roman numerals: 1607; 1620; 1763; 1789; 1914.

ADDITION AND SUBTRACTION

Addition is the process of finding the *sum* of two or more quantities of the same kind; as, the sum of 5 reams, 7 reams, and 8 reams is 20 reams.

Subtraction is the process of finding the *difference* between two quantities of the same kind; as, the difference between 36 picas and 24 picas is 12 picas.

The quantity to be subtracted from is named the *minuend*, the quantity subtracted the *subtrahend*, and the result the *difference*, or *remainder*. To prove a problem in subtraction, add the difference to the subtrahend and the result will be the minuend.

EXERCISE II

1. A man bought a suit of clothes for $15, a hat for $2.25, a pair of shoes for $3.50, a pair of gloves for 85 cents, and a necktie for 35 cents. Find the amount of the bill. The man gave the clerk one five-dollar and two ten-dollar bills. What change should he receive?

2. An apprentice, working two hours a day, sets 842 ems Monday, 964 ems Tuesday, 1248 ems Wednesday, 1468 ems Thursday, 1276 ems Friday, and 1520 ems Saturday. How many hours did he work? How many ems did he set? If he pied 346 ems Saturday, how many ems had he to his credit for the week?

3. January 1, 1910, was Saturday. Counting January 1 and May 30 as holidays, find the total number of working days from January 1 to July 1.

4. The shipping department delivered 5420 catalogues

on Monday, 8680 on Tuesday, 5960 on Wednesday, and 12,400 on Thursday. If the order called for 40,000 copies, how many must be delivered on Friday to complete the order?

5. The engineer ordered thirty tons of coal delivered. If the deliveries were as follows, find the amount to be delivered on Saturday to complete the order.

DAY	NO. LBS.
Monday	12400
Tuesday	8600
Wednesday	9720
Thursday	6480
Friday	11500

6. Find the sum of the following quantities, ten thousand, five hundred twenty-nine; forty-nine thousand, nine hundred ninety-four; ninety-eight thousand, four hundred forty-nine; two million, five hundred forty-eight thousand, seventy-four.

7. In any given problem in subtraction by how much does the minuend exceed the subtrahend? Prove that the sum of the minuend and the subtrahend plus the difference is twice the minuend, and that the sum of the minuend and the subtrahend less the difference is twice the subtrahend.

8. Find the amount of the following bill:

One proof press	$50.00
Ten case stands	45.00
Twenty cases	16.00
Two hundred pounds of type	70.00
One imposing stone	50.00
One hundred pounds of leads and slugs	20.00
One planer	1.25
One mallet	.75
Ten galleys	25.00
Fifty pounds of metal furniture	15.00

9. Frank and James together earn in one week $5.60. If James earns 40 cents more than Frank, how much does each boy earn?

10. At a certain election 584,712 votes were cast for two candidates, A and B. A received a majority of 2854 votes. How many votes did each receive?

11. What number must be added to 56,840 to make 72,320?

12. John has $1200 more than James, and $800 less than Frank, who has $7200. Fred has as much as John and James together. How much has Fred?

MULTIPLICATION AND DIVISION

Multiplication is the process of taking a number as many times as there are units in another number. The number to be multiplied is named the *multiplicand*, the number multiplied by, the *multiplier*, and the result the *product*. Since the multiplier and the multiplicand make the product, they are the factors of the product. The multiplier is always an abstract number, and the product is like the multiplicand. The sign $\times$ is read *times*, or *multiplied* by, depending upon the arrangement of the factors; as, 5×12 ems $= 60$ ems, is read 5 times 12 ems equals 60 ems; 12 ems $\times 5 = 60$ ems is read 12 ems multiplied by 5 equals 60 ems.

Division is the process of finding how many times one number is contained in another number, or the process of separating a number into equal parts. The number to be divided is named the *dividend*, the number divided by, the *divisor*, and the result is called the *quotient*; if the divisor is not exactly contained in the dividend, the part left over is called the *remainder*. Since the dividend corresponds to the product, and the divisor is one of the factors, the process resolves itself into, having given the product of two factors, and one of the factors to find the other factor. The quotient indicates either how many units like the divisor there are in the dividend, or the size of the parts the dividend is divided into; as, 18 picas $\div$ 3 picas $= 6$. The quotient, 6, represents the number of times the measure or standard is contained in the dividend. 12 picas $\div 3 =$ 4 picas. The 4 picas, the quotient, represents the size of the equal parts into which the dividend is divided.

In problems where several of the fundamental operations are to be performed, the operations of multiplication and division always precede the combinations of addition and subtraction; as,

$5+6\times3=23$	$(5+6)\times3=33$
$5\times6+3=33$	$24\div3+6\times3=26$
$5+(6\times3)=23$	$12\times6\div3+4=28$

The signs of aggregation in common use are the parentheses (), the vinculum, or bar ——, the braces { }, and the brackets []. If any of the signs of aggregation enclose quantities, perform the operations indicated within the signs before the operation indicated by the sign that precedes it is performed.

EXERCISE III

1. $25+6\times4+3-9\times8\div6=$
2. $\{200-\overline{8\times8}+\overline{3\times9}-8\}\div5=$
3. $42+2\times3-4+6\times3\div9=$
4. $(64+11)\div25+3-5+6=$
5. $9\times\{3+\overline{16+5}\div3+(6+4)\div2\div\}5=$
6. $36+4\times3-8+12\div3=$

Principles of division. Multiplying the dividend, the divisor remaining the same, multiplies the quotient; as,

$$\text{If } 24\div4=6, \text{ then } (24\times2)\div4=(6\times2)$$

Dividing the dividend, the divisor remaining the same, divides the quotient; as,

$$(24\div2)\div4=(6\div2)$$

Multiplying the divisor, the dividend remaining the same, divides the quotient; as,

$$24\div(4\times2)=(6\div2)$$

Dividing the divisor, the dividend remaining the same, multiplies the quotient; as,

$$24 \div (4 \div 2) = (6 \times 2)$$

Multiplying or dividing both dividend and divisor by the same quantity does not change the value of the quotient; as,

$$(24 \times 2) \div (4 \times 2) = 6$$
$$(24 \div 2) \div (4 \div 2) = 6$$

These principles may be embraced in one general law: a change by multiplying or dividing the *dividend* produces a *like* change in the quotient; but a change by multiplying or dividing the *divisor* produces an *opposite* change in the quotient.

An *average* or *mean* of two or more quantities is found by dividing the sum of the quantities by the number of quantities added.

If an apprentice's standing in composition is 94 in March, 96 in April, 95 in May, and 97 in June, his average standing would be found as follows:

$$94+96+95+97=382$$
$382 \div 4 = 95\frac{1}{2}$, average standing.

If a boy's time-sheet shows the following records, find his average speed per hour as follows :

FROM	TO	HOURS	EMS
7:45	8:45	1	860
9:15	10:45	$1\frac{1}{2}$	1244
11:15	12:15	1	840
1:00	4:30	$3\frac{1}{2}$	2180
		7	5124

5124 ems $\div$ 7 = 732 ems, speed per hour.

The temperature in Chicago at 7 o'clock a. m. for one week was as follows: Sunday $+2°$, Monday $+15°$, Tuesday $+20°$, Wednesday $+5°$, Thursday $-5°$, Friday $0°$, Saturday $+5°$.

Find the average temperature for the week.

$$(+2°)+(+15°)+(+20°)+(+5°)$$
$$+)+5°) \quad +(0°)=+47°.$$
$$(+47°)+(-5°)=+42°.$$

$42° \div 7 = 6° =$ average daily temperature.

All standings in the school except deportment are based upon the quality and quantity of work done. Time-limits are set on each job or assigned task according to past experience. If the jobs are performed within the time-limits set, and the quality of the work is up to the standard of the department, a credit of 100 is given, which means *satisfactory* work both as to quality and quantity. The quality *must* be standard, hence the standing becomes largely a *time-basis* record. Above 100 indicates *excellent* work—standard quality in less than the time-limit set. Ninety-five is the *bonus* standard. Ninety indicates *fair* work; eighty-five or less, *failure*. Standings less than 100 indicate that more than the time-limit was taken to perform the job. In determining the average performance, the standings have the following values:

	STANDING	RELATIVE VALUE	TOTAL VALUE
Trade	90	5	450
Academic . . .	95	3	285
Deportment . . .	100	2	200
Total		10	(935
Average			93.5

EXERCISE IV

1. Find the average for six months of a boy whose monthly marks are as follows: 96, 97, 107, 102, 95, 98.

2. Find the average standing of a class whose marks for

a certain week follow: 96, 80, 78, 98, 102, 104, 107, 112, 96.

3. Find the average temperature for the week when the daily temperatures are as follows: Monday 50°, Tuesday 61°, Wednesday 63°, Thursday 48°, Friday 45°, Saturday 41°, Sunday 40°.

4. Find the average speed of an automobile for a twenty-five hour trip. The speedometer shows speeds as follows: for 3 hours, 20 miles per hour, 2 hours, 22 miles per hour, 5 hours 18 miles per hour, 8 hours 15 miles per hour, and the remaining 7 hours, 28 miles per hour.

5. Find the average cost per volume for rebinding a library of 1000 volumes costing as follows: 300 volumes bound in morocco, $2 per volume; 200 volumes half-bound, $1 per volume; 150 volumes bound in buckram, $.75 per volume; 350 volumes bound in cloth $.30 per volume.

GENERAL PROBLEMS

The following general problems are inserted to train the student to reason from the abstract to the concrete.

Answer each general problem and then illustrate it by an original example in printing; as, given, the subtrahend and the minuend to find the difference. The subtrahend and the minuend being given, to find the difference, subtact the subtrahend from the minuend and the result will be the difference. The length of a lead is 25 picas, a piece 17 picas long is cut off. Find the length of the other piece. 25 picas, the minuend — 17 picas, the subtrahend = 8 picas, the difference.

Given the dividend, the quotient, and the remainder to find the divisor. The length of a rule was 20 picas, 6 pieces of equal length were cut off and a piece 2 picas long remained. Find the length of the pieces cut off.

20 picas − 2 picas = 18 picas.

18 picas ÷ 6 = 3 picas = the length of the pieces cut off.

20 picas is the dividend, 6 is the quotient, 2 picas is the remainder.

3 picas, the result is the divisor sought.

Given the sum of two numbers and their difference to find the numbers.

The length of two rules is 24 inches and their difference is 6 inches. Find the length of the rules.

24 inches + 6 inches = 30 inches.

30 inches ÷ 2 = 15 inches = length of the longer rule.

24 inches − 15 inches = 9 inches = length of the shorter rule.

Proof: 15 inches + 9 inches = 24 inches.

Second method: 24 inches − 6 inches = 18 inches.

18 ÷ 2 = 9 inches = length of shorter rule.

24 inches − 9 inches = 15 inches = length of longer rule.

EXERCISE V

1. Given two or more numbers to find their sum.

2. Given the parts of a whole to find the whole.

3. Given the subtrahend and the minuend to find the difference.

4. Given the subtrahend and the remainder to find the minuend.

5. Given the remainder and the minuend to find the subtrahend.

6. Given one of two numbers and their sum to find the other number.

7. Given the sum of two numbers and their difference to find the numbers.

8. Given the multiplicand and the product to find the multiplier.

9. Given the product of two factors and one of the factors to find the other.

10. Given the dividend and the divisor to find the quotient.

11. Given the multiplicand and the multiplier to find the product.

12. Given the multiplier and the product to find the multiplicand.

13. Given the dividend and the quotient to find the divisor.

14. Given the divisor and the quotient to find the dividend.

15. Given the dividend, the quotient, and the remainder to find the divisor.

16. Given the divisor, the quotient, and the remainder to find the dividend.

17. Given the factors of a number to find the number.

EXERCISE VI

1. Find the sum of each column.

PRIME NUMBERS	SQUARES OF NUMBERS	CUBES OF NUMBERS
1	1	1
2	4	8
3	9	27
5	16	64
7	25	125
11	36	216
13	49	343
17	64	512
19	81	729
23	100	1000
29	121	1331
31	144	1728
37	169	2197
41	196	2744
43	225	3375
47	256	4096
53	289	4913
59	324	5832
61	361	6859
67	400	8000
71	441	9261
73	484	10648
79	529	12167
83	576	13824
89	625	15625
97	676	17576

2. Write the prime numbers between 200 and 250 and find the sum.

3. A roll of paper 36 inches wide contains 720 pounds net weight. If 500 sheets cut from the roll 24 inches $\times$ 36 inches in size, weigh 60 pounds, how many feet of paper in the length of the roll.

4. James deposited $2.50 in the bank each week from April 1 to July 1. He withdrew, May 10, $3.25, and June 1, $3.75. He is credited $1.75 interest July 1. Find the balance he has in the bank July 1.

May	10		3	25	Apr.	1		2	50
June	1		3	75	"	8		2	50
July	1	Bal.	27	25	"	15		2	50
					"	22		2	50
					"	29		2	50
					May	6		2	50
					"	13		2	50
					"	20		2	50
					"	27		2	50
					June	3		2	50
					"	10		2	50
					"	17		2	50
					"	24		2	50
					July	1		1	75
			34	25				34	25

5. Find the average run per hour of press No. 15, the following being the record for the week:

PRESS No. 15

DAY	HRS.	RUN	DAY	HRS.	RUN
Monday	$6\frac{1}{2}$	3820	Thursday	8	8891
Tuesday	8	9482	Friday	8	9524
Wednesday	5	4577	Saturday	$7\frac{1}{2}$	8617

6. Find the run on press No. 18 for two weeks ending May 15, the following being taken from the record sheet:

May 3, 9230	May 7, 9475	May 12, 5400
May 4, 8550	May 8, 5765	May 13, 6300
May 5, 8770	May 10, 6100	May 14, 5900
May 6, 9800	May 11, 5400	May 15, 3000

7. On presses Nos. 20 and 24 the record sheets show the following runs for the week as taken from the counters:

PRESS No. 20			PRESS No. 24		
DAY	HRS.	RUN	DAY	HRS.	RUN
Monday	8	6866	Monday	8	11622
Tuesday	8	9200	Tuesday	8	11419
Wednesday	8	10100	Wednesday	8	10528
Thursday	8	9362	Thursday	8	12671
Friday	8	10461	Friday	8	11864
Saturday	$6\frac{1}{2}$	9195	Saturday	5	4488

Find total run of each press. The stock is 32×44 inches, weight 60 pounds per ream of 500 sheets. Find the cost at 5 cents per pound of paper used on each press.

In figuring the number of reams of paper needed for a given number of impressions, one must consider that a sheet is completed or perfected, that is, printed on both sides. Hence to find the number of reams, the press count is divided by 1000, a ream being 500 sheets, and each sheet being recorded twice by the counter.

8. A compositor sets 9140 ems on Monday, 9280 ems on Tuesday, 9640 ems on Wednesday, 9560 ems on Thursday, 9840 ems on Friday, and 6480 ems on Saturday. Find his weekly wages at 45 cents per 1000 ems.

9. A compositor set on Monday 8420 ems of 8 point, on Tuesday 9450 ems of 8 point, on Wednesday 7420 ems of 8 point, on Thursday he sets 5460 ems of 6 point, on

Friday 7480 ems of 6 point, and on Saturday 4280 ems of 6 point. He is paid 40 cents per 1000 ems for setting. What does he earn during the week? What are his average daily earnings?

10. A linotype operator sets on Monday 44,620 ems of 10 point 16 picas wide, on Tuesday he sets 45,930 ems 5½ point 12½ picas wide, on Wednesday he sets 51,930 ems 5½ point 12 picas wide, and on Thursday, Friday, and Saturday he sets respectively 54,000, 52,980, 41,000 ems 5½ point 14 picas wide. He is paid at the rate of 16 cents per 1000 ems for 10 point matter, and 14 cents per 1000 ems for 5½ point matter; what is his pay?

11. On press No. 36 the following was the record for one week:

PRESS No. 36

DAY	HRS.	RUN	DAY	HRS.	RUN
Monday	10	14373	Thursday	13¼	18291
Tuesday	13¼	18262	Friday	13¼	18234
Wednesday	9	11503	Saturday	4¾	5984

Find the number of reams of paper used. The stock was 43½ inches × 62 inches, weight 150 pounds per ream. Find value at 5 cents per pound.

The pressman received 50 cents per hour and the feeder received 30 cents per hour. Find the weekly wages of each, if the regular shop-hours, are 48 hours per week. And time and a half is allowed for each hour overtime.

The feeder averaged one half ream to each lift from the truck to the feed-board, and the spoilage averaged three sheets to a lift. Find value of spoiled sheets.

12. If the boilers in the boiler-room consume the following loads of coal for the week ending May 20, find the

value at $2.65 per ton, also the average number of tons burned per day, including Sunday.

Fri.	11800 lbs. 11800 lbs.	Tues.	11800 lbs. 12175 lbs.
Sat.	11800 lbs. 12000 lbs.	Wed.	11800 lbs. 12150 lbs.
Mon.	12150 lbs. 12100 lbs.	Thurs.	11800 lbs.

13. Make the following entries on a form similar to that in problem number four.

Deposited, June 15, $5.75; June 28, $12.25; July 2, $9.15; July 12, $15.75; August 3, $5.85; September 8, $4.25; September 18, $15.60. Withdrawn, August 5, $4.00; September 20, $5.00. Find the balance October 1.

14. The maximum floor-load on the second floor of The Lakeside Press building is 300 pounds per square foot, how many reams of paper 24 inches × 36 inches, 80 pounds to a ream, can be piled upon an area 2 feet × 3 feet and not violate the rule regarding floor load?

15. If a room is 50 feet long, 20 feet wide, and 12 feet high, how many cubic feet of air does it contain? If there are fifteen people in the room, how many cubic feet of air are there for each person?

16. If the rent of a room, 20 feet by 50 feet, is $500 per year, what is the monthly rental per square foot?

EXACT DIVISORS AND FACTORS

An *exact divisor* of a number is one that will divide it without a remainder; as, 3 and 5 are exact divisors of 15.

An *even number* is one that is exactly divisible by 2; an *odd number* is not exactly divisible by 2.

A *prime number* has no exact divisors except itself and one, or it is a number that cannot be factored; as, 7, 13, 37.

A *composite number* has exact divisors, or it is a number that can be factored. The *factors* of a number are the whole numbers which multiplied together will produce the number; as,

$12=3\times2\times2$ or the factors of 12 are 3, 2, 2.

A *power* is the product arising from multiplying a number by itself, or using it a certain number of times, indicated by an *exponent,* as a factor; as, $3^2=3\times3=9$. An *exponent* is a superior figure indicating the power to which a number is to be raised; as, $2^3=2\times2\times2=8$. A *root* is one of the equal factors of a number; as, 3 is the square root of 9. The square root may be indicated by the *radical* sign $\sqrt{}$; as, the square root of 9 may be written $\sqrt{9}=3$.

COMMON FACTORS

Common factors are factors that are common to two or more numbers; as, 3 picas is a common factor of 9 picas, 12 picas, and 15 picas, that is, leads 3 picas long can be cut from leads either 9, 12, or 15 picas long without waste.

A *common divisor* of two or more numbers is a common factor of the numbers. The *greatest common divisor* (G. C. D.), or the *highest common factor* (H. C. F.) of two or more numbers is the product of the common factors, or the largest number that is exactly contained in each of the numbers; as, to find G. C. D. of 12, 18 and 24, or to find the length of the longest leads that can be cut without waste from strips either 12, 18, or 24 units (either picas, nonpareils, inches, or some other measure).

$$12 = 2 \times 2 \times 3$$
$$18 = 2 \times 3 \times 3$$
$$24 = 2 \times 2 \times 2 \times 3$$

The common factors are 2 and 3. The product of the common factor is 6. Six is the G. C. D. It is the length of the longest leads that can be cut from strips either 12, 18, or 24, of whatever length the unit may be, as picas, nonpareil, or inches.

A *multiple* of a number is a number exactly divisible by a given number. A *common multiple* of two or more numbers is a number exactly divisible by each of the numbers. The *least common multiple* (L. C. M.) of two or more numbers is the least number that will contain each of the numbers. The L. C. M. of two or more numbers is the product of all the prime factors of those numbers using each factor the greatest number of times it occurs in any one of the given numbers; as, to find the L. C. M. of 12, 24, and 36 to find the least measure that will exactly contain 12, 24, or 36 units, as picas or inches.

$$12 = 2 \times 2 \times 3$$
$$24 = 2 \times 2 \times 2 \times 3$$
$$36 = 2 \times 2 \times 3 \times 3$$

The factors to be multiplied are 2, 2, 2, 3, and 3. Their product is 72. The L. C. M. is 72.

It is the length of the shortest measure, as in picas or inches, that will exactly contain 12, 24, or 36 of the units of the same denomination.

If an apprentice desired to test the accuracy of his composing stick by using em quads of either 8 point, 12 point, or 36 point type, he could set the stick at 6 picas, or 72 points in order to test with the quads desired, as 72 is the least number that exactly contains the units selected 8, 12, and 36. 72 is the L. C. M.

EXERCISE VII

1. Find the common factors of 12, 18, 24, 36.

2. Find the G. C. D. of 18, 30, 36, 42.

3. Find the L. C. M. of 12, 15, 24, 36.

4. Factor, 360, 1728, 2445.

5. Separate each number into two equal factors, 196, 256, 576, 625.

6. Separate each number into three equal factors, 729, 1728, 2744, 9261, 15,625.

7. What numbers will exactly divide 360?

8. Why was 360° taken as the standard of measurement in circles?

9. A court 868 feet long and 35 feet wide is to be paved with squares of cement of the largest equal size. Find number of squares that will be used.

10. On a certain job the cutter was obliged to waste a strip 8″×28″. Find largest size squares that could be cut from this waste; also number of squares per sheet.

11. An apprentice putting away leads finds he has strips 16, 24, and 32 picas long; he wishes to cut them to the longest uniform length. What will be the length.

12. If there are in the stock room six leads 18 picas long, nine leads 24 picas long, and twelve leads 36 picas long, find how many leads of the longest uniform length can be cut from the 27 pieces.

13. An apprentice desired to test his composing stick by

using em quads of 9 point, 12 point, and 18 point type. At what measure must he set the stick?

14. Find the square root of the sum of the squares of 12 and 16.

15. Find the square root of the difference of the squares of 30 and 18.

16. Find the sum of the prime numbers between 100 and 150.

17. Find the square root of the sum of the squares of 15 and 20.

18. Find the square root of the difference of the squares of 45 and 15.

FRACTIONS

A number that shows what part or what number of parts of a unit is taken is called a fraction. The term *common fraction* is used when the fraction consists of two numbers. One, called the *denominator*, is usually written below a horizontal line and indicates into how many parts the unit is divided; the other, called the *numerator*, is written above the line and shows how many of the equal parts indicated by the denominator are taken. In the fraction $\frac{5}{8}$ of an inch, the denominator, 8, shows that the inch is divided into eight equal parts and the numerator, 5, shows that five parts are taken. The horizontal line may be considered a sign of division, the numbers taking the places of the periods in the usual sign of division, as $5 \div 8 = \frac{5}{8}$.

If a pica is divided into 12 equal parts, each of the parts is called a point, and one of the equal parts or one point would be $\frac{1}{12}$ of a pica, 6 of the equal parts or 6 points would be $\frac{6}{12}$ or $\frac{1}{2}$ of a pica. A nonpareil is $\frac{1}{2}$ of a pica. One half $\frac{1}{2}$, one twelfth $\frac{1}{12}$, six twelfths $\frac{6}{12}$ are fractions.

The *terms* of a fraction are the numerator and denominator. A fraction is said to be reduced to its *lowest terms* when the numerator and denominator are prime to each other, that is have no common factor.

A *proper fraction* is one whose value is less than one; as, $\frac{5}{6}$. An *improper fraction* is one whose value is one or greater than one; as, $\frac{4}{4}$, $\frac{6}{4}$. A *complex fraction* is one having one or both of its terms fractional; as, $\frac{\frac{2}{3}}{\frac{3}{4}}$. A *com-*

pound fraction is a fraction of a fraction; as, $\frac{2}{3}$ of $\frac{3}{4}$. A *mixed number* is a number having an integer and a fraction taken together; as, $3\frac{2}{3}$. *Similar fractions* are fractions having a common denominator; as, $\frac{5}{6}$, $\frac{1}{6}$.

Consider the numerator of any given fraction as the dividend, the denominator as the divisor, and the value of the fraction as the quotient, and apply the general principles of division as given on page 8.

The L. C. D. *least common denominator* of two or more fractions may be found by finding the L. C. M. of the *denominators* of the given fractions.

To reduce two or more fractions to fractions having a common denominator: divide the common denominator by the denominator of each of the given fractions, and multiply both terms of the fraction by the quotient; as to reduce $\frac{2}{3}$ of an inch, $\frac{5}{8}$ of an inch, and $\frac{7}{12}$ of an inch to least common denomination.

The L. C. M. of the denominators is 24. The fractional part of an inch must be reduced to 24ths of an inch.

$\frac{2}{3}$ of an inch $= \frac{16}{24}$ of an inch, $\frac{5}{8}$ of an inch $= \frac{15}{24}$ of an inch and $\frac{7}{12}$ of an inch $= \frac{14}{24}$ of an inch.

ADDITION AND SUBTRACTION OF FRACTIONS

The general principle in whole numbers that only quantities of like denomination can be combined holds true with fractions, hence before combining two or more fractions the quantities if not of the same denomination must be reduced to similar fractions.

To add fractions: reduce the fraction to similar fractions, if necessary, then find the sum of the numerators of the resulting fractions and write this result over the common denominator; in adding mixed numbers add separately the integers and the fractions and find the sum of the results.

Find the sum of $\frac{5}{16}$ of an inch, and $\frac{7}{8}$ of an inch, and $\frac{7}{12}$ of an inch. The L. C. D. of the fractions is 48ths. These fractions reduced to 48ths of an inch equal respectively $\frac{15}{48}$ of an inch, $\frac{42}{48}$ of an inch, and $\frac{28}{48}$ of an inch and adding the numerators, the result is $\frac{85}{48} = 1\frac{37}{48}$ inches.

To subtract fractions: reduce the fractions to similar fractions, if necessary, then subtract the numerator of the resulting subtrahend from the numerator of the minuend and write the difference over the common denominator; as,

To subtract $\frac{2}{3}$ of a foot from $\frac{3}{4}$ of a foot. These fractions reduced to a common denominator equal, respectively, $\frac{8}{12}$ of a foot and $\frac{9}{12}$ of a foot.

$\frac{9}{12}$ of a foot, $-$ $\frac{8}{12}$ of a foot $=$ $\frac{1}{12}$ of a foot

EXERCISE VIII

1. Reduce to fractions having the least common denominator: $\frac{2}{3}$ and $\frac{4}{5}$; $\frac{2}{5}$ and $\frac{1}{6}$; $\frac{2}{5}$ and $\frac{5}{8}$; $\frac{2}{3}$, $\frac{5}{8}$, and $\frac{5}{6}$; $\frac{2}{3}$, $\frac{5}{6}$, and $\frac{8}{15}$.
2. $17\frac{1}{2}$ reams $+ 9\frac{2}{3}$ reams $+ 12\frac{5}{6}$ reams $=$
3. $4\frac{2}{3}$ reams $+ 15\frac{1}{2}$ reams $=$
4. $16\frac{1}{2} + 17\frac{1}{6} + 10\frac{2}{3} =$
5. $5\frac{1}{2}$ days $- 3\frac{2}{3}$ days $=$
6. Change to similar fractions, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{5}{6}$; $\frac{3}{4}$, $\frac{5}{8}$, $\frac{1}{2}$; $\frac{3}{4}$, $\frac{5}{6}$, $\frac{7}{8}$.
7. Change to hundredths, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{1}{8}$, $\frac{3}{8}$, $\frac{5}{8}$, $\frac{7}{8}$.
8. In the six days of a week a man works $9\frac{1}{4}$ hours, $9\frac{1}{2}$ hours, $9\frac{2}{3}$ hours, $10\frac{1}{3}$ hours, $8\frac{3}{4}$ hours, and $6\frac{1}{2}$ hours. What does he earn at 40 cents an hour?
9. If John does $\frac{1}{4}$ of a job, Henry $\frac{1}{3}$ of it, and Frank $\frac{1}{6}$ of it, what part is completed? What part remains to be done?
10. Find the total weight, in tons, of five loads of coal weighing respectively $3\frac{1}{2}$ tons, $3\frac{3}{4}$ tons, $4\frac{1}{3}$ tons, $3\frac{1}{4}$ tons, and $4\frac{1}{2}$ tons.

11. Find the sum of $\frac{2}{3}$ of a pica, $\frac{3}{4}$ of a pica, and $\frac{1}{2}$ of a pica.

12. From the sum of $\frac{5}{6}$ of an inch and $\frac{1}{3}$ of an inch take $\frac{1}{2}$ of an inch.

13. Find the number of reams in the following bill of paper: $5\frac{2}{3}$ reams blue, $10\frac{1}{2}$ reams white, $3\frac{1}{4}$ reams pink.

14. From a rule 48 picas long two pieces were cut, one $3\frac{1}{2}$ picas long and the other $12\frac{3}{4}$ picas long; find length of the part remaining.

15. A certain job is scheduled at $16\frac{1}{2}$ days. A works $3\frac{2}{3}$ days, B $5\frac{1}{2}$ days, and C $2\frac{3}{4}$ days; what part of the work remains to be done?

MULTIPLICATION AND DIVISION OF FRACTIONS

The denominator of a fraction denotes the size of the parts into which something is divided, and the numerator the number of these parts there are; as, $\frac{3}{4}$ of an apple means that the apple is divided into quarters and that there are three of these quarters.

To multiply a fraction by a whole number: either multiply the number of parts, as 3 quarters of an apple multiplied by 2 is 6 quarters of an apple, or make the size of the parts twice as large, as, 3 quarters of an apple multiplied by 2 equals 3 halves of an apple.

$$\frac{3}{4}\times 2=\frac{3\times 2}{4}=\frac{6}{4}=\frac{3}{2} \text{ or } \frac{3}{4}\times 2=\frac{3}{4\div 2}=\frac{3}{2}$$

Hence the rule, multiply the numerator or divide the denominator.

To divide a fraction by a whole number: either divide the number of parts, as 3 quarters of an apple divided by 2 equals $1\frac{1}{2}$ quarters of an apple or make the size of the parts into which the apple is divided only half as large, as 3 quarters of an apple ÷ 2 is then 3 eighths of an apple.

$$\frac{3}{4}\div 2=\frac{3\div 2}{4}=\frac{1\frac{1}{2}}{4}=\frac{3}{8} \text{ or } \frac{3}{4}\div 2=\frac{3}{4\times 2}=\frac{3}{8}$$

Hence the rule, divide the numerator or multiply the denominator. The division of a fraction by a whole number is therefore the reverse of multiplication of a fraction by a whole number.

To multiply a whole number by a fraction: as, two apples multiplied by two thirds, follow the same rule as when multiplying a fraction by a whole number as the product of two numbers is always the same no matter which is used as the multiplicand and which as the multiplier; as,

$$\frac{2}{3}\times 2=\frac{4}{3} \text{ also } 2\times\frac{2}{3}=\frac{4}{3}$$

To divide a whole number by a fraction: as, to find how many boys can be given each $\frac{3}{4}$ of an apple out of 6 apples. If we cut the 6 apples into quarters we have 24 quarters. Three quarters will go into 24 quarters 8 times, and 8 boys can each have $\frac{3}{4}$ of an apple apiece.

$$6\div\frac{3}{4}=\frac{24}{4}\div\frac{3}{4}=8$$

But we have learned that to divide a fraction we divide the numerator or multiply the denominator and the problem may be written thus:

$$\frac{6}{1}\div\frac{3}{4}=\frac{6\div\frac{3}{4}}{1} \text{ or } \frac{6}{1\times\frac{3}{4}}=\frac{6}{\frac{3}{4}}=\frac{6\times 4}{3}=\frac{24}{3}=8$$

The process of transposing the numerator and denominator is called inverting.

Hence the rule, invert the fraction and proceed as in multiplication.

Since the quotient indicates either how many units like the divisor there are in the dividend, or the size of the parts the dividend is divided into, the results in division of fractions may tend to mislead. Any quantity divided by a quantity less than one gives a result larger than the original quantity; why?

EXERCISE IX

1. 36 picas $\times \frac{5}{6} =$
2. $\frac{7}{8}$ of an inch $\times 8 =$
3. $\frac{7}{8}$ of a foot $\times 6 =$
4. $\frac{3}{8}$ of an inch $\div 3 =$
5. 6 picas $\div \frac{2}{3} =$
6. $\frac{5}{8}$ of a foot $\div \frac{2}{3} =$
7. If a power-house uses $64\frac{3}{8}$ tons of coal in $5\frac{1}{2}$ days what is the average daily consumption?
8. If a compositor sets 480 ems in $\frac{3}{4}$ of an hour, at the, same rate how many ems would he set in 9 hours?
9. Any quantity multiplied by a quantity greater than one will give a product greater than the original quantity. Why? Illustrate.
10. Any quantity multiplied by a quantity less than one will give a product less than the original quantity. Why? Illustrate.

To multiply a fraction by a fraction: as $\frac{7}{8}\times\frac{5}{6}$ may be written

$$\frac{7\times\frac{5}{6}}{8}=\frac{\frac{35}{6}}{8}=\frac{35}{6}\div 8=\frac{35}{6\times 8}=\frac{35}{48}$$

Hence the rule, multiply the numerators for the new numerator and the denominators for the new denominator.

To divide a fraction by a fraction: as $\frac{7}{8}\div\frac{5}{6}$ may be written

$$\frac{7\div\frac{6}{5}}{8}=\frac{7\times\frac{6}{5}}{8}=\frac{\frac{42}{5}}{8}=\frac{42}{5}\,\frac{42}{5\times 8}=\frac{42}{40}$$

But we have learned that division is the reverse of multiplication, and if we transpose the terms of the divisor and multiply we obtain the same result; as,

$$\frac{7}{8} \div \frac{5}{6} = \frac{7}{8} \times \frac{6}{5} = \frac{42}{40}$$

Hence the rule, invert the divisor and proceed as in multiplication.

EXERCISE X

1. Find the number of square inches in a zinc plate (zinc) that measures $3\frac{1}{2} \times 5\frac{3}{4}$ inches. What would the zinc cost at 6 cents per square inch?

2. Find the cost of a 133-screen half-tone plate (half-tone size $4\frac{1}{2}$ inch $\times 6\frac{2}{3}$ inches), at 14 cents per square inch.

3. A 175-screen half-tone measures $6\frac{2}{3}$ inches $\times$ $8\frac{1}{4}$ inches; find cost at 18 cents per square inch.

4. Copper weighs 8.9 times as much as water per equal volume. Water weighs about $62\frac{1}{2}$ pounds per cubic foot. The weight of a substance as compared with an equal volume of water is called the specific gravity (sp. gr.) of that substance; as the sp. gr. of copper is 8.9.

Find the weight of $12\frac{3}{4}$ cu. in. of copper.

5. Find the weight of a half-tone (copper plate) that measures 8 inches $\times$ 10 inches and is $\frac{1}{16}$ of an inch thick.

6. A photograph measures 8 inches $\times$ 10 inches. If a half-tone is made from the photograph reduced size, to scale 1 inch = $2\frac{1}{2}$ inch, find cost of the half-tone at 16 cents per square inch.

7. Find the cost of twelve electrotype plates (electros) each $8\frac{1}{2}$ inches $\times$ $12\frac{2}{3}$ inches, at 4 cents per square inch.

8. Find the cost of a mounted electro $7\frac{1}{2}$ inches $\times$ $8\frac{2}{3}$ inches, at 4 cents per square inch.

9. The zinc used in printing the proof marks in the

Apprentice School measures $7\frac{1}{4}$ inches × $3\frac{7}{8}$ inches. Find the cost at 6 cents per square inch.

10. Find the cost of a half-tone $6\frac{1}{2}$ inches × $7\frac{3}{4}$ inches at 15 cents a square inch.

GENERAL PROBLEMS IN FRACTIONS

To find what part one quantity is of another quantity of the same kind: divide the number which is the part by the number of which part is to be found; as, what part of 6 is 3? 3 is such a part of 6 as 6 is contained times in 3, or $3 \div 6 = \frac{3}{6} = \frac{1}{2}$ ∴ 3 is $\frac{1}{2}$ of 6.

To find a number when a fractional part is given: divide the given number, which is the fractional part, by the indicated fraction; as, 16 is $\frac{2}{3}$ of what number? $16 \div \frac{2}{3} = 24$ ∴ 24 is the required number.

To find any fractional part of a number: multiply the given number by the fraction and the result will be the required fractional part; as, find $\frac{2}{3}$ of 12. $12 \times \frac{2}{3} = 8$ ∴ 8 is the required fractional part.

EXERCISE XI

State the first five of the following problems in at least three different forms before solving; as, what part of $\frac{1}{2}$ is $\frac{1}{4}$? One fourth is what part of $\frac{1}{2}$? What is the relation of $\frac{1}{2}$ and $\frac{1}{4}$? What is the quotient obtained by dividing $\frac{1}{2}$ by $\frac{1}{4}$? How many hundredths of $\frac{1}{2}$ is $\frac{1}{4}$?

1. What part of 100 is 25?
2. What part of 100 is $62\frac{1}{2}$?
3. What part of 75 is 50?
4. What part of $\frac{2}{6}$ is $\frac{2}{3}$?
5. What part of $\frac{1}{3}$ of 6 is $\frac{2}{5}$ of 10?
6. What part of 4 is 2?

7. Two is what part of 4?

8. What part of 2 is 4?

9. What part of a mile is 40 rods?

10. What part of three picas is four nonpareils?

11. What part of an em quad is a 4-to-em space?

12. Two thirds of 6 is $\frac{3}{4}$ of what number?

13. What part of $\frac{1}{2}$ is $\frac{1}{8}$?

14. Henry is 18 years old. Albert is $\frac{5}{6}$ as old. How old is Albert?

15. What part of $4\frac{1}{4}$ is $3\frac{1}{2}$?

16. A can do a piece of work in 6 hours, B in 8 hours, and C in 12 hours. Find the time they can do the job working together.

17. A and B together have $102. $\frac{2}{3}$ of A's money equals $\frac{3}{4}$ of B's money. How many dollars has each? Analyze and prove.

18. If $\frac{3}{8}$ of a job is done in 45 minutes, how long would it take at the same rate to do $\frac{1}{2}$ of the job?

19. The floor of a room 28 ft.$\times$36 ft. is to be covered with strips of linoleum 27 inches wide; how many yards of the strips of linoleum, laid edge to edge, will it take to cover the floor without waste?

20. If the floor of a room 28 ft.$\times$35 ft. is to be covered with linoleum strips 27 inches wide, how many yards of the strips will it take to cover the floor with the least waste? Find the cost of the linoleum at 57 cents per yard.

21. Water weighs $62\frac{1}{2}$ lbs. per cu. ft. What will be the weight of the water in a cubical tank 10 ft. deep full of water.

22. A grocer bought butter at $22\frac{1}{2}$c per lb. and sold it at 27c per lb. thereby gaining $36. What was the cost of the butter?

23. Three men hire a pasture for $42. The first put in

3 horses, the second 7 horses, and the third 11 horses. How much should each pay?

24. A man drew out $\frac{4}{5}$ of the money he had in the bank. The next day he deposited $200, when he found that he had $\frac{2}{5}$ as much in the bank as at first. How much had he at first in the bank?

25. If A and B can do a piece of work in 10 days and A alone can do it in 16 days, in what time can B alone do it?

26. If a stone falls $16\frac{2}{25}$ feet to the first second, three times as far the second second, five times as far the third second, seven times as far the fourth second, how far does it fall during the four seconds?

27. If $\frac{5}{9}$ of a ton of coal costs $4, how many tons can be bought for $145.75?

28. A can do a piece of work in 5 days, B in 6 days, C in 8 days. After A and B have worked at it 2 days each, how long will it take B and C to finish it?

30. Find the cost of a half-tone plate $8\frac{1}{4}'' \times 5\frac{1}{2}''$ at 20c per square inch.

DECIMAL FRACTIONS

A *decimal fraction* is one whose denominator is 10 or some power of 10. The denominator is usually not written but is indicated by the position of the decimal point.

The general principles of fractions apply to decimals; the only points calling for special attention are the reading and the writing of decimals, and the rules for addition, subtraction, multiplication, and division.

The following table is inserted for reference. Observe the use of the hyphen, and that the names of all the decimal orders end with the letters "ths."

NOTATION SCALE

Etc.	Millions	Hundred-thousands	Ten-thousands	Thousands	Hundreds	Tens	Units	Decimal Point	Tenths	Hundredths	Thousandths	Ten-thousandths	Hundred-thousandths	Millionths	Ten-millionths	Etc.
							1	.	1							
						1	0	.	0	1						
					1	0	0	.	0	0	1					
				1	0	0	0	.	0	0	0	1				
			1	0	0	0	0	.	0	0	0	0	1			
		1	0	0	0	0	0	.	0	0	0	0	0	1		
	1	0	0	0	0	0	0	.	0	0	0	0	0	0	1	

Careful study of the following examples will show the methods of reading and of writing decimals; 125.003 is read, one hundred twenty-five and three thousandths; 2056.9078 is read, two thousand fifty-six and nine thousand seventyeight ten thousandths; 248.300 is read, two hundred forty-eight and three hundred thousandths; 59.00003 is read, fifty-nine and three hundred-thousandths; 8125.0709 is read, eight thousand one hundred twenty-five and seven hundred nine ten-thousandths.

To reduce a common fraction to a decimal: reduce the fraction to a fraction having some power of 10 for a denominator; as, $\frac{3}{4}$ reduced to a decimal $=\frac{75}{100}=.75$

In a whole there are $\frac{100}{100}$, $100 \div 4 = 25$. Both numerator and denominator must be multiplied by 25 to reduce the fraction to hundredths.

$$\frac{3}{8}=.375 \qquad \frac{8}{8}=\frac{1000}{1000}=\frac{100}{100}$$

$$\frac{1}{8}=\frac{125}{1000}=\frac{12\frac{1}{2}}{100}$$

$$\frac{3}{8}=\frac{375}{1000}=\frac{37\frac{1}{2}}{100}=.375=.37\tfrac{1}{2}$$

Under division of decimals a short method of reducing fractions to decimals will be given.

To reduce a decimal to a common fraction: write the indicated denominator under the given decimal and reduce to the lowest terms; as,

$$.75=\frac{75}{100}=\frac{3\times5\times5}{4\times5\times5}=\frac{3}{4}$$

$$.37\tfrac{1}{2}=\frac{37\frac{1}{2}}{100}=\frac{\frac{75}{2}}{100}=\frac{75}{200}=\frac{3\times5\times5}{8\times5\times5}=\frac{3}{8}$$

EXERCISE XII

1. Write in words,

259,728.0007; 84,268.8023; 28,800.800; 59.089; 458.00609.

2. Write as decimals,

$\frac{1}{2}, \frac{1}{4}, \frac{2}{5}, \frac{1}{8}, \frac{3}{8}, \frac{5}{8}, \frac{7}{8}, \frac{9}{8}, \frac{1}{16}, \frac{1}{12}, \frac{1}{20}, \frac{1}{25}$.

3. Write as common fractions reduced to the lowest terms,

$.125, .16\frac{2}{3}, .25, .375, .625, .75, .875, .625$

4. Write as hundredths,

$\frac{1}{4}, \frac{1}{5}, \frac{1}{6}, \frac{1}{8}, \frac{3}{8}, \frac{5}{8}, \frac{7}{8}, .16\frac{2}{3}, 25, .375, .875$

5. Reduce the following common fractions to decimals:

$\frac{3}{4}, \frac{9}{16}, \frac{3}{16}, \frac{5}{16}, \frac{1}{3}, \frac{3}{7}, \frac{3}{32}, \frac{5}{64}.$

6. Reduce the following decimals to common fractions:

.375, .625, .875, .75.

7. Reduce to decimals the following sizes on a rule, $\frac{3}{16}$ of an inch, $\frac{5}{32}$ of an inch, $\frac{7}{8}$ of an inch.

8. A carpenter has three bits that measure respectively $\frac{3}{8}$ of an inch, $\frac{3}{16}$ of an inch, and $\frac{7}{16}$ of an inch; reduce to a decimal basis.

ADDITION AND SUBTRACTION OF DECIMALS

To add or subtract decimals, write the numbers so that the decimal points are in a vertical column, then proceed as with whole numbers, writing the decimal point in the result directly under the other points.

Find the sum of the following decimals and write the results in words, 57.009, 654.784, 458.069, 1978.00645, and 89.030.

```
  57.00900
 654.78400
 458.06900
1978.00645
  89.03000
----------
3236.89845
```

Three thousand two hundred thirty-six and eighty-nine thousand eight hundred forty-five hundred-thousandths.

From 97.096 take 48.0075, prove, and write the result in words.

97.0960	48.0075
48.0075	49.0885
49.0885	97.0960

Forty-nine and eight hundred eighty-five ten thousandths.

EXERCISE XIII

1. From the sum of 78,579.036, 8487.304, and 86,472.0048 take the sum of 32,428.003 and 476.03076.

2. From the sum of three thousand forty-eight and three thousandths, and ninety-two and seven hundred-thousandths take sixty-four and six hundred thousandths.

3. 94.48+72.920−51.068+79.06−29.732+128.406=

4. A standard piece of type is .918 of an inch in height; if a halftone cut lacks .004 of an inch of being type-high, find the height of the cut.

5. The subtrahend is 479.0968, the remainder is 781.4032; find the minuend.

MULTIPLICATION OF DECIMALS

To multiply decimals: multiply them as if they were whole numbers and from the right of the product point off as many places as there are decimal places in the multiplier and multiplicand together.

Multiply .078 by .05.

$$\begin{array}{r} .078 \\ .05 \\ \hline .00390 \end{array}$$

When the multiplier ends in naught arrange as follows:

$$4.87 \times 500 =$$

$$\begin{array}{r} 4.87 \\ 500 \\ \hline 2435.00 \end{array}$$

DIVISION OF DECIMALS

To divide decimals: divide as in whole numbers and point off as many places to the right in the quotient as those in the dividend exceed those in the divisor.

Before dividing, if necessary, annex ciphers to the dividend so that the number of decimal places in the dividend is equal to or greater than the number in the divisor.

Divide 64 by .008.

$$.008 \,|\underline{64.000} \\ \quad 8000$$

When dividing by a number ending in naughts proceed as follows, to find the number of reams in 285,450 sheets. One ream = 500 sheets.

$$285{,}450 \div 500 =$$

$$5|00 \;|\underline{2854|50} \\ \quad 570.9$$

Divide 500 by .07.

$$.07|\underline{500.00} \\ \quad 7142.857+$$

If the quotient does not come out exact, it is usually not necessary to carry out over four decimal places. The + sign is sometimes placed after the last figure in the quotient, when the division is not exact, to show that the result is really larger.

It is necessary in actual work to determine to what degree the accuracy of the result will be affected by discarding the fraction or decimal, obtained by multiplication or divison; for example, in rough work to measure to inches or eighths of an inch might be accurate enough, while in fine work it might be necessary to measure to thousandths of an inch. While $\frac{1}{50}$ or .02 might be readily discarded in many problems, in computations involving dollars, it might mean a large amount; as $\frac{1}{50}$ or .02 of a dollar is 2 cents, the price of a postage stamp. If one were to send out 1,000,000 letters, first-class postage, the stamps alone would cost $20,000.

A tax of $\frac{1}{8}$ of a mill on a dollar on the assessed valuation of the property in the city of Chicago would represent a large sum, while $\frac{1}{8}$ of a mill in a small transaction would be discarded.

In casting up tabular work it is necessary to figure to points ($\frac{1}{72}$ of an inch). To discard or neglect the fraction would lead to work that would not justify.

EXERCISE XIV

1. $48.72+7.05\times8.4+7.20\div.9=$
2. $84.75\times2100=$
3. $3\div570=$
4. $3.5\div.70=$
5. $.35\div.070=$
6. $.035\div7.0=$
7. $35\div.007=$
8. $285{,}750\div500=$
9. $72{,}500\div2000=$
10. $2{,}825{,}500\div500=$
11. Find the cost of 16,480 pounds of coal at $3.75 per ton.

12. If 1500 pounds of coal cost \$3.60, what will 4875 pounds cost at the same rate?

13. If 60 pounds of paper cost \$5.10, find the cost of 1020 pounds at the same rate.

14. If pens cost 48 cents per gross, how many can be bought for 16 cents at the same rate?

15. Find the cost of 2450 pounds of hard coal at \$6.75 per ton.

To change a common fraction to a decimal: place a decimal point after the numerator, annex as many ciphers as necessary, and divide by the denominator; as,

$$\frac{7}{8}=.875 \qquad 7.000\div 8=.875$$

$$8\,|\underline{7.000}$$
$$.875$$

$$\frac{3}{4}=.75 \qquad 3.00\div 4=.75$$

$$4\,|\underline{3.00}$$
$$.75$$

To change a decimal to the nearest equivalent fraction having any desired denominator: multiply the decimal by the desired denominator, the result will be the numerator of the desired fraction; as to change .375 to 16ths.

$$.375\times 16=6.000, \quad .375=\frac{6}{16}$$

Change .52 to 64ths.

$$.52\times 64=33.28. \quad .52=\text{about }\frac{33}{64}$$

Explanation:

$$.375=\frac{375}{1000};\ \frac{375}{1000}\times\frac{.016}{.016}=\frac{6.000}{16.000}=\frac{6}{16}$$

EXERCISE XV

1. Change the following common fractions to decimals: $\frac{8}{16}$, $\frac{5}{8}$, $\frac{7}{16}$, $\frac{7}{8}$, $\frac{7}{9}$, $\frac{2}{3}$, $\frac{3}{7}$.

2. Reduce to the decimals of an inch, $3\frac{7}{8}$ inches, $\frac{15}{32}$ of an inch $\frac{17}{64}$ of an inch, $\frac{5}{8}$ of an inch, $\frac{9}{16}$ of an inch.

3. Bare copper wire, gauge 14 (Brown & Sharpe, B. & S. standard), measures .06408 inches in diameter. Find the diameter expressed in a common fraction.

4. Reduce to the decimal of a foot, 5 inches, $8\frac{2}{3}$ inches, 3 inches, $2\frac{1}{2}$ inches, $1\frac{7}{8}$ inches.

5. Reduce $.12\frac{1}{2}$ to 50ths, $.6\frac{1}{4}$ to 25ths.

6. Find the diameter expressed in a common fraction of B. & S. gauge 0 copper wire, which measures .375 inches in diameter.

7. In figuring standard time (shop standard), all figures are in hours and tenths of an hour, the divisions on the clocks being in tenths of an hour instead of minutes; as, 48 minutes $= \frac{48}{60} = \frac{8}{10} = .8$ of an hour.

8. The estimated time on a job was 3.6 hours. A compositor began on the job at 8.2 a. m. and finished at 10.9 a. m.; what time did he gain?

9. Estimated time 8.4 hours, actual time 6.8 hours. Find the time gained?

10. Find elapsed time on a job that was begun at 8.3 a. m. and finished at 11.9 a. m.

11. An apprentice left on an errand at 9.4 a. m. and returned at 11. 6 a. m. Find the elapsed time in hours and minutes.

WEIGHTS AND MEASURES

To measure length, extent, dimension, capacity, quantity of matter, or money value, is to compare it with some unit selected as a standard.

To meet the modern demands for uniformity and precision all length standards are based upon the international meter, which is defined as the distance, at the temperature of melting ice, between two fine lines ruled on a bar of platinum-iridium preserved at the International Bureau of Weights and Measures near Paris, France. Accurate copies have been made and are kept by the different governments. The government of the United States has copy number 27, which is preserved in the Bureau of Standards at Washington. From this standard are derived all of our standards of length, including the yard, using the relation between the meter and the yard (1 meter = 39.37 inches) fixed by law in 1866.

LINEAR MEASURE

The yard is the usual standard of linear measure in the United States. One yard = 36 inches = 3 feet. Inches are divided into halves, quarters, sixteenths, tenths, hundredths, thousandths, etc., depending upon the instrument used and the accuracy required in the measurements.

The multiples of the yard in common use are:

$5\frac{1}{2}$ yds. = $16\frac{1}{2}$ feet = 1 rod.

320 rods = 1760 yards = 5280 feet = 1 mile.

Various other denominations are in use, as the fathom, league, furlong, link, chain, or hand. These terms may be found in the dictionary, or any standard arithmetic, if one has occasion to use them. Nearly every industry has its own units of measurements; as, in the printing industry one point = about $\frac{1}{72}$ of an inch, 12 points = 1 pica. Type-high = .918 inches.

The unit of linear measure, as explained in a preceding paragraph, is the meter. The divisions of the meter as are also the divisions of the unit of area, and of volume, or capacity, are formed by using as prefixes the Latin numerals, deci, tenth; centi, hundredth; milli, thousandth.

1 decimeter (dm) = $\frac{1}{10}$ of a meter (m).
1 centimeter (cm) = $\frac{1}{100}$ of a meter.
1 millimeter (mm) = $\frac{1}{1000}$ of a meter.
1000 mm = 100 cm = 10 dm = 1 m.

The multiples of the meter, as are also the multiples of the unit of area and of volume, or capacity, are formed by using the Greek numerals deka, ten; hecto, hundred; kilo, thousand.

1 dekameter (dkm) = 10 m.
1 hectometer (hcm) = 100 m.
1 kilometer (km) = 1000 m.

EXERCISE XVI

1. How many inches in three feet seven inches?
2. Find number of yards in 48 feet.
3. Compare the length of a foot rule with the metric unit, and determine about how many centimeters there are in twelve inches.
4. Compare the mile and the kilometer.
5. Compare 42 centimeters and 16 inches.
6. Show by lines the difference between twice as long and two times longer.

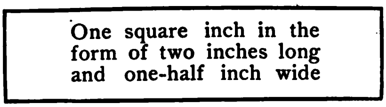
SURFACE MEASUREMENT

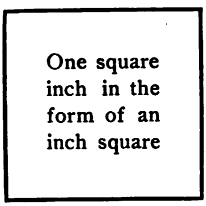
The unit of surface measurement, or area, is a given surface, or area having two dimensions, length and breadth. The selected unit is compared with the given surface and the result is called the area.

For measuring small surfaces the unit is either the square inch or the square foot; for larger surfaces the square yard or the square rod; and for large surfaces, as land areas, acres or square miles.

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

A square inch, the unit of measure, as a term is applied to a surface one inch on each side, while a surface having an area of one square inch may have any shape; as, a rectangle four inches long and $\frac{1}{4}$ inches wide has an area of one square inch.





An acre may be in the form of a square about 12.7 rods on a side or it may be a rectangle 40 rods long and 4 rods wide, or it may be in circular (round) form having a distance around (circumference) of 44.83 rods and a distance through (diameter) of 14.27 rods.

The square mile is the unit of comparison for large land areas; as, Chicago has an area of about 200 square miles, while Illinois has an area of 56,650 square miles; New York, 49,170 square miles; England, 50,863 square miles; Texas, 265,780 square miles; France, 204,092 square miles; Rhode Island, 1250 square miles; Alaska, 590,883 square miles.

In the metric system the square meter (m^2) is the unit. The divisions are:

Square decimeter (dm^2).
Square centimeter (cm^2).
Square millimeter (mm^2).

The multiples:

1 square dekameter (dkm^2) = 100 m^2) = are, 1 square hectometer (hm^2) = 10000 m^2 = 1 hectare.

These multiples are used in land measurements in countries using the metric system as a standard.

EXERCISE XVII

1. Show by diagram the difference in area between two square inches and a two-inch square.

2. Find the distance around a square mile in the form of a square. A square mile contains 640 acres, or a section (understood to be square). A quarter-section contains 160 acres. Find the number of rods of fence necessary to fence a section sub-divided into quarters.

3. The Lakeside Press building extends 200 feet on Plymouth Court and runs back 100 feet. Find the area of a floor in acres or the fractional part of an acre.

4. A folio sheet measures 17×22 inches and a sheet letter size measures $8\frac{1}{2} \times 11$ inches. Show by diagram drawn to scale comparative sizes of the two sheets. Find the area

in square inches of each sheet and compare the sizes, first using the folio sheet as the unit measure and then use the letter size sheet as the standard.

5. Compare the area in square inches of a sheet 25×38 inches and one 28×42 inches.

6. Compare the size (area) of a sheet 24×36 inches with one $45\frac{1}{2} \times 57$ inches.

7. Show by diagram the reduction that will be made if a drawing 12×18 inches is reduced one half.

8. Select various surfaces and find the area of each.

VOLUME, CAPACITY, WEIGHT

The unit of measure in volume is the cubic yard, that is a solid having three dimensions, length, breadth and thickness. A cube has six faces, twelve edges and eight corners. The divisions of the cubic yard are:

27 cubic feet = 1 cubic yard.
1728 cubic inches = 1 cubic foot.

In the metric system the cubic meter is the unit (m^3). The divisions in common use are:

Cubic centimeter (cm^3).
Cubic decimeter (dm^3)

The unit of capacity in liquid measure is the gallon 231 cubic inches.

2 pints = 1 quart.
4 quarts = 1 gallon.
$31\frac{1}{2}$ gallons = 1 barrel.

The unit in dry measure is the bushel = 2150.4 cubic inches.

32 quarts = 1 bushel.
8 quarts = 1 peck.
4 pecks = 1 bushel.
2 pints = 1 quart.

1 quart liquid measure = 57.75 cubic inches.

1 quart dry measure = 67.2 cubic inches,

The unit of capacity in the metric system for both liquid and dry measure is the liter.

The liter = 1 dm^3.

One great advantage of the metric system is seen in the unit for capacity as compared with the units for liquid and dry measure in the English system.

The standard of mass (commonly called weight) is a certain cylinder of platinum-iridium, known as the international kilogram also kept at the International Bureau of Weights and Measures. The Bureau of Standards in Washington has two copies numbers 4 and 20. From this kilogram are derived all other units of mass as the pound avoirdupois used in weighing most articles, the pound troy used in weighing precious metal, and the apothecaries' pound used in weighing drugs, retail.

It is necessary to distinguish between mass and weight. The mass of a body is the quantity of matter in it and is entirely independent of gravity. The weight of a body is the force with which the body is pulled downward by gravity.

The quantity of matter, mass, is constant while the attraction of gravity for the body, weight, varies even on the surface of the earth.

AVOIRDUPOIS

Avoirdupois weight is in general use in this country for weighing all matter except drugs (retail), sold by apothecaries' weight and certain jewels, sold by Troy weight.

The pound avoirdupois contains 7000 grains.

16 ounces (oz.) = 1 pound (lb.)

100 pounds = 1 hundredweight (cwt).

2000 pounds = 1 ton (T).

TROY

The pound troy contains 5760 grains, as also does the apothecaries' pound.

24 grains (gr.) = 1 pennyweight (dwt.).
20 dwt. = 1 ounce (oz.).
12 ounces = 1 pound (lb.).

APOTHECARIES'

60 grains = 1 dram (dr.).
8 drams = 1 ounce.
12 ounces = 1 pound.

The gram is a unit of mass equivalent to one-thousandth of a kilogram. A cubic centimeter (cm^3) of distilled water at 4° centigrade weighs one gram.

The divisions are:

1000 milligrams (mg) = 100 centigrams (cg) = 10 decigrams (dg) = 1 gram (g).

The multiples are:

1 dekagram (dkg) = 10 grams.
1 hectogram (hg) = 100 grams.
1 metric ton (t) = 1000 kilograms.

EXERCISE XVIII

Find the volume in cubic inches of the quart measure, of the measuring cup, of a berry box, or similar measures as used in the home. Compare with the standards as given in the tables.

1. A man buys a bushel of beans, dry measure, and retails them by the quart, liquid measure. If he paid $4.00 for the bushel and retails at 15 cents a quart, what per cent did he gain on a bushel?

2. Show by diagram the difference between a three inch cube and three cubic inches. Compare the volume of the three inch cube with three cubic inches.

3. A silver dollar weighs 412.5 grains, Troy, and is .9 pure silver. What is the weight of pure silver in a dollar? A gold dollar weighs about one-sixteenth as much as a silver dollar and is also .9 pure. Find the weight of pure gold in a ten dollar gold piece.

4. A cubic foot of pure (distilled) water weighs about 62.5 pounds. What is the weight of a gallon of water?

5. Mercury weighs about 13.5 times as much as water. Find the weight of 30 cubic inches of mercury.

6. Find the weight of a liter of water in grains.

7. Which weighs more, and how much, a liter or a quart of water?

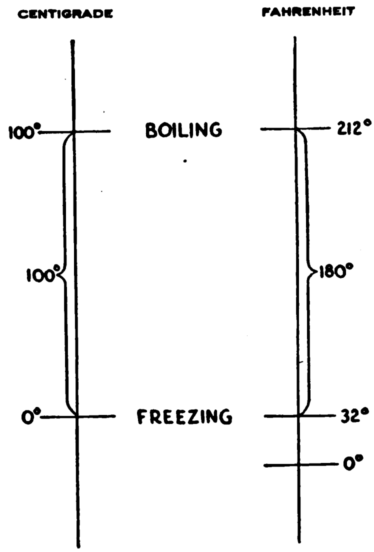
8. Find the cost of 6840 pounds of coal at $6.25 a ton. Use short methods in figuring.

9. A druggist bought five pounds of a drug at $2.00 a pound, avoirdupois, and retailed it at 25 cents an ounce, apothecaries.' What was his gain?

10. A water meter read 5768 cubic feet July 15; and 6880 cubic feet September 15. How many gallons of water were used during the period?

THE THERMOMETER

A thermometer is an instrument used to measure changes in temperature, not the quantity of heat. The principle upon which the thermometer is constructed is the unequal expansion or contraction of the different materials. A common form is made by enclosing a column of mercury in a glass tube. The unequal expansion of the mercury and the glass causes the mercury to rise or fall with the changes in temperature.



COMPARATIVE SCALE OF FAHRENHEIT AND CENTIGRADE SCALES

The freezing and the boiling points of water under normal air pressure at sea level are taken as standards in graduating thermometers. The Fahrenheit thermometer, in common use, locates freezing at 32° above zero and boiling at 212° above zero, while the Centigrade thermometer locates freezing at 0° and boiling at 100° above zero.

To change from Fahrenheit (Fahr.) to Centigrade (C.) or vice versa study the comparative scale.

$$100° \text{ Centigrade} = 180° \text{ Fahrenheit}$$
$$1° \text{ Centigrade} = \tfrac{9}{5}° \text{ Fahrenheit}$$

As the Fahrenheit freezing point is 32° above zero, this number must be added or subtracted in making changes.

122° Fahrenheit equals what temperature Centigrade?

$$122° \text{ Fahrenheit} - 32° \text{ Fahrenheit} = 90° \text{Fahrenheit}$$
$$90° \text{ Fahrenheit} \div \tfrac{9}{5} = 50° \text{ Centigrade.}$$

What temperature Fahrenheit does 60° Centigrade equal?

$$60° \text{ Centigrade} \times \tfrac{9}{5} = 108° \text{ Fahrenheit}$$
$$108° \text{ Fahrenheit} + 32° = 140° \text{ Fahrenheit.}$$

EXERCISE XIX

1. Change 80° Centigrade to Fahrenheit.
2. Change 50° Fahrenheit to Centigrade.
3. If lead melts at 621° Fahrenheit express the temperature in Centigrade.
4. A Fahrenheit thermometer indicates 18° above zero, what would a Centigrade scale read at the same time?
5. Indicate 12° below zero (−12°) Fahrenheit in the Centigrade scale.

RATIO AND PROPORTION

Division may be expressed by writing the dividend before and the divisor after a colon. Such an expression is called *a ratio;* as, $\frac{8}{2}$, $8 \div 2$, and $8:2$ are different ways of saying that 8 is divided by 2.

Ratio is the relation which one quantity or magnitude has to another of the same kind. It is expressed by the quotient obtained by dividing the number compared by the number with which it is compared; as, find the ratio of 24 picas to 6 picas, 24 picas ÷ 6 picas = 4. The 4 is the relation, or ratio. The *terms* of a ratio are the numbers compared. The first term or the dividend is called the *antecedent;* the second term or the divisor is the *consequent;* the quotient is the *ratio.* The general principles of division apply as in fractions. Ratio is usually indicated by the colon (:); as,

24 picas : 6 picas = 4

If the circumference of a circle is 22 inches and the diameter is about 7 inches, what is the ratio of the circumference to the diameter? $22:7=\frac{22}{7}=3\frac{1}{7}$.

When two ratios are equal, the four terms are said to be in *proportion.* A *proportion* is written with the sign of equality between the ratios; as,

$$8:2=12:3$$

The double colon was formerly used to indicate a proportion.

This is read "8 is to 2 as 12 is to 3," and means that 8 is just as many times 2 as 12 is times 3.

In a proportion the first and the last terms are called the *extremes* and the two middle terms the *means.* In the proportion 8 : 2 = 12 : 3, 8 and 3 are the extremes, 2 and 12 are the means.

In any proportions, the product of the extremes equals the product of the means; as,

$$8 : 2 = 12 : 3 \qquad 8 \times 3 = 2 \times 12$$

Either extreme, therefore, is equal to the product of the means divided by the other extreme, and either mean is equal to the product of the extremes divided by the other mean; as,

$$8 : 2 = 12 : 3$$

$8 = \frac{2 \times 12}{3}$ and $3 = \frac{2 \times 12}{8}$ Likewise, $2 = \frac{8 \times 3}{12}$ and $12 = \frac{8 \times 3}{2}$

EXERCISE XX

1. What is the approximate ratio of the diameter of a circle to its radius?

2. What is the approximate ratio of the radius of a circle to its diameter?

3. Which is the greater ratio 12 : 4 or 10 : 5? 3 : 9 or 2 : 4? 8 : 2 or 12 : 3?

4. Find the missing terms in the following proportions:
(a) 7 : 14 = 5 : x; (b) 3 : 12 = 16 : x; (c) 9 : x = 3 : 6; (d) x : 2 = 100 : 50.

5. If 16 men can dig a trench in 24 days, how many men will be required to dig it in 32 days?

6. When a post 8 feet high casts a shadow 10 feet long, how high is a smoke stack that casts a shadow 100 feet long?

7. In a scale drawing if a 3 inch line represents a foot, how long a line will represent 3 feet 4 inches?

8. If a ream of paper 25″×38″ weighs 70 lbs., find the weight of a ream of the same grade of paper 32″×44″.

32″×44″ : 25″×38″ = 70 lbs.

The product of 32″×44″×70 lbs. divided by the product of 25″×38″ = the weight required, 104 lbs.

9. If the weight of a ream of paper 17″×22″ is 20 lbs., find the weight of a ream of the same grade 19″×24″.

10. The basis, or standard size and weight of a ream of paper is 25″×38″—60 lbs.; find the weight of a ream of the same grade 28″×42″.

11. Find the weight of three reams of paper size 19″×24″, the basis weight being 17″×22″—20 lbs.

12. Find the cost at 5¢ per pound of 7 reams of paper 28″×42″, the basis weight being 24″×36″—50 lbs.

MECHANICS

Work is the overcoming of resistance through space. To lift a weight, or overcome resistance of any kind, requires the application of a force. The applied force and the distance through which the body moves under the influence of the force, the product of the two values, gives a measure of the work done and is expressed in the term foot-pounds; as a 10 lb. weight lifted 5 feet requires the performance of 50 foot-pounds of work. Time is not considered as a factor in determining the amount of work done in overcoming a resistance through a certain space.

Twenty galleys of type carried up two flights of stairs requires the same amount of work, or foot-pounds, whether done in 10 minutes, or two hours.

The time element may be used in connection with foot-pounds and then the rate at which work is done is expressed, usually, in horse power. To raise one pound one foot in one second gives a standard, or measure. An engine or other mechanical device that will lift 550 pounds one foot in one second is rated one horse power (H. P.).

A machine is a device by which a given force is made to accomplish indirectly a result that would not be possible by a direct application of the force.

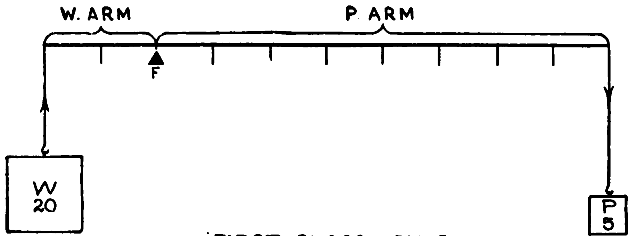
The efficiency of a machine, or the amount of work done by a machine, is always less than the energy applied, as a part of the energy is used in overcoming friction. If a machine performs 440 foot-pounds of useful work per second and the energy applied is one H. P. (550 foot-pounds per second) the machine is only 80 per cent efficient.

Any mechanical device, however complicated can be analyzed, or separated into certain elementary parts, commonly known as the simple machines.

The simple machines as usually classified are: the lever; the wheel and axle; pulleys; inclined plane; the wedge; the screw.

LEVERS

A lever is a rigid bar, free to move about a single point called the fulcrum, and is used to exert a pressure on a given weight at some point in its length by a given power at some other point. It is the simplest form of a machine. There are three classes of levers, depending upon the relations of the power, the weight, and the fulcrum.



FIRST CLASS LEVER

In a lever of the first class the power (P) is at one end. the weight (W) is at the other end, and the fulcrum (F) somewhere between.

The product of the distance from the weight to the fulcrum, or the weight arm, times the weight, is equal to the product of the distance from the power to the fulcrum, or the power arm, times the power; as, $2 \times 20 = 8 \times 5$.

The relation of the parts is best expressed by a proportion.

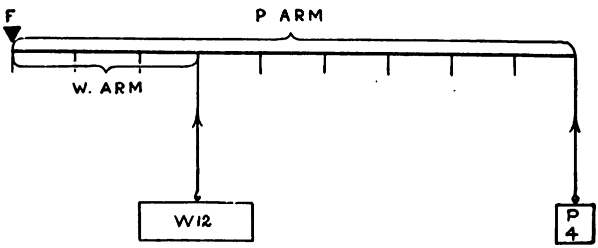
The proportion is expressed as follows P:W = W arm: P arm. 20 lbs.: 5 lbs. = 8 in.: 2 in.

Examples of levers of the first class in common use are crow-bar and shears.

Ordinary shears have short power arms, while tinners' snips have long power arms. Why?

Find the power which at 10 inches from one side of the fulcrum will balance a weight of 25 lbs. two inches from the other side of the fulcrum. The weight of the lever itself is not reckoned in the examples.

Let x = the power
10 = the power arm
25 = the weight
2 = the weight arm
then 25 : x = 10 : 2
10x = 50
x = 5 = the power.



SECOND CLASS LEVER

In a lever of the second class the fulcrum is at one end, the power at the opposite end, and the weight between.

The weight arm is 3, the weight 12 lbs., the power arm, the length of the lever 9 and the power is 4 lbs. The proportion is as follows, 12 lbs. : 4 lbs. = 9 : 3.

Examples of the lever of the second class are wheelbarrow, nut-cracker.

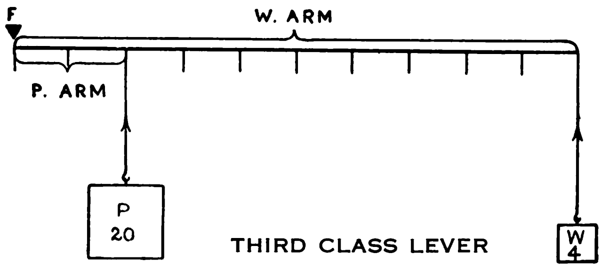
1. Find the distance from the fulcrum at which 32 pounds must be placed in order to balance 8 pounds, 16 inches from the other side.

2. How far from the fulcrum must 10 pounds be placed to balance $6\frac{1}{2}$ pounds, 1 foot 3 inches from the other side?

3. A weight of 36 pounds on one side of the lever is to be balanced by a weight three times as far from the fulcrum on the other side. How heavy is the weight?

4. What power is required to lift a 300 pound stone, if the total length of the lever is 8 feet and the weight arm is 2 feet?

5. If a 6 pound power is placed 36 inches from the fulcrum, how far must 8 pounds be placed to balance it?



THIRD CLASS LEVER

In the third class lever the fulcrum is at one end, the weight at the other, the power between. Power is lost but time is gained.

If a lever 12 inches has a weight of 4 pounds at one end it will require a power of 16 pounds, three inches from the fulcrum, to lift the weight. The proportion is as follows: 4 lbs. : 16 lbs. = 3 : 12.

Examples of the third class lever are: tongs, tweezers, sheep shears.

1. With balance placed 15 inches, and a weight of 5 pounds, 45 inches from the fulcrum, find the power.

2. The weight is 20 pounds, the length of weight arm 4 ft., and the force arm $\frac{1}{6}$ the weight arm, find the force.

Classify the following as levers: garden rake; hammer; drawing a nail; pencil; ax; tweezers; tongs; nut-cracker.

EXERCISE XXI

1. If a weight of 14 pounds be placed 1 foot 7 inches to the left of the fulcrum, and a weight of 3 pounds, 2 feet 2 inches to the right, how many pounds must be added, and to which weight, in order to balance?

2. If 10 pounds be placed $12\frac{1}{2}$ inches to the left of the fulcrum and 5 pounds 20 inches to the right, which weight must be moved out and how far in order to balance?

3. If a weight of 26 pounds be placed 12 feet to the right of the fulcrum, and 18 pounds 13 feet to the left, how many pounds must be added, and to which, in order to balance?

4. Two weights, one 12 pounds and the other 60 pounds, are 72 inches apart. In order to make the weights balance, how far must each be placed from the fulcrum?

5. Two weights, one 14 pounds and the other 56 pounds, are placed 50 inches apart. In order to make the weights balance, how far must each be placed from the fulcrum?

6. If a weight of 15 pounds be placed 12 feet to the right of the fulcrum, and 45 pounds 8 feet to the left, how far must one weight be moved, and which way, in order to balance?

7. Ten pounds is placed 20 inches to the left of the fulcrum and 18 pounds 70 inches to the right. How many pounds must be added and to which side in order to balance?

8. If the weight to be raised is 200 pounds, how many pounds pressure is required in order to balance the weight,

which is 3 inches from the fulcrum, and the lever is 12 inches long?

9. If the load of 360 pounds is placed 3 inches from the fulcrum, how much force is required to balance the load if the force arm is 5 feet 9 inches?

10. If the weight arm is 12 inches and the force arm is 48 inches, how much pressure will be required to raise a load of 300 pounds?

11. A weight of 400 pounds is 9 inches from the fulcrum and the force is 36 inches from the fulcrum. Find the force.

12. What weight 12 inches from the fulcrum will balance a force of 20 pounds, 36 inches from the fulcrum?

13. A wheel has slipped from a 284 pound truck containing 427 Directories, each weighing 3 pounds 12 ounces. The load has shifted so $\frac{3}{7}$ of the weight of the books and $\frac{1}{4}$ of the weight of the truck will have to be raised. In doing so a 70 inch crowbar is used with the fulcrum 8 inches from the axle. How much force will be required to raise the truck enough to replace the wheel?

14. The fulcrum is at one end of a ten foot lever, a power of 20 pounds is at the opposite end; how far from the fulcrum may a 100 pound weight be placed in order to be lifted by the power?

15. A lever of the second class is 8 inches long, the weight of 10 lbs. is 2 inches from the fulcrum; find the force necessary to lift the weight.

16. The force is 13 pounds, the weight 28 pounds, and the lever is 10 feet long. Locate the fulcrum.

17. A boy wishes to lift a 200 pound weight, which is one foot from the fulcrum. He exerts 40 pounds force 4 feet from the fulcrum, but finds he cannot lift it; where must he grasp to raise it?

18. What is the weight being lifted, if the weight arm is 1 foot, the force exerted 20 pounds, and the power arm $6\frac{3}{4}$ times the length of the weight arm?

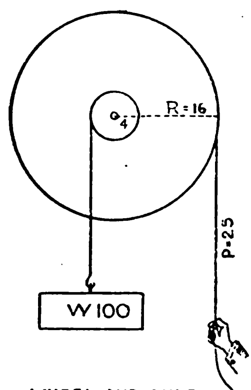
19. If the weight is 48 pounds, and an 8 pound force is 6 feet from the fulcrum, what is the length of the weight arm?

20. The length of a lever is 9 feet, the power 28 pounds and $4\frac{1}{2}$ times the weight. What is the length of the weight arm if the force is between the fulcrum and the weight?

WHEEL AND AXLE

The wheel and axle consists of a large wheel and a small wheel, or cylinder, the axle, fastened to a common axis. The wheel and axle is practically an application of the lever, the fulcrum being the common axis of the wheel and axle. The weight arm is the radius of the axle, and the power arm is the radius of the wheel.

The weight lifted on the axle is as many times the force applied to the wheel as the radius of the wheel is times the radius of the axle.



WHEEL AND AXLE

W = Weight

P = Power

R = Radius of wheel

r = Radius of axle

The proportion is:

W : P = R radius of wheel : r radius of axle.

$$P \times R = W \times r$$

If the wheel is 16 inches in diameter and the axle is 4 inches in diameter, what force will be required to lift a weight of 100 lbs.?

$$100 : x = 8 : 2$$
$$100 \times 2 = 8 \times x$$
$$200 = 8x$$
$$25 = x$$

EXERCISE XXII

1. If the radius of the axle is 5 inches and of the wheel 15 inches, how much force will be required to lift a 21 pound weight?

2. If the diameter of the axle is 12 inches and of the wheel 26 inches, how much force will be required to lift a 52 pound weight?

3. If the force is 20 on a 4 inch axle and a 20 inch wheel, how heavy a weight can be raised?

4. A pulls 200 lbs., B one half as much as A, and C one half as much as A and B. How heavy a weight can they raise with an 8 inch axle and a 24 inch wheel?

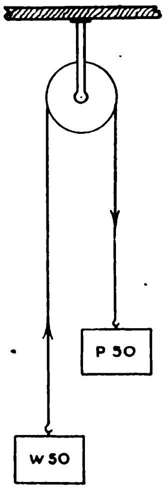
5. Find the force necessary to raise a bucket of metal where R is $1\frac{1}{2}$ feet, r 6 inches and W 120 pounds.

6. Find the weight being lifted, where the force is 80 pounds, R 2 feet and r one fourth of R.

7. How heavy a load is a man able to lift by means of the wheel and axle, if the diameter of the axle to which the load attached is 16 inches, the diameter of the wheel is 72 inches, and the man exerts 224 pounds force?

THE PULLEY

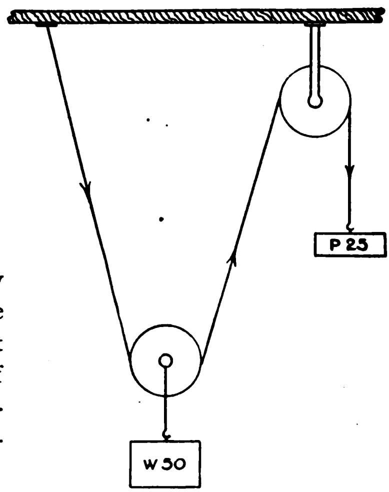
The pulley as a mechanical device in its simplest form consists of a grooved wheel called a sheave, turning within a movable frame, or block, by means of a rope or cord. When the pulley is suspended from a fixed point it is called a fixed pulley and has no mechanical advantage, but simply changes the direction of the rope. The force equals the weight. If the weight to be lifted is 50 lbs. what force will be required to lift the weight with a single fixed pulley?



SINGLE FIXED PULLEY

$$W = 50 \text{ lbs.}$$
$$P = W$$
$$P = 50 \text{ lbs.}$$

When one end of the cord is attached to a fixed point while the pulley itself is free to move with the weight, the relation between the force and the weight is changed. The weight and the pulley are supported in part by the fixed point; hence the force will be but one half the weight if the weight of the pulley and friction are neglected.



SINGLE FIXED AND SINGLE MOVABLE PULLEYS

If the free end of the rope is passed over a fixed pulley to change direction, the force, which is one half the weight, will move twice as far as the weight.

Blocks with several sheaves may be used either as fixed or movable pulleys and the free end of the rope may be wound upon a drum or on a wheel or axle. Every time the rope is passed over the movable pulley the power is reduced one half.

Resistance × its displacement = Effort × displacement.

Force × its distance = Weight × its distance.

Neglect the weight of the pulleys also friction in all the problems

EXERCISE XXIII

1. What force will lift a weight of 100 pounds using two fixed and two movable pulleys? Show the relation of parts by diagrams.

2. A 60 pound weight is to be lifted 28½ feet by a single fixed pulley. What is the force necessary to lift the weight and what amount of work is done?

3. A weight is to be lifted by a single movable pulley. If the weight is 180 pounds, what would be the reading on a scale attached to the other end?

4. If 680 foot-pounds of work are done through the means of a single movable pulley and 24 feet of cable is taken in during the work, what is the weight?

5. If 540 pounds is lifted by a single movable pulley, 4 feet, find the pounds-force.

6. What is the force, if the weight lifted is 680 pounds, and there are 8 strands?

7. If a piano weighing 680 pounds is to be raised 80 feet and the total number of strands is 9, how many feet of cord must be pulled in and what force required?

8. A beam weighing 2400 pounds is hoisted up a new building 180 feet high, and a single movable pulley is used. How many foot-pounds of work are done and what force is necessary to raise the beam?

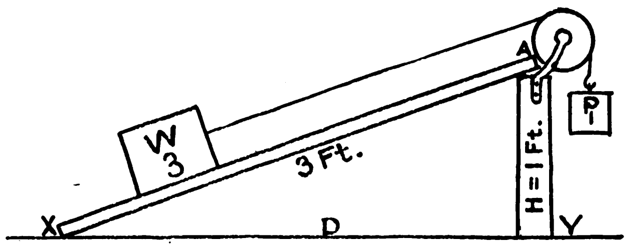
9. The weight is 840 pounds, the pounds-force 220;

find the total number of strands used in the operation, if the weight is hoisted by a combination of pulleys.

10. Find the weight of a rock which was hoisted, if the number of strands supporting the weight are 4 and the pounds-force 40.

INCLINED PLANE

An inclined plane is a plane surface inclined to the horizontal. With an inclined plane a weight can be raised with a force of less magnitude than if it were raised vertically to the same height. The relation between the power and the weight depends upon the length of the incline and the height of the raised end.



INCLINED PLANE

Suppose the weight W is to be raised from the horizontal XY to the point A. If the weight is raised in a vertical line, as AY the P and W act through the same space. Therefore, as we have seen before, P = W.

If the weight is drawn up the incline AX then the force acts through the distance AX, while the weight is actually lifted the distance AY. Then we have the ratio of the force to the weight equal to the ratio of the vertical to the inclined plane.

Or: P : W = AY : AX and from the equation is obtained the following formulæ:

$$P = \frac{W \times AY}{AX}$$

and $$W = \frac{P \times AX}{AY}$$

EXERCISE XXIV

Neglect friction in all the problems.

1. A weight of 3400 pounds is to be drawn up an incline 642 feet in length and 84 feet above the horizontal. Find the force necessary to lift the weight.

2. What weight can be drawn up an incline 10 feet long and 4 feet high with a pull of 300 pounds?

3. If A's pull is twice B's and C's is $\frac{2}{3}$ of A's and B's, how much did each exert in pulling a crated linotype machine weighing 2546 lbs. up an incline $10\frac{1}{2}$ ft. long and 4 ft. 10 inches above the horizontal, with a single movable pulley?

4. Find the foot-pounds necessary to raise a 350 pound case up a 14 foot incline, top of which is 4 feet high.

5. Find the pounds-force necessary to raise a 350 pound case up an incline; top of incline is 6 feet from the ground and the base of triangle formed by inclined plane is 15 feet.

6. Find the weight which is being pulled up an inclined plane, the pounds-force being 200, the length of plane 19 feet, and the height $4\frac{1}{2}$ feet.

7. What is the length of an inclined plane; the height is $6\frac{1}{2}$ feet, the pounds-force 824, and the weight 2400 pounds.

8. Find the pounds-force necessary to raise a 600 pound weight up a 15 foot inclined plane 6 feet high.

9. Find the height of an incline, the length of which is 26 feet and the base 17 feet.

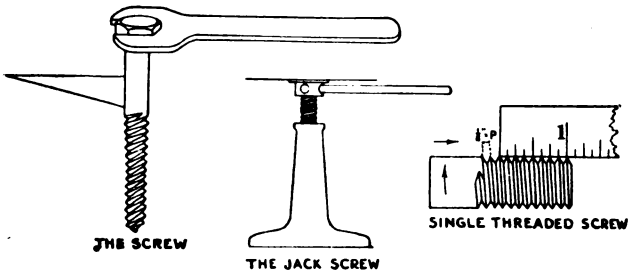
10. How long must an inclined plane be, if by its use a force of 320 pounds should lift 4800 pounds to a height of 32 inches?

THE WEDGE

A wedge is a double inclined plane and the principles of the inclined plane apply to the wedge.

THE SCREW

The screw may be regarded as a combination of an inclined plane and the wheel and axle, the screw thread being the inclined plane wound around a cylinder.



The screw consists of a cylindrical rod of metal around which have been cut *grooves* or *threads* which advance uniformly a certain distance each turn of the screw in a similar thread cut in a base, or nut. When the screw is turned once around, it moves in a direction in (up), or out (down) equal to the distance between two successive threads. This distance from the center of one thread to the center of the next thread measured in a line parallel to the axis is called the *pitch* of the screw. There may be any number of grooves, so there may be any number of threads, but only single-threaded screws will be considered in this elementary outline of the subject.

The distance that a thread advances in one turn is called the *lead* of the screw. Lead and pitch are practically synonomous terms with single-threaded screws.

If an inch be divided by the pitch of the screw the result will give the *number of turns* that the screw makes to an inch; as, if the pitch is $\frac{1}{8}$ inch, the turns to an inch =

1 inch $\div \frac{1}{8}$ inch $= 8 =$ number of turns to an inch.

If a jackscrew supports 2000 pounds and the pitch is $.12\frac{1}{2}$ inches, find the work required to lift the weight.

2000 pounds $\times .12\frac{1}{2}$ inches $= 250$ foot-pounds = work required.

The force multiplied by the circumference of the circle through which the force arm moves equals the weight multiplied by the pitch of the screw.

F = Force. 2π r. F. = Circumference of the circle moved over by the end of the lever. Effort = Pounds-force.

W = Weight. P = Pitch.

Work out = Work in.

$W \times P = \text{Effort} \times 2\pi$ r. F.

EXERCISE XXV

1. What is the work done by a screw when turned once, if the weight on top of the screw is 4850 pounds and the pitch is .06 feet?

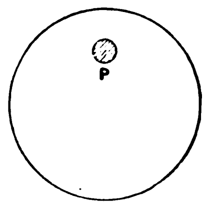
2. What is the pitch of a jackscrew, if the pounds-force is 150, the weight 4800 pounds, and the length of the lever 4 feet?

3. There are 24 books on a letter press, to be put under pressure, if each book gives way $\frac{1}{8}$ of an inch the resistance offered by all is 800 pounds. The diameter of the handle is $1\frac{1}{2}$ feet, the pitch .02 feet, how many revolutions can the handle make and what pounds-force is exerted?

4. If the material to be measured by a micrometer is $\frac{3}{8}$ of an inch long and the micrometer as taken up reads 1.025 inches, how many turns must be made to correctly measure the material if the pitch is $\frac{1}{40}$ of an inch?

THE CAM AND THE ECCENTRIC

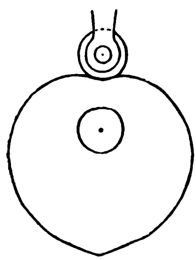
If a circular disk is pivoted at a point other than the center as the point P in the figure and is made to rotate around that point, it is said to have an eccentric motion, and is itself called an eccentric.



THE ECCENTRIC

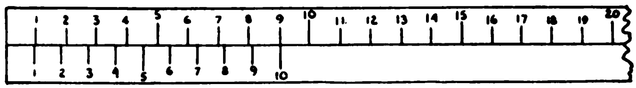
A cam is in effect the same as an eccentric, differing mainly in the shape of the periphery (the distance around the figure). By changing the shape of the disk an indefinite number of straight line motions can be produced. A study of the various parts of the different machines in a printing plant will lead one to see the different eccentrics and cams and the motions produced by each.

Drawings should be made of several in common use and draw conclusions as to the shape of the disk necessary to produce a required motion.

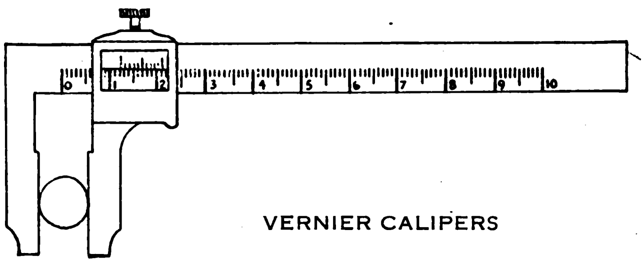

THE CAM

THE VERNIER

In measuring a length by means of a linear scale it often happens that while one end of the scale may coincide with a division the other end may fall somewhere between two divisions. One who has had experience may estimate the distance between divisions quite accurately, but reading of much greater accuracy may be obtained by using a vernier.



VERNIER



VERNIER CALIPERS

A vernier consists of a series of equal divisions on one or both sides of a sliding index. The index line is the zero of the vernier, while the other lines are used to aid in determining the exact position of the index on the scale.

The vernier divisions are made to differ in length from those of the scale, in every case in such a manner that N vernier divisions are equal to $N+1$ or $N-1$ scale divisions. In every case each vernier division is $\frac{1}{N}$ of a scale division longer or shorter than each scale division.

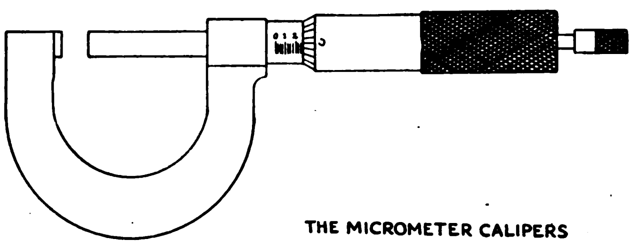
A decimeter is divided into ten equal parts each called a centimeter or ten millimeters, if nine centimeters or nine-tenths of a decimeter be divided into ten equal parts each part will contain nine millimeters, or lack one millimeter of being as long as one division of the decimeter scale.

There are many different measuring instruments where the vernier is an essential part.

One in common use is the vernier calipers; with a vernier caliper a length of $\frac{1}{100}$ is accurately measured.

MICROMETER CALIPERS

The micrometer (small measure) consists of an accurately cut screw of a definite pitch turning in a fixed block. One turn of the screw advances its end by an amount equal to the distance between two threads. A longitudinal scale gives the number of whole turns of the screw and the graduations on the head of the screw give the fractions of a turn. The micrometer is an essential part of the micrometer caliper used in measuring the length of type, the thickness of paper, and in various other operations when great accuracy is necessary.



THE MICROMETER CALIPERS

The micrometer calipers consists of a metal frame with two parallel arms, one of which is threaded to contain the screw while the other is provided with an adjustable stop. The face of the screw and the face of the stop form exactly opposite parallel planes. The screw head is a hollow cylinder, or barrel, which slides over the stem, or nut, through which the screw passes and is turned by means of a milled head. Running lengthwise on the stem is a straight line divided into divisions made to correspond with the pitch of the screw. The edge of the cylinder moves along the edge of this scale as the screw is turned. Fractions of a turn may be noted by observing the divisions marked on the beveled edge.

If the pitch of the screw is $\frac{1}{40}$ of an inch, the linear scale will be $\frac{1}{40}$ of an inch, and if the edge of the cylinder be divided in 25 equal parts to advance the screw through a single part will advance it $\frac{1}{25}$ of $\frac{1}{40}$ of an inch or .001 of an inch.

A vernier is often added to the micrometer, so that divisions of .0001 may be measured.

The actual use of the instrument is best taught by use in measuring type, paper, copper or zinc plates.

TRANSFERENCE OF POWER

Power may be transferred by various devices; as, direct connection; belts; cables; ropes; link belts; gear wheels; friction pulleys; or chains.

Belts and gear wheels will be considered. In using a belt, if the drive-pulley and the driven-pulley are of the same diameter the speed of the driven-pulley will be of the same speed as the driver. To increase the speed of the driven-pulley decrease its diameter in proportion to the drive-pulley. To decrease the speed of the driven-pulley increase its diameter in proportion to the drive-pulley. The direction of the driven-pulley in relation to the drive may be changed by crossing the belt.

Find the speed revolutions per minute (R. P. M.) of a dynamo having a pulley 8 inches in diameter driven by a belt on a 6 foot fly wheel running 200 R. P. M.

72 inches : 8 inches = x : 200

x = 1800, the speed of the dynamo.

Find the speed of a pump having a pulley 3 feet in diameter belted to a motor having a 6 inch drive-pulley running 240 R. P. M.

36 inches : 6 inches = 240 : 40
the speed of the pump is 40 R. P. M.

EXERCISE XXVI

1. What is the speed of a lathe, which has friction pulleys for transmission of power and the pulley is 10 inches in diameter, while that of the driven-pulley is $2\frac{1}{2}$ inches in diameter and has a speed of 400 R. P. M?

2. If the speed of an engine lathe is 200 R. P. M. and the driven-pulley is 12 inches in diameter, twice as large as the driver-pulley, what would be the actual speed of the driver?

3. How many R. P. M. does the drill of an engraver's cutter make, if the diameter of the drill is one half inch, while the diameter of the pulley on the drill is 2 inches? The diameter of driver-pulley is 6 inches and the speed 250 R. P. M.

4. If the counter on a cylinder press records 1800 sheets for an hour run, one sheet to every two revolutions, what is the speed of the motor if the ratio of the driver-pulley to the driven cylinder's pulley is $3\frac{1}{2}$ to 3?

5. The piston on a motorcycle goes up and down 2400 times per minute; the driver-pulley is $6\frac{1}{2}$ inches in diameter and is connected to the rear wheel by a belt. If the diameter of the rear pulley is 2 feet, how many revolutions does the rear wheel make?

6. A pulley 10 inches in diameter and the speed 200 R. P. M. is connected to a shaft on which are two pulleys of 4 and 6 inches diameter. The belt leads to the pulley

of 4 inches but another belt leads from the 6 inch pulley to another pulley of 12 inches diameter. What is the R. P. M. of the last pulley?

GEARS

One gear is usually a driver, the other a driven or follower.

$$\frac{\text{The product of the teeth in the driver} \times \text{its revs.}}{\text{No. teeth in follower} \times \text{No. revolutions of follower}} =$$

EXERCISE XXVII

1. Find the number of revolutions of the follower, if the number of teeth in the driver are 24 and the R. P. M. 5 times the number of teeth and there are 8 teeth in the follower.

2. The speed of the driver to the follower is 3 : 1, while the number of teeth on the driver is 42, find the number of teeth on the follower.

3. Find the number of teeth in the follower, if its speed is $\frac{1}{3}$ that of the driver, while the number of teeth in the driver is 72.

4. How many teeth must a gear have to revolve 20 times, while a 75 tooth mate revolves 16 times?

5. How many teeth must a follower have in order to make 96 revolutions, while a 42 tooth driver makes 64?

6. How many revolutions of the driver will drive the follower two revolutions?

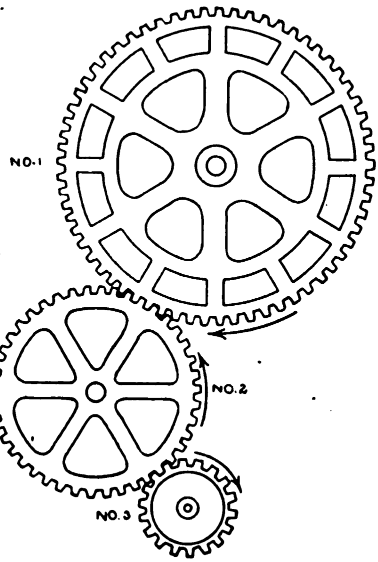
7. The ratio of the number of teeth on the driver to the follower is 5 : 8. Which gear has the greater speed, and what direction has the one to the other?

8. In a train of 3 gears respectively A, B and C, B

being the intermediate or idler, what is the direction of B to the other gears and what direction have A and C to each other?

If the motor makes seven revolutions to each impression on a two revolution cylinder press, show by diagrams the relative size of the connecting wheel and the cylinder wheel required to transfer the power from the motor to the cylinder, also show by diagrams the relative sized wheels necessary to drive the fountain wheel which turns once to each impression.

SPEED



No. 1—cylinder wheel.

No. 2—connecting wheel.

No. 3—motor wheel.

Cylinder wheel—63 teeth.

Connecting wheel—42 teeth.

Motor wheel—18 teeth.

$\frac{18}{42}=\frac{3}{7}$ $\frac{42}{63}=\frac{2}{3}$

$\frac{2}{3}$ of $\frac{3}{7}=\frac{2}{7}$

Speed of cylinder $\frac{2}{7}$ of motor.

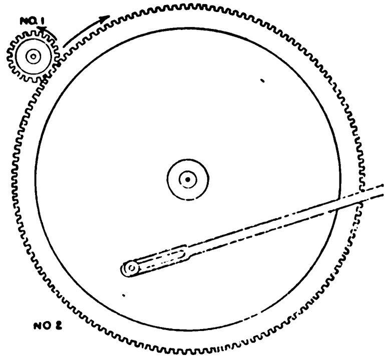
Motor goes $3\frac{1}{2}$ times as fast as the cylinder. Cylinder makes two revolutions to each impression.

$$3\tfrac{1}{2}\times 2=7$$

Motor makes 7 revolutions to each impression.

No. 1—motor wheel.

No. 2—wheel which works the shaft on the fountain.



Motor wheel—20 cogs.

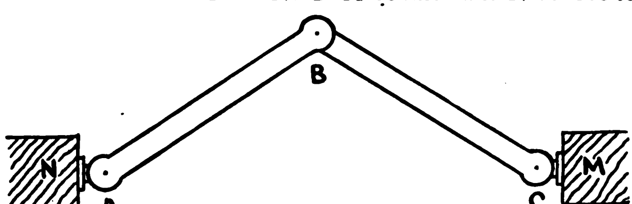
Fountain wheel—140 cogs.

$\frac{20}{140}=\frac{1}{7}$

Fountain wheel goes $\frac{1}{7}$ as fast as the motor. The motor turns 7 times to each impression. The fountain turns $\frac{1}{7}$ as fast or 1 time to each impression.

THE TOGGLE JOINT

If two bars as AB and BC are pivoted at B as in the diagram and pressure is applied at B, the pressure exerted will be transferred to M and N. If M be fixed and N be free to



THE TOGGLE JOINT

move, as in a press, the pressure resulting will be enormous as compared to the pressure applied. Study the toggle joint, as the above described device is called, as you find it used on presses, stamping machines, smashing machines, and paper cutters.

COMPOSITION OF TYPE METAL

Mass is the quantity of matter in a body and is a constant quantity no matter where the body may be placed.

Weight is the measure of the force exercised upon a body by gravitation and varies according to the mass of the body and the distance of the body from the center of the earth.

Specific gravity is the ratio of the weight of a cubic foot of any material to the weight of a cubic foot of water (62.5 lbs.)

Water freezes at 32° Fahr. (0° Cent.) and boils at 212° Fahr. (100° Cent.).

A gallon contains 231 cubic inches.

A cubic foot is approximately 7½ gallons.

Type metal is a mixture of lead, tin and antimony. Lead is the base. Antimony is added to make it hard and to offset the shrinking of the lead while cooling. (Antimony expands in cooling, making a sharp face.) Tin reduces the fusing point of the mixture and acts as a binder for the lead and the antimony. These metals in their raw state fuse at different temperatures, so that mixtures are made to suit the requirements of their special uses on the monotype, the linotype or as foundry type.

The proportion of the metals used for the different classes is indicated in the following table. (These proportions may vary in different foundries):

KIND OF METAL	ANTIMONY	TIN	LEAD
Linotype......	12%	5%	83%
Monotype.....	18%	8%	74%
Foundry Type.	25%	10%	65%

The melting point of antimony is 1166°, of tin 449.4°, of lead 621.3°, all Fahrenheit.

The specific gravity of antimony is 6.7, of tin 7.29, of lead 11.3.

The pot of metal on a linotype machine is usually kept at a temperature about 550°, on the monotype machine about 725° and on a machine casting foundry type at about 900°, all Fahrenheit.

A pot of linotype metal contains 1400 lbs. Analysis shows 15% antimony, 4% tin and 81% lead. What metals and how much of each must be added to bring the batch up to standard?

15% of 1400 lbs. = 210 lbs. of antimony in the batch.
Let 210 lbs. = 12% of the batch when brought to standard.
Then $\frac{100}{12}\times 210 = 1750$ lbs. in new batch.
5% of 1750 = 87.5 lbs. of tin in new batch.
4% of 1400 = 56 lbs. tin in old batch.
87.5 lbs. − 56 lbs. = 31.5 lbs. of tin to be added.
83% of 1750 = 1452.5 lbs of lead in new batch.
81% of 1400 = 1134 lbs. of lead in old batch.
1452.5 lbs. − 1134 lbs. = 318.5 lbs. of lead to be added.

A pot of linotype metal weighs 1400 pounds. Find the specific gravity of the linotype metal.

Sp. gr. of antimony	6.7 × 12% =	.804
" " " tin	7.29 × 5% =	.3645
" " " lead	11.3 × 83% =	9.379
Sp. gr. of the lino. metal		10.5475

EXERCISE XXVIII

1. If a pot of linotype metal contains 1400 lbs. and is 3.65% tin, 14% antimony and 82.35% lead, how much of each metal should be added to bring the metal up to standard analysis?

2. Given a lot of foundry type, weight 1150 pounds with the following analysis: antimony 20%, tin 6%, and lead 74%. What metals and how much of each must be added to convert the lot so that it can be used for monotype metal?

3. A pot of monotype metal weighs 1300 pounds and has 20% antimony and 4% tin. How much of each metal must be added to bring the lot up to standard analysis and what will be the weight, toned?

4. A pot of linotype metal weighing 1200 pounds is found by analysis to contain antimony 16%, lead 80%, and tin 4%. How much lead and tin must be added to tone the batch to the antimony?

5. A lot of monotype metal weighs 1600 pounds. The analysis shows 20% antimony, 7% tin and 73% lead. Tone the metal to the antimony and find the weight of the resulting batch.

PERCENTAGE

In percentage the number whose percentage is taken is spoken of as the *base*, the given number of hundredths to be taken as the rate or the per cent, and the answer found by taking the given number of hundredths as the percentage.

Per cent means by the hundred. The character % is used to indicate per cent; as, 20% is read 20 per cent and means $\frac{20}{100}$; 20% may be written .20, $\frac{20}{100}$, and the value is $\frac{1}{5}$. Any fraction may be reduced to hundredths, hence to per cent, and any per cent may be reduced to a common fraction.

Compare the following forms:

Division $12 \div 4 = 3$.
Fraction $\frac{12}{4} = 3$.
Ratio $12:4 = 3$.
12 is 400% of what number?
12 is $\frac{400}{100}$ of 3, or 12 is 400% of 3.

Problems in fractions may have any fractional unit, while in percentage the fractional unit is always one hundredth, hence percentage is a limited form of decimal fractions.

EXERCISE XXIX

1. Change the following fractions to decimals; to per cents: $\frac{1}{2}$, $\frac{3}{4}$, $\frac{1}{8}$, $\frac{3}{8}$, $\frac{5}{8}$, $\frac{7}{8}$.

2. Change the following per cents to decimals; to common fractions: $12\frac{1}{2}$%, $16\frac{2}{3}$%, 25%, $33\frac{1}{3}$%, $37\frac{1}{2}$%, $62\frac{1}{2}$%, 75%, $87\frac{1}{2}$%, $112\frac{1}{2}$%, 125%, $137\frac{1}{2}$%, 225%, $462\frac{1}{2}$%.

3. Change to per cents; to common fractions, .125, .375, .625, .6625, $4.37\frac{1}{2}$.

PROBLEMS IN PERCENTAGE

The general problems under fractional relations of numbers are here stated as problems in percentage.

To find any per cent of a number: multiply the given number by the indicated per cent expressed as a fraction and the result will be the required per cent of the number; as, find 25% of 24. $24 \times 25\% = 6$ ∴ 6 is the required per cent of 24.

EXERCISE XXX

1. Find 25% of 720.
2. Find .5% of 720.
3. If a certain order calls for 8000 volumes, and $62\frac{1}{2}\%$ are delivered Tuesday, how many volumes must be delivered Wednesday to complete the order?
4. If $2\frac{1}{2}$ per cent of a consignment of 45,000 pounds of paper is damaged, find the value of the damaged stock at $4\frac{1}{2}$ cents per pound.
5. The count of a truck load of printed sheets was 3200, and $6\frac{1}{4}\%$ were damaged. Find value of damaged sheets at $12\frac{1}{2}$ cents each.

To find a number when a certain per cent is given: divide the given number by the indicated per cent and the result will be the required number; as, 6 is 25% of what number? $6 \div 25\%$ or $\frac{25}{100} = 24$ ∴ 24 is the required number.

EXERCISE XXXI

1. 360 is 25% of what number?
2. 480 is .5% of what number?

3. 250 sheets were the spoilage on a job. $2\frac{1}{2}\%$ of the job was spoilage. How many perfect sheets were delivered?

4. If the power-plant consumes 75 tons of coal per week and the developed horse-power at the switchboard is 14,000 kilowatt hours, and the efficiency is $87\frac{1}{2}\%$, what should be the number of K. W. hours developed?

5. If an apprentice has an attendance record for six months of 158 days and his per cent of attendance is $98\frac{3}{4}$, find whole number of working days in the six months.

To find what per cent one quantity is of another quantity of the same kind: divide the quantity which is the part by the quantity of which the part is to be found and express the result in hundredths; as, what per cent of 24 is 6? 6 is such a per cent of 24 as 24 is contained times in 6, expressed in hundredths, or $6 \div 24 = \frac{1}{4} = \frac{25}{100} = 25\%$ $\therefore$ 6 is 25% of 24.

EXERCISE XXXII

1. What per cent of 240 is 12?
2. What per cent of 4800 is 240?
3. If the spoilage on a job of 64,000 sheets is 3200 sheets, what is the per cent of spoilage?
4. If the efficiency of press number eighteen is 1200 sheets per hour and an apprentice can feed 1050 sheets per hour what is his per cent of efficiency?
5. If an apprentice can set a job in $6\frac{1}{2}$ hours and a journeyman can set the same job in 4 hours, what is the efficiency of the apprentice expressed in per cent?

EXERCISE XXXIII (REVIEW)

1. The standard, or estimated time on a job was 6.4 hours. A compositor completed the work in 5.6 hours. What was his gain expressed in per cent?

2. If the estimated time on a job is 4.2 hours, and a compositor takes 5 hours to do the work, what is his efficiency expressed in per cent?

3. The standard time on two jobs is, for No. 1, 6.8 hours and for No. 2, 7.3 hours. The jobs are given to two compositors, A and B. A completes job No. 1 in 5.9 hours and B completes job No. 2 in 6.4 hours. Compare their efficiency.

4. If an apprentice is rated as seven tenths of a journeyman's time and the estimated time on a job is 6.3 hours and an apprentice does the work in 7 hours, how many hours credit does he receive?

5. The estimated time of make-ready on a job was 15 hours. The pressman completed the job in $10\frac{1}{2}$ hours. Find the per cent gained.

6. If a pressman runs 1000 sheets per hour for nine hours and the earning rate of the press is $2.00 per 1000 sheets, find net earnings of the press for the nine hours, with 4% off for spoilage.

7. The estimated time on a job was 6 hours; a compositor completed the work in 4 hours, but was charged .5 hours for corrections which is deducted from the time gained. Find what per cent the net gain is of the estimated time.

8. The standard efficiency of a press is 1200 sheets per hour; if an apprentice feeds 1000 sheets in an hour and there is a spoilage of 10% due to carelessness, what is his per cent efficiency? The sheets are 25×38 and weigh 60 pounds to a ream. Find the value of spoilage at $4\frac{1}{2}$ cents a pound.

9. The standard time on a job is 8 hours; if a compositor completes the job in 9.2 hours what is his per cent of efficiency?

APPLICATIONS OF THE GENERAL PROBLEMS OF PERCENTAGE

The only applications of the general problems of percentage, without the time element, that will be considered are *Profit and Loss* and *Discount*.

The new things to be learned are the terms used and the business usages in each transaction.

PROFIT AND LOSS

The *cost* of any article is the amount paid for it by the purchaser.

The *selling price* of any article is the amount received for it by the seller.

The *gain* is the amount above the cost price that an article is sold for.

The *loss* is the amount below the cost price that an article is sold for.

Gain or *loss* per cent is always reckoned on the cost. The cost is always 100% of itself.

A paper dealer purchased 240 reams of paper, 28″×42″ —80 lbs., at $3\frac{1}{3}$ cents per pound. Forty reams were damaged and he was obliged to sell them at $2\frac{1}{2}$ cents per pound. For the remaining 200 reams he received $4\frac{1}{2}$ cents per pound. Did he gain or lose, and how much? What was his gain or loss per cent?

80 lbs.×240=19,200 lbs., total weight.

$3\frac{1}{2}$c×19,200=$640 cost.

80 lbs.×40=3200 lbs., weight of damaged stock.

$2\frac{1}{2}$c×3200=$80 selling price of damaged stock.

80 lbs.×200=16,000 lbs., weight of stock not damaged.

$4\frac{1}{2}$c×16,000=$720, selling price of stock not damaged.

$720+$80=$800, selling price.

$800 − $640 = $160, gain.

The gain, $160, divided by the cost, $640, gives the gain per cent. $160 is $\frac{1}{4}$ of $640 therefore the gain is $\frac{1}{4}$, $\frac{25}{100}$, or 25%.

EXERCISE XXXIV

1. A machine bought for $1240 was sold for $1420. Find gain per cent.

2. A dealer purchased a book for 84 cents and sold it for $1.20. What was his gain per cent?

3. The loss on a certain job was $48. The loss was $6\frac{1}{4}$% of the entire value of the job. Find what was received for the job.

4. The gain on a bill of merchandise was $12. The gain was 10% of the cost of the goods. Find the selling price.

5. On a certain job 3% was allowed for spoilage, 5000 perfect sheets were printed. How many sheets did the stock man deliver to the pressman?

TRADE DISCOUNT

The *catalogue* or *list price* is the price asked for any article and is usually fixed at a certain per cent above the cost price.

A *discount* is a certain per cent deducted or *thrown off* from the catalogue or list price. The list price is usually published in the catalogue and does not vary from time to time, the fluctuations in the market being indicated in the discount sheets that are furnished the dealers as the prices change.

These discounts are known as *trade or commercial discounts*. There may also be a discount for cash.

The *net price* is the price the purchaser pays. It is the list price less all discounts.

Trade, commercial, or successive discounts, are figured as follows: If the list price of a machine is \$750, and discounts of 20% and 10% off and a cash discount of 2% are allowed, find net price.

100%, list price, $-$20% = 80%
\$750 × 80% = \$600 = net after first discount.
100% $-$ 10% = 90%
\$600 × 90% = \$540 = net after second discount.
100% $-$ 2 = 98%
\$540 × 98% = \$529.20 = net price.

EXERCISE XXXV

1. Find net price of four copies of De Vinne, "Correct Composition," list price \$2.00—discounts 20%, 6% cash.

2. Find cost of 8½ reams of paper, weight 60 lbs., at 6¾ cents per lb. Discounts 20% and 3% for cash.

3. Which is better, and how much, on a bill of \$50,000, successive discounts of 35%, 15%, and 10%, or a flat discount of 50%?

4. A dealer bought a machine listed at \$480.00, less two discounts of 25% and 10%; he asked a customer a price 33⅓% above cost, but being unable to make a sale reduced his price 12½%. What did he receive for machine?

5. A machine cost \$720.00. There were two discounts, 20% and 10%. Find list price.

INTEREST

The only application of percentage with the time element that will be considered is *interest.*

Interest is money paid for the use of money.

The *principal* is the sum of money upon which interest is paid.

The *rate* of interest is a certain per cent of the principal which is paid for its use, and is usually computed on a yearly basis of 360 days, or twelve months of thirty days each.

The principal plus the interest is the *amount*.

A *promissory note* is a written instrument in which a person, called the *maker*, promises to pay a person, called the *payee*, a certain sum, called the *face of the note*, at a given time, called the date of *maturity of the note*. A note also usually specifies the *rate* of interest, when payable, where payable, and why given (for value received).

The following form illustrates a *negotiable promissory note:*

CHICAGO, March 1, 1910.

Two years, 6 months, 18 days after date, for value received, I promise to pay to the order of John Blank, $848.60,
eight hundred forty-eight and $\frac{60}{100}$ .... Dollars,
with interest at the rate of 5% per annum.

Payable at The Apprentice Bank. JOHN DOE.

Find the interest on $648.60 for 3 years, 9 months, 18 days, at 5%.

$$
\begin{array}{r}
\$648.60 \\
.05 \\
12\,|\overline{\$32.4300} \times 3 = 97.29 \text{ interest for 3 years.} \\
\$\ 2.7025 \text{ interest for one month.} \\
9.6 \\
\hline
162150 \\
243225 \\
\hline
\$25.94400
\end{array}
$$

$ 97.29 interest for 3 years
$ 25.94 int. for 9 mo. 18 days.
$123.23 total interest.

To determine the part of a month the given number of days equals, divide the number of days by three and express the result as tenths of a month, as 24 days ÷ 3 = .8 of a month.

There are many methods of solving problems in interest, all depending upon the same fundamental principles. It is better to learn one method and be accurate in the work than attempt many methods.

EXERCISE XXXVI

1. Find the interest on $425.60 for 2 years, 9 months, and 18 days, at 5%.

2. Find the amount of $228.50 for 5 years, 7 months, 27 days, at 7%.

3. The principal is $1245.80, the time is 4 years, 3 months, 21 days, the rate 5%; find the interest.

4. Find the interest on $25.60 for 9 years, 11 months, 9 days, at 5½%.

5. Find interest on $480 for 90 days at 7%.

6. Find the interest on $480.00 for two years three months twenty-one days at 5%.

7. Find the interest on $5.00 for one year at 3% weekly.

8. Find the interest on $225.60 for three years, 6 mo. 21 days at 5%.

9. If an apprentice saved each week 10 per cent of his wages the first two and one half years and thereafter saved in addition to the 10 per cent of 5.00, 33⅓ per cent of his increased wages and deposited his savings in the savings bank each week, how much would he have at the end of his apprenticeship of seven years? Figure that the bank pays 6 per cent interest, compounded semi-annually.

The following is the rate of wages to use in figuring:
First year, $2.40.
Second year, $3.00.
First half third year, $5.00.
Second half third year, 6.50.
Increase thereafter, $1.50 every six months.

NOTE.—Compound interest is interest computed upon interest. The interest is added to the principal at the end of period.

10. Find the interest on $5125.80 for three years, seven months and twenty-seven days at 4%.

11. Find the interest on $35.60 for two years, three months, twenty-two days at $4\frac{1}{2}\%$.

12. A note dated Chicago, August 10, 1908, was paid August 10, 1910; the face of the note was $600.00; the rate 5%; the time on or before August 10, 1910; the maker, H. J. Jones; and the payee, Frank Smith. A payment of $100.00 was made Febuary 10, 1909; how much was due at maturity?

NOTE.—When partial payments are made that exceed the interest then due, the interest is computed to the date of the payment and added to the principal, the amount thus found is reduced by amount of the payment, and the balance is then treated as a new principal.

ARITHMETIC AS USED IN THE COMPOSING–ROOM

A knowledge of a few of the terms used in the composing-room is necessary in order to estimate the amount of type required to set a given job, to measure the number of ems of composed type, or to calculate the number of pages manuscript copy will occupy. The *point* is the unit of the American point system and is, for practical purposes, one seventy-second of an inch. (It is equal to the decimal .0138 + or 72.46 points equal an inch.)

The *size* of any given type body is its *thickness* or the height of the body up and down the face of the letter. This size is designated by points. For example, the size of a certain body is $\frac{1}{6}$ of an inch in height. It is called 12 *point*.

An *em* is a type as wide as it is high. For example, an em of 12 point is 12 points wide, of 8 point 8 points wide, and of 6 point 6 points wide.

The em is the unit of measurement of the quantity of type. A line four inches long is 288 points long, and if set in 12 point type contains 24 ems of 12 point, if set in 8 point type contains 36 ems of 8 point.

An *en* is one half the width of an em.

Quads 3 ems wide are called *3-em quads*.

Quads 2 ems wide are called *2-em quads*.

Quads 1 em wide are called *em quads*.

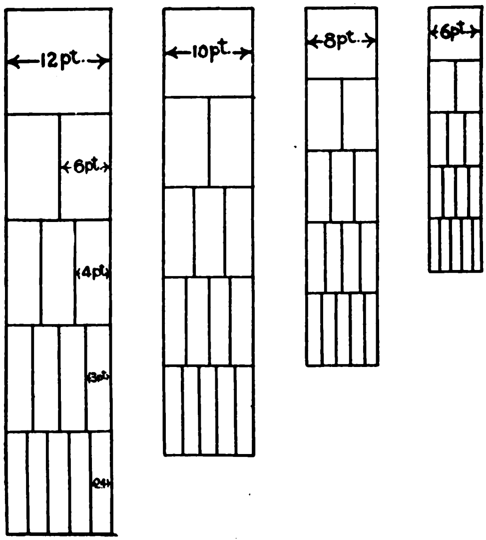
Quads 1 en wide are called *en quads*.

Spaces $\frac{1}{3}$ of an em wide are called *3-to-em spaces*.

Spaces $\frac{1}{4}$ of an em wide are called *4-to-em spaces*.

Spaces $\frac{1}{5}$ of an em wide are called *5-to-em spaces*.

The relation of spaces and quads in the same and different sizes of type may be shown in figures and in a diagram. A 12 point em quad is 12 points square; a 12 point en quad is 12 points high and 6 points set, while a 12 point 3-to-em space is 12 points high and 4 points set.



COMPARISON OF SPACES IN DIFFERENT SIZES OF TYPE

An 8 point em quad is 8 points square. An en quad of the same size type is 8 points high and 4 points set, while a 4-to-em space is 8 points high and 2 points set. A 6 point em quad is 6 points square and an en quad is 6 points high and 3 points set. The width of any given type page is called its *measure*, and is usually expressed in picas. A pica is 12 points $=\frac{1}{6}$ of an inch. To reduce picas to inches divide by 6; as, find the width in inches of a page which measures 28 picas; 28 picas $\div 6 = 4\frac{1}{2} =$ the width in inches.

Agate is $5\frac{1}{2}$ point type. It is also a standard of newspaper or advertising measurement. Under the point system, thirteen lines agate, set solid, make one inch, but advertising rates are usually quoted *per agate line, fourteen lines to an inch.*

The following are the old names of various type sizes and their corresponding sizes in points.

OLD NAMES	POINTS APPROXIMATE	BODY OR HEIGHT IN IN.	SPECIMEN
Excelsior	3	$\frac{1}{24}$	
Brilliant	$3\frac{1}{2}$	$\frac{1}{20}$	
Diamond	$4\frac{1}{2}$	$\frac{1}{16}$	
Pearl	5	$\frac{1}{14}$	Lakeside
Agate	$5\frac{1}{2}$	$\frac{1}{13}$	
Nonpareil	6	$\frac{1}{12}$	Lakeside
Minion	7	$\frac{7}{72}$	
Brevier	8	$\frac{1}{9}$	Lakeside
Bourgeois	9	$\frac{1}{8}$	Lakeside
Long Primer	10	$\frac{1}{7}-$	Lakeside
Small Pica	11	$\frac{1}{7}+$	Lakeside
Pica	12	$\frac{1}{6}$	Lakeside
English	14	$\frac{1}{5}$	Lakeside

EXERCISE XXXVII

1. How many inches in a line 24 picas wide?

2. How many points in a line 16 picas wide?

3. A page measures 27 picas. How many inches in a line?

4. A page is 18 picas wide. How many ems of 12 point type in a line? how many ems of 10 point? how many ems of 8 point? how many ems of 6 point?

5. If a point is .0138 an inch, how much will 24 picas lack of being four inches?

6. Compare a line gauge 72 picas long with a foot-rule and determine how much the line gauge lacks of being a

foot long. Bear this fact in mind when ordering work done that is measured in inches and will be used with type measured in picas.

7. Determine the width or measure in picas of several pages. What is the width or measure in picas of a column in the leading newspapers?

8. If a cut is 3 inches wide how much longer is it than a line of 8 point type 18 picas wide?

9. How much longer and wider is a cut $3 \times 5\frac{1}{8}$ inches than a page of type 18×32 picas?

10. How many ems of $5\frac{1}{2}$ point type in 8 lines each 18 picas long?

TO MEASURE COMPOSED TYPE

In order to determine the number of ems of the size used, multiply the number of ems of the given size in the length of a line by the number of lines.

Leads and other ordinary blanks are usually measured as type.

A page set in 8 point type is 18 picas wide and 30 picas long. Find number of ems.

18×12 points $= 216 =$ points in a line.

216 points $\div$ 8 points $= 27 =$ the number of ems in a line.

30×12 points $= 360 =$ points in the length of a page.

360 points $\div$ 8 points $= 45 =$ the number of lines to a page.

27, the number of ems to a line, multiplied by 45, the number of lines, gives 1215, the number of ems to a page.

TO CHARGE FOR COMPOSITION

The length of the page, including running head is measured with a line gauge, and if folioed at the top one line is added and the length is multiplied by the width as measured by the gauge. If folioed at the bottom the length includes running head and also folio line at the bottom. The dimensions are measured to the nearest em of the size of type used, fractions being discarded.

Find the number of ems in a book of 296 pages, including front matter, three pages blank (no charge for composition, presswork charged) set in 12 point. The page is 18 picas wide and 33 picas long, including running head and folio at the bottom.

18 ems = width × 33 ems = length = 594 ems to a page.

296 pages − 3 (blank) = 293 = pages of composition.

594 ems to a page × 293 pages of composition = 174,042 ems.

Find the number of ems of 8 point in a book of 84 pages, two being blank. The page is 27 ems (18 picas) of 8 point in width, and 48 ems (32 picas) of 8 point in length, being folioed at the top.

27 ems = width in 8 point × (48 ems + 1 em for folio line at bottom) = 1296 = ems of 8 point to a page.

84 pages — 2 (blank) = 82 pages of composition. 1296 ems to a page × 82 pages of composition = 106,272 = ems in the book.

APPROXIMATE NUMBER OF WORDS IN A SQUARE INCH

If one counts the number of words in a given space, set in type of different sizes, he will discover that the number of words varies but little for a given size of type, and that a basis for figuring the number of pages a given amount of manuscript copy will make can be estimated.

This method enables one to form a table showing the average number of words to a square inch, in different sizes of type, set solid or two points leaded. These examples, will enable one to see how the table is prepared.

The inch square, set in 6 point, solid, contains 52 words.

The machinery in all departments is strictly up to the times, and selected to produce the finest work at the lowest possible price. In the press-room on the third floor, where the finest work is done, every press fronts a window, giving the pressman the advantage of the best light for the proper

The 2-inch square, set in 8 point, solid, contains 120 words, or an average of 30 words to a square inch.

The machinery in all departments is strictly up to the times, and selected to produce the finest work at the lowest possible price. In the press room on the third floor, where the finest work is done, every press fronts a window giving the pressman the advantage of the best light for the proper performance of his work. In the press room in the basement are the heavy and fast-running presses, the foundations of which are independent of the foundation of the building, thus securing the greatest possible speed known to flat bed presswork. In this press room are run the large edition of catalogues. The composing room is supplied with large and carefully selected fonts of all book types. Special care is given

The 2-inch square, set in 10 point solid, contains 85 words, or an average of 21 words to a square inch.

The machinery in all departments is strictly up to the times, and selected to produce the finest work at the lowest possible price. In the press room on the third floor, where the finest work is done, every press fronts a window giving the pressman the advantage of the best light for the proper performance of his work. In the press room in the basement are the heavy and fast-running presses, the foundations of which are independent of the foundations of the building, thus secur-

To determine how many pages of a given size and a given type a manuscript will take, figure in the following manner: Take any page or proof of the required size of type. Divide the number of words contained in the page or proof by the number of square inches. Multiply the number of square inches contained in the page in which the manuscript is to be set by the number of words to a square inch. The result will be the number of words that will be contained in the new page. The total number of words in the manuscript, divided by the number of words in the page, will give the number of pages required for the manuscript.

If a page set in 10 point, 24×40 picas, contains 560 words, how many pages 16×27 picas will it take to set up a manuscript of 4000 words?

$24 \div 6 = 4 =$ inches in a line. $40 \div 6 = 6\frac{2}{3} =$ inches in the length of a page.

$4 \times 6\frac{2}{3} = 26\frac{2}{3} =$ number square inches in a page.

560, number of words in a page, $\div 26\frac{2}{3} = 21 =$ number of words to a square inch of 10 point set solid.

A page 16×27 picas contains 12 square inches.

21, number of words to a square inch $\times 12 = 252 =$ words to a page.

4000, words in the manuscript $\div 252 = 16 =$ number of pages required.

If a page set in 12 point Philadelphia, 18×32 picas, contains 224 words, how many pages, each 21×36 picas, will it take to set a manuscript of 6000 words?

A page 18×32 picas contains 16 square inches. 224, number of words in a page, $\div 16 = 14 =$ number of words in a square inch.

A page 21×36 picas contains 21 square inches. 14, number of words to a square inch, $\times 21 = 294 =$ words to a page.

6000, words in the manuscript, $\div 294 = 21$ = number of pages required.

In calculating the number of pages manuscript copy will occupy, these figures may be used.

	Words to a sq. inch		Words to a sq. inch
18 point, solid	7	9 point, leaded	21
14 point, solid	11	8 point, solid	32
12 point, solid	14	8 point, leaded	23
12 point, leaded	11	7 point, solid	38
11 point, solid	17	7 point, leaded	27
11 point, leaded	14	6 point, solid	47
10 point, solid	21	6 point, leaded	34
10 point, leaded	16	5 point, solid	69
9 point, solid	28	5 point, leaded	50

The above table is approximate only.

Leaded, as here used, means an opening of lines with 2 point leads.

Different authors use words of different lengths. Also different subject matter requires words of different lengths, as scientific works are liable to require longer words than novels.

TO DETERMINE THE AMOUNT OF TYPE REQUIRED FOR A PAGE

To determine the amount of *body type* required for a given page find the number of square inches in the page, divide by four, and the quotient will be the approximate weight of type.

Find about the weight of type required for a page 16 picas by 31 picas.

16 picas $\div 6 = 2\frac{2}{3}$ = the number of inches in a line.

31 picas $\div 6 = 5\frac{1}{6}$ = the number of inches in length of the page.

$(2\frac{2}{3} \times 5\frac{1}{6}) \div 4 = 3\frac{4}{9}$ = number of pounds, approximately.

EXERCISE XXXVIII

1. How many ems of 12 point type in five square inches?
2. How many ems of 12 point type in a five inch square?

3. How many ems of 10 point type in three square inches?

4. How many ems of 11 point type in five square inches?

5. How many ems of 8 point type in a five-inch square?

6. Find the number of ems of 24 point type in a five-inch square.

7. Find the number of ems of 6 point type in six square inches.

8. Find the number of ems of 6 point type in a six-inch square.

9. Find the cost of composition, at 40 cents per 1000 ems, of a pamphlet containing twelve pages, set in 12 point Philadelphia, size $3'' \times 5\frac{1}{4}''$.

10. Find the cost, at 40 cents per 1000 ems, of a 16-page pamphlet set in 10 point Lakeside, size 16 picas by 30 picas.

11. About how much would the type weigh necessary to set a book of 200 pages in ten point Lakeside, $3'' \times 5\frac{1}{4}''$? Find value of type at 40 cents per pound, less a discount of 20%, and 5% for cash.

12. How many ems of 12 point Caslon O. S. in a page 24 picas by 42 picas? If the page is reset, same size, in 8 point Lakeside, how many ems would there be? What should be the weight of the composed page in each size of type?

13. Find the number of pounds of 10 point type required to set a page 16 picas wide and 30 lines to a page.

14. Find the cost, at 40 cents per pound, of 12 point type necessary to set a 16-page pamphlet, size 21 picas by 36 picas. Also find cost of composition at 40 cents per thousand ems.

15. Find the weight of 10 point type required to set a page 20 picas by 35 picas.

16. A catalogue page set in 8 point O. S. No. 83 is 24 picas by 42 picas. Find cost of composition at 40 cents per 1000 ems. About what would be the weight of the composed page.

17. A quotation in a page of 10 point is set in 8 point, the quotation being indented 10 points to correspond with the body; what space should be used with the 8 point quad to secure the indention? Show by lay-out.

18. An extract is set in 8 point in a page of 11 point. What space should be used with the 8 point quad to secure proper indention?

19. A page 20 picas wide contains 16 lines of 12 point, 12 lines of 10 point, and 15 lines of 8 point type. Find number of ems to the page, also its length.

20. Find the average number of words per square inch, having given the following data:

Measure 16 picas; 10 point type set solid.

1. Manuscript 562 words. Set 71 lines.
2. Manuscript 495 words. Set 70 lines.
3. Manuscript 612 words. Set 73 lines.
4. Manuscript 494 words. Set 68 lines.

Compare result with data given in table above.

21. Compute number of words per square inch when set in 14 point modern, leaded; the following data being given:

Measure 25 picas.

1. Manuscript 282 words. Set 36 lines.
2. Manuscript 223 words. Set 32 lines.
3. Manuscript 280 words. Set 33 lines.

22. Find the cost of composition of a book containing 12,536 words, set in 12 point Philadelphia, solid, at 40c per 1000 ems. The size of page is 20×37 picas.

23. In three pages, each 30×18 picas, set in 12 point Cheltenham wide, double leaded, there are 419 words. Find the average number of words to a square inch.

24. There are 536 words in two paragraphs, one 27×42 picas, and others $42\frac{1}{2} \times 42$ picas, set in 14 point modern, 8 point leaded. Find the average number of words to the square inch.

HOW TO DETERMINE NUMBER OF LEADS REQUIRED FOR A GIVEN PAGE

Multiply the width of the given page (in inches) by one less than the number of lines of type and the result will be the running length of leads to the page. Divide the running length of leads by 144 for 2 point leads, 96 for 3 point leads, and 288 for 1 point leads, and the result will be the number of pounds of leads required for the page.

Find the number of pounds of leads required for a page set in 12 point type; the page is 18 picas wide, and there are 31 lines to a page, 2 point leads.

18 picas $=3$ inches, width of page.

31 lines of 12 point type to a page.

$31-1=30$ leads to a page.

30×3 inches $=90$ inches, running length of leads to the page.

$90 \div 144=\frac{5}{8}$ pounds the required weight of leads to the page.

EXERCISE XXXIX

1. Find the cost, at 22 cents a pound, of leads required for a 64-page pamphlet, set in 8 point type, the page is 16

picas wide, and there are 31 picas to the page, 2 point leads.

2. Find the cost, at 15 cents a pound, of leads required for an 8-page pamphlet, set in 18 point type: the page is 24 picas wide and there are 39 lines to a page, 3 point leads.

3. Find the cost of spacing, 8 points between lines, 32 pages set in 14 point modern, measure 42 picas, 29 lines to a page. Leads and slugs cost 15 cents per pound. Determine the length of the page.

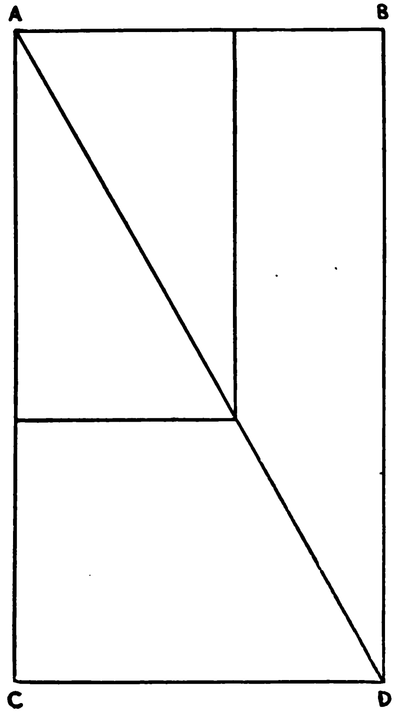
4. A page in 14 point is leaded six points, measure 25 picas, 21 lines to a page. Determine the length of the page—also weight of slugs to a page.

5. Find the number of pounds of 2 point leads required for a book containing 500 pages, measure 36 picas, with 49 lines to a page.

TO DETERMINE A WELL PROPORTIONED PAGE

To obtain the proper proportion, a general rule is that the diagonal of any page should be twice the width of the page. This rule will hold for pages from 15 to 25 picas wide. In narrower measure the length may be slightly increased, and for wide set pages decreased so as to give the page a squarer appearance. When applying the above rule the running head should be included in the length of the page. The folio, when at the bottom of a page, is not included in the length, being placed in the margin.

In the diagram, let AB be the width of the page and AB and AD be the diagonal, to determine the length AC. First method: by measurement, with a line gauge measure off a diagonal length of the composed type in a galley equal to twice its width of the proposed page, or the length of the lines, as AD, then measure from the point D to B which



will be the length of the page required. Second method: by computation, square the width of the page also the diagonal of the page, then extract the square root of the difference of the squares, and the result will be the length required.

If a page is 18 picas wide, what should be the length to have it well proportioned?

18 picas = width of the page.

18 picas $\times$ 2 = 36 picas, the diagonal of the page.

$18^2 = 324.$

$36^2 = 1296.$

$1296 - 324 = 972.$

$\sqrt{972} = 31$ picas = length of the page.

EXERCISE XL

1. If a page is 20 picas wide, what should be the length in order to be well proportioned?

2. A page is 25 picas wide and 35 picas long. Is it well proportioned? Why?

3. How many ems in a well proportioned page set in 12 point Philadelphia, whose diagonal is 32 picas?

4. How many nonpareils in a well proportioned page, 20 picas wide?

5. Which page has the larger number of ems, a well proportioned page 15 picas wide, set in 6 point, or a page whose diagonal is 50 picas set in 12 point.

6. A page set in 12 point is 24 picas wide. Find length of a well proportioned page, and compute cost of composition at 40 cents per 1000 ems.

7. If a given page is set 16 picas wide what should be its length in order to have proper proportion? How many ems of 10 point type, set solid, would it contain?

WEIGHT OF TYPE IN EACH BOX

In ordering sorts *always* send a capital H and a lower-case m of the font to be matched. These letters should be sent no matter what the characters are that one wishes to match.

The following table shows what each box in the ordinary news case will hold:

a c d i s m n h o u t r boxes, each hold	2	pounds
f b l v g y p w boxes, each hold . .	15	ounces
j k z x q and all figure boxes, each hold	6	ounces
e box holds	3	pounds
Cap and small cap boxes, each hold .	5	ounces

For reference only, not to be memorized.

Six point type averages eight original package lines to a pound; 8 point, 6 lines; 10 point, $4\frac{4}{5}$ lines; 12 point, 4 lines. A type founder's paging galley is 36 picas wide.

HOW TO SET A TABLE

Given the following table to set in a measure of 18 picas:

NUMBER	APPROX. LINKS IN 10 FEET	WORKING STRAIN AT 200 FEET PER MINUTE	MAXIMUM SPEED FEET PER MINUTE	WILL RUN ON SPROCKET WHEEL	LIST PRICE PER FOOT PLAIN
144	45	1300	700	2 and 62	.25
145	46	1325	700	To order	.35
146	47	1350	700	" "	.45
147	48	1400	700	" "	.55
189	49	1490	700	3 and 43	.65
192	49½	1500	700	4 and 54	.75
200	50	1650	700	6 and 40	.85

Set the above table 18 picas wide. Box heads set in six point type and body matter in 8 point. The first step necessary is to find the depth of the table. The largest box head, which is in the third column, is 5 lines deep. Five lines of

6 point type equals 30 points, allowing one 2 point leap after the parallel rule, and a 2 point horizontal rule, equal 34 points. There are 7 lines of 8 point body matter, or 56 points, plus 34 points, equals 90 points, 7½ picas, the depth of the table.

The next step is to determine the number of columns, in this case 6. Dividing 18 picas by 6, gives 3 picas for each column, providing there are no rules in the table. An allowance must be made for 5 rules of 2 points each, and 2 points for squeeze, or 12 points, 1 pica, which must be obtained from the other columns. In order not to set any of the columns in bastard or odd point measures, the best way is to take 6 points each, from the two narrowest columns, in this case the second and sixth, setting them each 2½ picas. This leaves the remaining 4 columns 3 picas each. To prove that this is correct add the number of points in the table. It will be found that:

4 columns of 3 picas each =	144 points
2 columns of 2½ picas each =	60 points
10 points allowed for rules =	10 points
2 points allowed for squeeze =	2 points
Total =	216 points or 18 picas.

NUMBER	APPROX. LINKS IN 10 FEET	WORKING STRAIN AT 200 FEET PER MINUTE	MAXIMUM SPEED FEET PER MINUTE	WILL RUN ON SPROCKET WHEEL	LIST PRICE PER FOOT PLAIN
144	45	1300	700	2 and 62	.25
145	46	1325	700	To order	.35
146	47	1350	700	" "	.45
147	48	1400	700	" "	.55
189	49	1490	700	3 and 43	.65
192	49½	1500	700	4 and 54	.75
200	50	1650	700	6 and 40	.85

REDUCING TABLES TO A GIVEN MEASURE

NUMBER	APPROX. LINKS IN 10 FEET	WORKING STRAIN AT 200 FEET PER MINUTE	MAXIMUM SPEED FEET PER MINUTE	WILL RUN ON SPROCKET WHEEL	LIST PRICE PER FOOT PLAIN
2	74	1300	700	2 and 62	.47
H4	59	1300	700	To order	.50
145	74	550	700	45 and 151	.29
148	46	1200	700	78	.40
150	55	1400	700	To order	.45
151	74	900	700	151	.33
153	79	1000	700	153	.50
158	59	1100	700	To order	.33
161	60	1500	700	" "	.62
162	73	1000	700	62 and 162	.37
N285	88	750	700	42	.36
K303	73	1250	700	To order	.49
O321½	46	2300	600	320	.76
337	30	2750	500	To order	.81
567	56	1400	700	567	.36

To reduce the above table to 18 picas, the first step necessary is to count the number of columns, in this case 6. Dividing 18 picas by 6, gives 3 picas for each column. There are 5 rules of 2 points each, making 10 points, with

2 points for squeeze, a total of 12 points to be allowed for. This space must be taken from the other columns. The proper way to do this is to take the two narrowest columns and reduce them 6 points each. In this case the second and the last columns should be reduced, leaving all other columns 3 picas wide, except the second and last which will be 2½ picas each. The width of table after allowing for rules and squeeze will then be 18 picas.

NUMBER	APPROX. LINKS IN 10 FEET	WORKING STRAIN AT 200 FEET PER MINUTE	MAXIMUM SPEED FEET PER MINUTE	WILL RUN ON SPROCKET WHEEL	LIST PRICE PER FOOT PLAIN
2	74	1300	700	2 and 62	.47
H4	59	1300	700	To order	.50
145	74	550	700	45 and 151	.29
148	46	1200	700	78	.40
150	55	1400	700	To order	.45
151	74	900	700	151	.33
153	79	1000	700	153	.50
158	59	1100	700	To order	.33
161	60	1500	700	" "	.62
162	73	1000	700	62 and 162	.37
N285	88	750	700	42	.36
K303	73	1250	700	To order	.49
O321½	46	2300	600	320	.76
337	30	2750	500	To order	.81
567	56	1400	700	567	.36

ARITHMETIC AS APPLIED TO PAPER

The manufacture of paper was introduced into southern Europe about 1100 by the Moors. The first mill in England was built about 1600 and the first one in America was built at Germantown, Pa., in 1690. In all these mills paper was manufactured by hand. The first machine for the manufacture of paper was built in Paris about 1800.

Paper is manufactured from various subtances, and, whether made from rags or wood, depends upon vegetable fiber for its substance and base. The better grades are produced from linen or cotton rags, linen producing the best. The steps in the manufacture, whatever the materials used, from the pulp to the finish, are practically the same.

Print paper, used largely for newspapers, the cheaper magazines and catalogues, directories and various other publications, all of which are short lived in character and used in large quantities, is made almost wholly of wood. The base, composed of about twenty-five per cent chemical wood pulp, furnishes the fiber which carries the remaining seventy-five per cent, ground wood. The cheapness of the material used in the product and the small expense of manufacture, owing to the lack of finish, makes the cost of the paper small.

Print paper is used principally on rotary perfecting presses, and comes in rolls varying in width and of a weight varying from 100 pounds to about 2000 pounds. These rolls come direct from the paper machines.

Print paper is also obtainable cut to certain sizes and sold in reams. It is usually shipped folded.

The finishes used for book papers are machine finish (designated as M. F.), sized and super-calendered (designated as S. & S. C.), and coated in enamel.

Machine finished papers are put through the rollers or calenders of the machine once and are more or less rough.

Sized and super-calendered paper is polished by being put through super-calenders, which are stacks of alternate steel and paper rolls placed one above the other in a vertical position. The reel of paper passes between these rolls and becomes highly surfaced. S. & S. C. paper is smoother than machine finished and has a slight gloss.

Coated or enameled paper is machine finished which has been coated with a bath of white clay or other substance and received a polish. This paper is especially coated for the printing of cuts.

Paper is made in various thicknesses. It is made in rolls and cut into such sizes as are required, and counted into reams of 500 sheets each (the old ream of 20 quires of 24 sheets each, 480 sheets, is becoming obsolete).

Paper is sold by the pound. Paper of a certain thickness and a certain size weighs so many pounds to a ream.

Paper 24×36—50 lbs. means that 500 sheets, or one ream of paper 24 inches by 36 inches, weighs 50 lbs. Paper of an equal thickness or *weight* 36×48 would weigh 100 lbs. to the ream.

Certain sizes and weights of book papers are kept in stock by paper houses for the convenience of customers; but paper of any size and weight can be made to order. The usual sizes and weights kept in stock are as follows:

24×36	40, 50, 60, 70, 80 lbs.
25×38	40, 50, 60, 70, 80, 100 lbs.
28×42	50, 70, 80, 90, 100, 120 lbs.
32×34	60, 70, 80, 120, 140 lbs.

Also double sizes of 24×36 and 25×38.

Coated papers are seldom made lighter than 25×38 —60 lbs.

Writing papers, commonly called *flats*, because formerly all book papers came folded in quires that it might readily be dampened, are carried in different sizes, which are often designated by their old names as:

Demy	16×21 ins.
Folio	17×22 ins.
Double Folio	22×34 ins.
Double Cap	17×28 ins.
Royal	19×24 ins.
Medium	18×23 ins.

For a full account of manufacture of paper read: Butler, "The Story of Paper Making;" Smith, "Printing and Writing Materials;" Dawe, "Paper and Its Uses." R. W. Sindall, "The Manufacture of Paper."

TO FIND THE EQUIVALENT WEIGHT OF PAPER IN ANOTHER SIZE

A sheet of paper 17 × 22 inches contains 374 square inches. If 500 sheets (one ream) of paper 17×22 inches weighs 20 pounds, one square inch will weigh $\frac{10}{187}$ pounds.

20 pounds $\div 374 = \frac{20}{374} = \frac{10}{187}$ = pounds to a square inch.

A sheet of the same grade paper 22×34 inches contains 748 square inches. A ream would weigh 748 square inches $\times \frac{10}{187}$ pounds = 40 pounds = weight of a ream of stock 22×34 inches, on a 17×22—20 pound basis.

Multiply the weight of the given paper by the size (in square inches) of a sheet of the paper whose weight is to be found and divide the product by the size (in square inches) of the given sheet; or by proportion, the size of the given sheet (in square inches) is to the required sheet (in square inches) as the weight of the given sheet is to (x), the weight of the required sheet.

Example—If a ream of 17″×22″ paper weighs 20 lbs., find weight of a ream 22″×34″.

17″×22″ : 22″×34″ = 20 lbs. : x lbs.

$$\frac{22'' \times 34'' \times 20 \text{ lbs.}}{17'' \times 22''} = 40 \text{ lbs., weight required.}$$

Example—Stock is 24×36—20 lbs.
What is the equivalent weight in size 32×44?

24×36 = 864 sq. in.
32×44 = 1408 sq. in.
1408×20 = 28,160
$28,160 \div 864 = 32\frac{512}{864}$
24×36—20 lbs. is equivalent to 32×44—33 lbs.

In determining the equivalent weight of paper from a given basis, figure to the nearest pound, discarding fractions in the final result.

Note.—Certain paper stocks are figured to the nearest half pound.

Find the cost at $8\frac{1}{2}$ cents per pound of $5\frac{1}{2}$ reams of record bond, size 19×24, basis 17×22—20 lbs.

$$\frac{19 \times 12 \times 20}{17 \times 11} = 24 \text{ lbs. weight per ream.}$$

24 lbs. × $5\frac{1}{2}$ = 132 lbs. of stock.
$ .08½ × 132 = $11.22 = cost.

If the basis weight is 25″×38″—70 lbs. find the equivalent weight in size 32″×44″ by using the table.

To use the Table of Comparative Weights follow down the column of basis sizes until size 25×38 is found, then down the column of weights until 70 is found, then follow the line across until the column headed 32×44 is found, and the number will be the required weight, which is 104 pounds.

TABLE OF COMPARATIVE WEIGHTS

FLAT WRITING PAPERS

		16×21	17×22	18×23	19×24	17×28
16×21	14		16	17	19	20
	16		18	20	22	23
	18		20	22	24	26
	20		22	25	27	28
	22		24	27	30	31
	24		27	30	33	34
	28		31	35	38	40
17×22	12	11		13	15	15
	14	13		15	17	18
	16	14		18	20	20
	18	16		20	22	23
	20	18		22	24	25
	22	20		24	27	28
	24	22		27	29	31
	28	25		31	34	36
18×23	20	16	18		22	23
	22	18	20		24	25
	24	19	22		26	28
	28	23	25		31	32
	32	26	29		35	37
	36	29	33		40	41
	40	32	36		44	46
19×24	16	12	13	15		17
	18	13	15	16		19
	20	15	16	18		21
	22	16	18	20		23
	24	18	20	22		25
	28	21	23	25		29
	32	24	26	29		33
17×28	20	14	16	17	19	
	24	17	19	21	23	
	28	20	22	24	27	
	32	23	25	28	31	
	36	25	28	31	34	
	40	28	31	35	38	

BOOK AND PRINT PAPERS

		24×36	24×38	25×38	28×42	32×44
24×36	20		21	22	27	33
	25		27	27	34	41
	30		32	33	41	49
	35		37	38	48	57
	40		42	44	54	65
	45		48	49	61	73
	50		53	55	68	81
	60		63	66	82	98
24×38	40	38		42	51	61
	45	43		47	58	69
	50	47		52	64	77
	55	52		57	71	85
	60	57		62	77	92
	65	62		68	84	100
	70	66		73	90	108
	75	71		78	97	116
	80	76		83	103	123
	100	95		104	129	154
25×38	30	27	29		37	44
	35	32	34		43	52
	40	36	38		50	59
	45	41	43		56	67
	50	45	48		62	74
	60	55	58		74	89
	70	64	67		87	104
	80	73	77		99	119
	100	91	96		129	148
28×42	40	29	31	32		48
	45	33	35	36		54
	50	37	39	40		60
	60	44	46	48		72
	70	51	54	57		84
	80	59	62	65		96
	100	74	77	81		120
	120	88	93	97		144
32×44	45	28	29	30	37	
	50	31	32	34	42	
	60	37	39	40	50	
	70	43	45	47	58	
	80	49	52	54	67	
	100	61	65	68	84	
	120	74	78	81	100	
	140	86	91	94	117	

EXERCISE XLI

1. Find the cost at $4\frac{1}{2}$¢ per lb. of 57,750 sheets of paper 28″×42″, basis 24″×36″—60 lbs.

2. If the basis is 25″×38″—80 lbs., find cost at $3\frac{3}{4}$¢ per lb. of 375,500 sheets 32″×44″.

3. Find cost at $6\frac{1}{4}$¢ per lb. of 2,457,250 sheets of paper 25″×38″, basis 24″×36″—40 lbs.

4. Find the cost $87\frac{1}{2}$ reams of paper, size 19″×24″, basis 17¢×22″—20 lbs., at $8\frac{1}{2}$¢ per lb.

5. Find cost of 375,450 sheets 25″×38″, basis 24″×36″ —40 lbs., at $3\frac{1}{2}$¢ per lb.

6. Find cost of 425,750 sheets of enameled Triumph at $7\frac{1}{2}$¢ per lb., size 32″×44″, basis 25″×36″—70 lbs.

7. What would 640,350 sheets of Record Bond, size 24″×38″, cost at $9\frac{1}{2}$¢ per lb., basis 17×22″—20 lbs?

8. Find cost at 4¢ per lb. of 2,345,625 sheets of Herald M. F., size 28″×42″, basis 32″×44″—80 lbs.

9. Find cost of $475\frac{1}{2}$ reams of Keith's linen at $10 per ream.

10. Find cost of 1,640,625 sheets of Silver Super S. S. & C. at $4\frac{1}{2}$¢ per lb., size 28″×42″, basis 25″×38″—70 lbs.

11. Find cost at 8 cents per lb. of 4500 sheets of paper, size 19″×24″, the basis weight being 17″×22″—16 lbs.

12. Find cost at 5 cents per lb. of 48,250 sheets 18″×42″, basis 24″×36″—30 lbs.

13. If the basis is 25″×38″—60 lbs., find cost at 4 cents per lb. of 250,750 sheets, 32″×44″.

14. Find cost at 8 cents per lb. of 285,250 sheets 18″×23″, the basis 16″×21″—18 lbs.

15. The basis is 17″×28″—24 lbs., find cost at 12 cents per lb. of 275,750 sheets 17″×22″.

16. Basis 24″×36″—50 lbs., find cost of 850,750 sheets 32″×44″ at 4 cents per lb.

17. Find cost of 2,450,500 sheets 28″×42″, at $3\frac{1}{2}$ cents per lb., basis 25″×38″—35 lbs.

18. Find cost of 6800 sheets 32″×44″, at 5 cents per lb., basis 24″×36″—20 lbs.

19. Find cost of 10,500 sheets 28″×42″, at 10 cents per lb., basis 17″×28″—24 lbs.

20. Find cost of 8400 sheets 16″×21″, at 16 cents per lb., basis 32″×44″—80 lbs.

21. Find cost of 7500 sheets 20″×28″, at 8 cents per lb., basis 17″×28″—65 lbs.

22. Basis 17″×22″—20 lbs., find weight of 7500 sheets $22\frac{1}{2}$″×$34\frac{1}{2}$″.

23. Find cost at $12\frac{1}{2}$ cents per lb., of 63,250 sheets $32\frac{1}{2}$″×$44\frac{1}{2}$″, the basis being 24″×36″—32 lbs.

24. Find the value of $7\frac{1}{2}$ reams of paper $28\frac{1}{2}$″×$42\frac{3}{4}$″ at $8\frac{1}{3}$ cents per lb., basis being 25″×38″—60 lbs.

25. At $16\frac{2}{3}$ cents per lb. find cost of 275,500 sheets of paper $25\frac{3}{4}$×$38\frac{1}{2}$″, the basis being 24″×36″—50 lbs.

26. The basis being 19″×24″—24 lbs., find the cost of 17,250 sheets $18\frac{1}{2}$″×$23\frac{2}{3}$″, at $6\frac{2}{3}$ cents per lb.

27. If the basis is ″17×28″—40 lbs., find weight of a ream 1″×1″.

28. The basis is 28″×42″—120 lbs., price 20 cents per lb. Find value of a single sheet.

29. A truck load of paper 22″×34″ in size, weighed 140 lbs., if the basis weight of the paper was 17″×22″—20 lbs., how many reams were there in the load?

30. How many reams of paper in a load of 4520 lbs., size 32″×44″, basis 25″×38″—70 lbs.?

TRADE CUSTOMS

To promote efficiency, uniformity and economy paper manufacturers have adopted trade customs which govern in the manufacture and sale of their product.

The following trade customs are printed for convenience in reference and to enable the student to learn to figure prices. Always consult the latest catalogues of the leading paper houses for complete up-to-date information.

WRITING PAPERS

BONDS, LEDGERS, FLAT WRITINGS AND LINEN PAPERS

This new system standardizes the thickness of papers and various sizes with the same substance number can be used with the certainty of obtaining exactly the same thickness of paper.

The basis of manufacturing will be 17×22—13, 16, 20, 24, 28, 32, 36, 40 and 44 lbs. The substance number means pounds to size 17×22. No. 20 means 17×22—20 lbs., in 17×28—25½ lbs.

In ordering odd sizes, all that is necessary is to determine the folio basis desired, then specify this folio basis, for example, substance number, together with the size of the sheet wanted and reams required.

Note: Intermediate substance numbers carry same ream price as next higher number. That is 17×22—18 lbs. will be billed as 20 lbs.

The following list shows standard sizes and weights, based on the new substance numbers of bonds and linens, flat writings and ledger papers, as adopted by the manufacturers.

SIZE	SUBSTANCE								
Nos.	13	16	20	24	28	32	36	40	44
14×34..........	16½	20½	25½	30½	35½	40½	46	51	56
16×21..........	11½	14½	18	21½	25	28½	32½	36	39½
16×26..........	14½	18	22	26½	31	35½	40	44½	49
16×42..........	23	29	36	43	50	57	65	72	79

17×22..........	13	16	20	24	28	32	36	40	44
17×26..........	15½	19	23½	28½	33	38	42½	47½	52
17×28..........	16½	20½	25½	30½	35½	40½	46	51	56
17×44..........	26	32	40	48	56	64	72	80	88
17×56..........	33	41	51	61	71	81	92	102	112
18×23..........	14½	17½	22	26½	31	35½	40	44½	48½
18×46..........	29	35	44	53	62	71	80	89	97
19×24..........	16	19½	24½	29½	34	39	44	49	53½
19×26..........	17	21	26½	31½	37	42½	47½	53	58
19×28..........	18½	23	28½	34	40	45½	51	57	62½
19×30..........	20	24½	30½	36½	42½	49	55	61	67
19×48..........	32	39	49	59	68	78	88	98	107
20×28..........	19½	24	30	36	42	48	54	60	66
20×56..........	39	48	60	72	84	96	108	120	132
21×32..........	23	29	36	43	50	57	65	72	79
21×33..........	24	29½	37	44½	52	59½	66½	74	81½
22×25½.........	19½	24	30	36	42	48	54	60	66
22×34..........	26	32	40	48	56	64	72	80	88
23×28..........	22½	27½	34½	41½	48	55	62	69	76
23×31..........	25	30½	38	45½	53½	61	68½	76	84
23×34..........	27	33½	42	50	58½	67	75½	83½	92
23×36..........	29	35	44	53	62	71	80	89	97
24×38..........	32	39	49	59	68	78	88	98	107
24×48..........	40	49½	61½	74	86	98½	111	123	135½
26×32..........	29	36	44	53	62	71	80	89	98
26×33..........	30	36½	46	55	64	73½	82½	92	101
26×34..........	31	38	47	57	66	76	85	95	104
26×38..........	34	42	53	63	74	85	95	106	116
27×40..........	37½	46	58	69½	81	92½	104	115½	127
28×34..........	33	41	51	61	71	81	92	102	112
28×38..........	37	46	57	68	80	91	102	114	125
28×40..........	39	48	60	72	84	96	108	120	132
28×42½	41½	51	63½	76½	89	102	114½	127½	140
30×38..........	40	49	61	73	85	98	110	122	134
31×53..........	57	70½	88	105½	123	140½	158	175½	193½
34×44..........	52	64	80	96	112	128	144	160	176

BOOK PAPER

Minimum basis of weight to be as follows: machine finish 25×38—45 lbs. to 500 sheets. For lighter weight the extra cost of manufacture to be added according to weight estimated, as follows:

For each pound below 25×38—45 lbs., to and including 25×38—40 lbs. to 500 sheets, three (3) cents per cwt.

For each pound below 25×38—40 lbs., to and including 25×38—30 lbs. to 500 sheets, five (5) cents per cwt.

For each pound below 25×38—30 lbs. to 500 sheets, ten (10) cents per cwt.

Super calendered 25×38—50 lbs. to 500 sheets.

For lighter weight the extra cost of manufacture to be added according to weight estimated as follows:

For each pound below 25×38—50 lbs. to and including 25×38—45 lbs. to 500 sheets, three (3) cents per cwt.

For each pound below 25×38—45 lbs. to and including 25×38—35 lbs. to 500 sheets, five (5) cents per cwt.

For each pound below 25×38—35 lbs. to 500 sheets, ten (10) cents per cwt.

Following list shows standard sizes and weights based on the new substance numbers of machine finish and super calendered book papers and adopted by the manufacturers.

Basis 25 ×38—	40 lb.	50 lb.	60 lb.	70 lb.	80 lb.	100 lb.
22 ×32..............	30	37	44½	52	59½	74
24 ×36..............	36	45	55	64	73	91
25 ×38..............	40	50	60	70	80	100
26 ×29..............	32	40	48	56	63	79
26 ×40..............	44	55	66	77	88	110
28 ×42..............	50	62	74	86	99	124
28 ×44..............	52	65	78	90	104	130
29 ×52..............	64	80	96	112	126	158
30½×41	53	66	79	92	105	132
32 ×44..............	60	74	89	104	119	148
33 ×46..............	64	80	96	112	128	160

34×44...............	63	79	95	110	126	157
35×45...............	66	83	100	116	133	166
36×48...............	72	90	110	128	146	182
38×50...............	80	100	120	140	160	200
41×61...............	106	132	158	184	210	264
42×56...............	100	124	148	172	198	248
44×56...............	104	130	156	180	208	260
44×64...............	120	148	178	208	238	296

COATED PAPER

2 — Minimum basis of weight for coated book (coated two sides) to be 25×38—70 lbs. to 500 sheets. For lighter weight extra cost of manufacture to added estimated at not less than 5 cents per 100 pounds for every pound or fraction thereof below the minimum.

3 — Minimum basis of weight for coated lithograph and label (coated one side) to be 25×38—60 lbs. to 500 sheets. For lighter weight extra cost of manufacture to be added estimated at not less than 5 cents per 100 pounds for every pound or fraction thereof below minimum.

Following list shows standard sizes and weights based on the new substance numbers of coated papers as adopted by the manufacturers.

Basis 25×38 —	60 lb.	70 lb.	80 lb.	90 lb.	100 lb.	120 lb.
24 ×36..............	55	64	73	82	91	10
25 ×38..............	60	70	80	90	100	120
26 ×29..............	48	56	63	72	79	95
25 ×40..............	63	74	84	95	105	126
28 ×42..............	74	86	99	111	124	149
28 ×44..............	78	90	104	117	130	159
29 ×45..............	82	96	110	124	137	165
29 ×52..............	96	112	126	144	158	190
30½×41..............	79	92	105	118	132	158
32 ×44..............	89	104	119	133	148	178
33 ×46..............	96	112	128	144	160	192
35 ×45..............	100	116	133	149	166	199

36×48	110	128	146	164	182	218
38×50	120	140	160	180	200	240
41×61	158	184	210	236	264	316
42×56	148	172	198	222	248	298
44×56	156	180	208	234	260	312
44×64	178	208	238	266	296	356

PRINT PAPER

Base weight for price 24×36, 32 lbs., 500 sheets soft fold. If flat and framed, 10¢ per cwt. additional. For each pound below 32 lbs. down to and including 25 lbs., 5¢ per cwt. additional. Special prices apply on weights below 25 lbs.

FOR COATED CARDBOARDS

The standard thickness of the various plys is as follows:

COATED BLANKS	
3 ply	.015
4 ply	.018
5 ply	.021
6 ply	.024
8 ply	.030
10 ply	.040
12 ply	.044
14 ply	.048

TOUGH CHECK	
3 ply	.012
4 ply	.018
6 ply	.024
8 ply	.030

THICK CHINA

.011

TRANSLUCENT

.010 to .020

RAILROADS	
4 ply	.018
6 ply	.024
8 ply	.030

Regular sizes of cardboard:

Blank 22×28 and 28×44; car sign blanks 22×42.

Post card and translucent 22×28 and $22\frac{1}{2}$×$28\frac{1}{2}$, or double these sizes.

TRADE CUSTOMS BASIS WEIGHT OF PAPER

EXERCISE XLII

1. Find the cost of $8\frac{1}{2}$ reams of paper at 5 cents a pound; the paper is M. F. 28×42, basis 25×38—35 lbs.

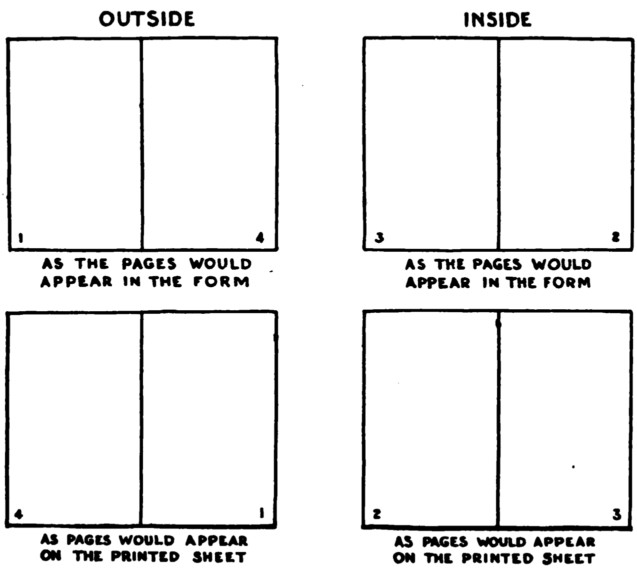
2. Find the cost at $5\frac{1}{2}$ cents per pound of $15\frac{1}{2}$ reams of S. & S. C. stock 32×44, basis 25×38—40 lbs.

3. The basis of a lot of M. F. stock is $26 \times 38 - 24$ lbs. Find cost at $5\frac{3}{8}$ cents per pound of 25 reams 32×44, less a cash discount of 5%.

TO FIND THE AMOUNT OF STOCK NECESSARY FOR A JOB

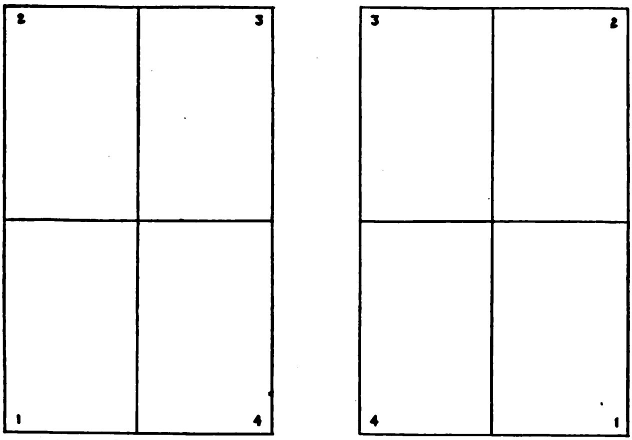
Imposition, or the proper arrangement of the pages of composed type or of the plates for printing, is not a simple thing to do, and will be considered only so far as is necessary to teach the beginner how to figure on the size of paper necessary for a given job.

FOUR PAGES PRINTED SHEETWISE



A 4-page folder may be printed from two forms of two pages each, pages 1 and 4 being printed from one form, a second form being used to print pages 2 and 3 the opposite side of the sheet. When a sheet is printed as described it is said to be printed *sheetwise*, and each printed sheet will make one folder. It will require 1000 impressions on each side or 2000 impressions to make 1000 complete folders. If, instead of printing from two forms of two pages

FOUR PAGES PRINTED WORK AND TURN



AS THE PAGES WOULD APPEAR IN THE FORM

AS PAGES WOULD APPEAR ON THE PRINTED SHEET

each, the four pages were arranged in one form and a sheet twice the size of the first sheet were used, being printed first on one side then turned end for end and printed on the opposite side, the term *work and turn* sheet is used. Each printed sheet is cut and makes two complete folders. This will require only 1000 impressions to make 1000 complete folders. It should be clearly understood that when a sheet is printed *work and turn* the form is twice the size of the form if the same number of pages were printed two forms *sheetwise*. The press is printing twice the number of pages each impression, and thus cuts the number of impressions in two.

In any regular forms the pages that fall together (the folios) will total one more than the number of pages in the form (signature) as, $1+4=5$; $3+2=5$; $1+16=17$; $8+9=17$.

The same principles are involved whether a sheet contains four pages or sixty-four pages, and it is well for the beginner to practice with four pages, both sheetwise and work and turn, until he understands the fundamental principles.

Factory waste is an allowance made for extra material used in setting machines, or preparing a form for printing; as, the allowance for make-ready on a press, or the sheets required to set a folder. The factory waste also includes the sheets spoiled incident to the handling of the job through the factory.

The amount of stock allowed is usually 50 sheets on the first 1000 and an additional 25 sheets for each 1000 after the first, up to 25,000.

Factory waste applies to ordinary book and S. & S. C. papers. There are various problems that arise with different papers that can be learned only by experience.

The following table is often used to cover factory waste, the allowance being a certain per cent of total run.

FACTORY WASTE ALLOWANCE

QUANTITY	FIRST COLOR	EACH EXTRA COLOR	BINDING
100-250	10 %	5 %	5 %
250-500	6 %	4 %	4 %
500-1000	5 %	2½%	2½%
1000-5000	4½%	2½%	2 %
5000-10,000	3½%	2½%	2 %
10,000-25,000	2½%	2½%	2 %
Over 25,000	2 %	2 %	2 %

Spoilage is material or stock ruined in the process of manufacture, and repr[illegible] a loss that must be made good by the printer, [illegible]tory waste is a legitimate item of expense in th[illegible]ture of a job.

The following exampl[illegible]ows the general method of figuring stock for a given job:

The stock for a sixty-four page catalogue is 25″×38″ —70 lbs. The pages, trimmed, are 6″×9″ and the edition is 10,000. Find number of pounds of paper necessary to order.

The usual allowance for trimming is $\frac{1}{4}$″ front and $\frac{3}{8}$″ for both top and bottom.

6″+$\frac{1}{4}$″=6$\frac{1}{4}$″ untrimmed.
9″+$\frac{3}{8}$″=9$\frac{3}{8}$″ pages.

25″×38″ size of stock.
6$\frac{1}{4}$″×9$\frac{3}{8}$″ untrimmed pages.

4 pages×4 pages on one side of a sheet.

16 pages×2=32= number of pages to a sheet.

64 pages in catalogue÷32 pages to a sheet=2= number of sheets to a catalogue.

10,000, number of catalogues × 2=20,000= the total number of sheets.

20,000 sheets ÷500 sheets=40= number reams.

70 lbs. × 40=2800 lbs. = amount of paper.

In actual practice the problem might be modified somewhat, as an allowance must be made for make-ready and spoilage. It is assumed the stock has been cut the right way of the grain to allow for the least waste in arranging pages as indicated.

EXERCISE XLII

1. If cardboard is 22$\frac{1}{2}$″×28$\frac{1}{2}$″, how many cards 4$\frac{1}{2}$″×3$\frac{1}{2}$″ can be cut from 25 sheets of cardboard?

2. How many cards, each 5″×3″ can be cut from a lot of 500 pieces of scrap stock bristol board 8″×16″?

3. An order calls for 12,000 16-page pamphlets, $3\frac{5}{8}''\times6\frac{7}{8}''$, trimmed. The ticket directs that the job shall be printed on a cylinder press, one 16-page work and turn form. How much stock will be required?

4. A certain job calls for 3500 booklets, size trimmed, $6\frac{3}{4}''\times10\frac{5}{8}''$, 16 pages and cover. The ticket calls for a press count of 3700; that it is to be printed on a cylinder press, in one 16-page work and turn form. How many sheets, and of what size, will be required?

5. Find number of sheets required to print 40,000 4-page folders, size $6''\times9''$ trimmed, one color, printed 1 w. and t. form, $12\frac{1}{2}''\times19''$. Stock $25''\times38''$—70 lbs. M. F. Usual allowance for factory waste.

6. Order stock for 20 M letterheads ($8\frac{1}{2}\times11$ inches) to be cut from Old Hamsphire Bond, size $17''\times22''$—24 lbs. and printed in two colors.

7. How much paper will be required for 9000 16-page price lists, size $7\frac{1}{8}''\times6\frac{3}{4}''$, trimmed? The stock is $17''\times28''$ —28 lbs. linen ledger, and is to be printed in two 8's, sheetwise.

8. An order for 10,000 24-page pamphlets, $4\frac{1}{2}''\times7\frac{7}{8}''$ trimmed, calls for stock $25''\times38''$— 100 lbs. If the job is printed on a cylinder press, in one 24-page work and turn form, and 300 sheets are allowed for spoilage, find number of reams of paper required.

9. An order calls for 20,000, 32-page pamphlets $6''\times9''$. If the stock selected is a $25''\times38''$—70 lbs. M. F., how much less would it cost at $3\frac{1}{2}$¢ a lb. to use a $24''\times36''$ size sheets printed two 16's sheetwise and allow no trim?

10. How much stock is required to print 3000 booklets, the following being the specifications as found on the job ticket: number of pages 24; quantity 3000; size, trimmed, 11 inches$\times$8 inches; sheets 25 inches$\times$38 inches; Snow

White enamel, press count 3500; to be run two 8-page sheetwise, one 8-page w. and t.

11. Find the amount of stock necessary to print 12,000 catalogues, the following being the specifications: 16 pages, size trimmed $6'' \times 6\frac{7}{8}''$; stock $25'' + 38''$; white antique; cylinder, one 16 page w. and t. form.

12. Find the cost at 7¢ per pound of stock necessary to print 5000, 32 page booklets, size trimmed $6'' \times 9''$, stock $25'' \times 38''$ — 80 lbs. White Enamel, press count 5300, to be run in two 16's sheetwise.

13. Find the amount of stock required for 175 M copies of a 32-page pamphlet, size $6'' \times 9\frac{1}{4}''$ trimmed; Run as two 16's sheetwise.

14. Find cost of body-stock necessary for 10,000 side stitched books printed in one color, size $6'' \times 9''$ trimmed, set in ten point solid, 23 ems wide, 38 ems long, having 50,000 words, manuscript copy. Use stock 80 lbs. basis at 6¢ per lb. Allow 5% for factory waste.

15. Find the amount of cover stock necessary for an order of 10,000 16-page pamphlets, cover to overlap $\frac{1}{4}$ inch, body $6'' \times 9''$ trimmed. To be printed on page 1 in 4 impressions. Wire stitched, saddlewise, size of sheet $20'' \times 25''$. Usual allowance for spoilage, in 4 impressions.

16. The body of the same booklet is printed from one 16-page work and turn form, in black with a tint border, on 25×38—70 lbs. Velvo Enamel, which sells at \$.07$\frac{1}{4}$. Find cost of the stock.

17. Find the amount body stock necessary for an issue of 25,000 28-page booklets, trimmed size $5\frac{1}{4}'' \times 7\frac{1}{2}''$. Printed two on from two 32-page work and turn forms on special $44'' \times 64''$ — 90 lbs. stock. Find the amount and cost of the stock at \$.05.

18. In estimating on the booklet in problem 16 the sales-

man figured the stock as 25″×38″—60 lbs. This enamel stock is not made in such light weight and the 25″×38″—70 lbs. had to be substituted. What was the loss on the stock?

19. For an issue of a 24-page price list, pages 6″×9″ trimmed, 25,000 to be printed, what stock size of M. F. book paper would you use? Would you print it w. and t. or sheetwise? How many reams of the stock selected would you order?

20. Find the cost of the body stock in an issue of 500 of a 16-page booklet, size of pages 5″×8″ trimmed, to be printed on Japanese paper 22×34—40 lbs. (20¢ a pound).

ROLL STOCK

To find the number of impressions that can be made from a roll of paper on a rotary press, having given the gross weight of the roll; the tare, including the core weight, the wrapper, the white waste and the core waste; the width of the roll; the circumference of the cylinder; and the basis weight.

If a 57 inch roll weighs 1217 pounds gross and the core weighs 25 pounds, the wrapper 17 pounds, the white waste 9 pounds, the core waste 3 pounds, how many impressions, each 57×45½ inches, can be made from the roll?

The stock basis is 25×38 inches—30 pounds.

1217 (gross) — (17+25+9+3 tare) = 1163 (net)

$$\frac{57\times91\times30}{25\times38\times2}=82=\text{weight per ream}$$

1163÷82 = 14.183 reams

14183×500 = 7092 impressions

$$\frac{1163\times1000}{82\times2}=7092 \text{ impressions.}$$

EXERCISE XLIII

1. If a 33″ roll weighs 787 pounds and the core weighs 19 pounds, the wrapper weighs 14 pounds, the white waste

weighs 4 pounds, the core waste 2 pounds, how many impressions each $33'' \times 45\frac{1}{2}''$ can be made from the roll?

The stock basis is $25'' \times 38'' = 26$ pounds.

2. How many impressions each $35'' \times 45\frac{1}{2}$ can be made from a 35″ roll weighing 831 pounds?

The core weighs 20 pounds.
The wrapper weighs 11 pounds.
The white waste weighs 4 pounds.
The core waste weighs 2 pounds.
The stock basis is $24'' \times 36'' - 25$ pounds.

3. Stock basis of the following 37″ roll is $25 \times 38 = 38$ pounds.

Gross weight 837 pounds.
Core weight 21 pounds.
Wrapper 15 pounds.
White waste 7 pounds.
Core waste 2 pounds.

How many impressions, each $37'' \times 45\frac{1}{2}$, can be made from the roll?

4. If a 51″ roll weighs 1197 pounds gross, the core weighs 22 pounds, the wrapper weighs 18 pounds, the white waste weighs 7 pounds, the core waste weighs 5 pounds, how many impressions each $51'' \times 68\frac{1}{4}''$ can be made from the roll?

The stock basis is $24'' \times 36'' = 25$ pounds.

5. How many 32 pp. sigs. can be made from a 38″ roll weighing 824 pounds gross?

Wrapper weighs 18 pounds.
Core weighs 20 pounds.
White waste weighs 7 pounds.
Core waste weighs 2 pounds.
Circumference of the cylinders is $45\frac{1}{2}''$.
Stock basis is $24'' \times 36'' - 50$ pounds.

6. How many impressions, each $34'' \times 45\frac{1}{2}''$ can be made from a roll weighing 859 pounds?

Tare weight is 19 pounds, the wrapper weight is 11 pounds, the white waste weight is 4 pounds, the weight of core waste is 2 pounds.

Stock basis is $24'' \times 36'' = 34$ pounds.

7. If a $51''$ roll weighs 987 pounds, how many impressions, each $51'' \times 70''$, can be made from the roll?

Stock basis is $24'' \times 36'' - 19$ pounds.
Core weighs 21 pounds.
Wrapper weighs 14 pounds.
White waste weighs 9 pounds.
Core waste weighs 3 pounds.

8. If a roll is $34\frac{1}{2}''$ wide and the stock basis is $25'' \times 38'' = 33$ pounds.

How many impressions each $34\frac{1}{4}'' \times 70''$ can be made from the roll?

Core weighs 17 pounds.
Wrapper weighs 9 pounds.
W. waste weighs 5 pounds.
Core waste weighs 2 pounds.

9. The basis weight of New York class stock is $24'' \times 35'' = 25$ pounds. How many impressions, each $37'' \times 45\frac{1}{2}''$, can be made from a roll weighing 839 pounds? The core (or tare) weight is 20 pounds, the wrapper weight 12 pounds, the white waste 3 pounds, and the core waste 5 pounds?

10. How many impressions, each $52\frac{1}{2}'' \times 68\frac{1}{4}''$, can be made from a roll weighing 978 pounds?

Wrapper weighs 18 pounds. White waste 11 pounds.
Core waste 5 pounds.
Tare is 20 pounds.
Stock basis is $24'' \times 36'' = 25$ pounds.

ARITHMETIC AS APPLIED TO BOOKBINDING

The art of fastening together and enclosing the leaves of a book, for use and preservation, is called bookbinding. The art has been practiced for many centuries. Even before the invention of printing the written or lettered pages were fastened together and enclosed in covers of wood, or of parchment.

The practice of binding books in the style now used originated in the fourth century. The old way of fastening a manuscript to two pieces of wood and winding it in a roll was found to be too bulky for the great libraries that princes and rulers of the Middle Ages were fond of collecting.

The first flat books had wood or ivory covers, richly carved and inlaid with jewels, consequently such volumes were of fabulous value. When leather was adopted for the covering of books, heavy skins, capable of elaborate decoration, were used and continued in use up to the beginning of the nineteenth century. These handsome books were bound with careful attention to each volume; they were therefore very costly.

Paper was substituted for the vellum and parchment (upon which the contents of books had been written) about the thirteenth century, and then, in 1786, substitutes for fine leather binding were found. Instead of goat or pigskin, tanned by slow processes in oak or sumac, or rare imported skins, prepared for use by the primitive but effective methods of the far East, cheap sheepskins, split into several layers and tanned quickly in strong acids, were grained in imitation of finer leathers, such as Morocco or seal. Acids were again used for cleaning and bleaching, and the skins were then dyed in brilliant colors. These became very popular. When, in 1850, coal tar dyes were discovered, they were used for coloring skins, with further weakening effect upon the fibers of the leather.

After the hair or wool has been removed by means of lime from the hides, acids are often used for tanning when large quantities are needed. Tanbark is still used in many parts of the country, and for very careful work, the old processes of oak, sumac, or a mixture of both, are still found to give the greatest satisfaction. Cowhide, sheepskin, calfskin and goatskin are all treated in this way. After tanning, the hides are stretched and scraped, then often split into several layers. When the skins are split very thin, to about the thickness of heavy paper, they are known as skivers. It is possible to make six layers from a cowhide or sheepskin.

There are so many finishes and imitations of leathers that only an expert can judge the kind of leather.

The following terms are applied to leathers:

Calf skins are known as calf and Russia.

Goat skin is known as Morocco.

Sheep skin is known as roan and skiver.

Leather can be impressed with a design by hand (called hand-tooling) and is then, like all hand work, very expensive. A method that is faster and nearly as effective, consists of placing the leather cover in a stamping machine and forcing hot brass dies into the surface. If the design is to be laid in with gold, sheets of gold leaf are placed over the flat surface before the dies are used.

The art of bookbinding has reached its highest stage in modern times, when, by use of machinery, many books, cheaply but serviceably bound, form the widely circulated product of a twentieth century bookbinding establishment.

Modern bookbinding may be grouped under two divisions: forwarding and finishing. Forwarding includes all operations necessary to the preservation of a book, and finishing, the operations pertaining to the ornamentation of the volume.

When cloth coverings came into use, and books could be bound cheaply in quantities, book-binding attained its greatest utility. In fact, until books were printed on cheap paper on high-speed presses and quickly bound in cloth or paper by the highly perfected machinery of a large commercial bindery, widespread education was an impossibility. On the other hand, in the wonderful volumes of the Middle Ages, and in the leather bound books that are carefully put together by the improved methods of the present time, bookbinding became and is still a fine art.

The material for the binding of books in most common use is cloth, which in a strong, stiff weave, can be provided cheaply, but at the same time in highly attractive effects. Cloth used in bookbinding comes in rolls of about 40 yards, and in different widths, 38 inches being standard width. There are various finishes and patterns, linen and silk being the most used. Pattern cloths cost more than the plain of the same grade.

Binder's board is a heavy cardboard, usually made from old rope, and is used for the covers of books. It is made in different thicknesses, is put up in packages of 50 lbs. each, whatever the thickness, and is known by the number of sheets to a package; as, number 12 board means that 12 sheets size, 22 inches $\times$ 28 inches (medium) or 20 inches $\times$ 30 inches (D. C., Double Cap) would weigh 50 pounds, and also the sheet is .177 inches in thickness or calipers .177 points.

The following are the principal numbers and the caliper of each in the two sizes:

No. 20	.108
No. 25	.084
No. 30	.070
No. 35	.060
No. 40	.056
No. 45	.050
No. 60	.036

THE PROCESS OF BINDING

Modern bookbinding may be grouped under two divisions: forwarding and finishing. Forwarding includes all operations necessary to the preservation of a book, and finishing, the operations pertaining to the ornamentation of the volume.

The bindery usually receives the printed sheets from the press room, flat. Each sheet is called a section or a signature, and is marked by signature marks placed at the lowest folio or page number, or by a collating mark at the back.

The counted sheets allow a certain amount for factory waste — usually 2% of the number of sheets.

The first operation in the bindery is folding the flat sheets into page size. This can be done by hand or on one of several kinds of folding machines, that can be adjusted to many different folds. The signatures are then bundled, which ejects the air and takes out the impression. The next step is to gather the signatures, that is, the separate sections are collected to form a volume, which is examined or collated for sequence of signatures. The end sheets,— the sheets that fasten the volume to the inside of the covers,—are tipped or sewed on the first and the last signatures.

The gathered volumes are sent to the smashing machine, where the signatures are pressed into the smallest desirable space to make the volumes. This also smooths out any wrinkles, and makes the unbound volumes more compact. Sewing is the next operation in the binding of a book, and this is done on thread machines that firmly fasten the sheets together, and if greater strength is needed sews bands of tape across the backbone to fasten to the cover. For large, heavy books or flexible books, tapes are important in adding strength to the binding.

After sewing, the volumes are trimmed to size. If the books are to be gilded, they are sent directly from the trimmer to the gilding room, where they are placed under heavy pressure, the edges scraped, then dampened with a sizing and laid over with sheets of gold leaf. After the gold leaf is thoroughly dried onto the surface it is rubbed in and burnished. Books may be gilded on one edge, but the more expensive volumes are gilded on three sides, unless the sheets have a deckle edge.

After trimming or gilding, according to the quality of the volumes, the books are sent to the rounding and backing machine. The backs are coated with glue and when dried are fed into this machine, which rounds them at back. Short strips of tape or cloth (called headbands) are pasted at each end of the backbone, and a strip of gauze, called super, is glued on. Sometimes another lining of paper is added for strength. The volumes are then ready for covers, so are sent to the casing-in machine.

Meanwhile the cases or covers have been prepared on the automatic case-making machine. This machine feeds the boards, while an operator feeds the cloth coverings.

The machine glues the cloth over the boards, presses and delivers the cases. Sometimes a strip of cardboard is glued to the backbone at the same operation. The case is passed under a stamping machine, where, by means of brass dies, the title of the book and any required design is blind-stamped into the surface. The covers are sized, laid over with gold leaf or foil, and stamped again. After the cases have been rubbed off, the design appears in gold. If the title is intended to appear in ink, the cases are printed on a job press. The covers are now ready for the casing-in machine.

The cases are stacked in the casing-in machine, where the volumes are fed to the same machine, which pastes the end sheets, and delivers the books. The cased books are placed in layers in a press, and allowed to stand until thoroughly dry. After removing from the press, the books are examined, and the defects, if any, are repaired. The finished books are wrapped, and are then ready for delivery.

If the books are to be bound in leather, the covers are made in a different manner. Skins, tanned and dressed, such as cowhide or Morocco, are cut to the size required; a skin may render several covers, depending upon the size of the skin and of the cover. The edges of the side to be turned in are skivered (shaved thin) to allow for flat folding at the edges and corners. The leather then is pasted on to boards by hand, turned and rolled. A strip of cardboard is placed at the backbone, and in some cases, especially in foreign bound books, heavy cording is laid in short strips at the back, crosswise. This gives the raised band effect. The case is fastened to the body of the book in the same way as the cloth cover, unless the book is one of a de luxe edition, bound in soft leather, with pliable covers, in which case the binding is all made and put on by hand.

Find the cost of binding an edition of five thousand textbooks, with the following specifications:

Number, 5000.
Pages, 256, size 5×7 inches, trimmed.
Full cloth, 12¢ a yard.
Board, Number 35.
Signatures, 8, 32 pages.
Printed sheet 22×32—50 lbs.
Sew in 32's, regular.
Headbands, yes, same as cloth.
Back, round, yes.
Re-inforce, yes, with muslin.
End sheets, plain, 38×50—170 lbs.
Supers, yes.
Trimmed, all round.
Cases, full cloth.
Cased-in, loose back.
Backbone and side stamped.
Ink, black.
Wrapped in 5's.
Printed jackets furnished.
Allowance for dies, $10.00.

OPERATIONS

The first step is to fold the sheets, 8, 32's at 60¢ a thousand signatures.

Tip end sheets on first and last signatures at 80¢ a thousand signatures.

Gather signatures at 25¢ a thousand.

The gathered books are smashed at 75¢ a thousand books.

Smyth (regular) sewed with linen thread, at $4.00 a thousand books.

The books are trimmed at $1.00 a thousand.

The books are rounded and backed at $2.00 a thousand.

The backbones are re-inforced with a strip of gauze (super), two headbands and paper lining are placed on, the whole operation being known as headbanding and lining; the charge is $4.00 a thousand books.

The volumes are now ready for the covers (cases), which have been prepared and stamped, ready for the volume.

The cases for a 5×7 inch book will be $12\frac{1}{2} \times 9$ inches; this includes backbone and turn-in for edges.

The operations in case-making are cutting and preparing the material used, at $1.50 a thousand books. The cloth used comes in rolls 38 inches wide and 40 yards to a roll. It will cut three cases ($12\frac{1}{2} \times 9$ inches) the width of the cloth to a roll, and four case-lengths (9 inches) to a running yard, or each running yard of cloth will make twelve cases. The price is 12¢ a yard.

Number 35 board is used, the size is $4\frac{7}{8} \times 7\frac{1}{4}$ inches for each piece; and will cut, from a 20×30 inch board, 16 pieces to a board. There are 35 boards to a bundle and 16 pieces to a board. Two boards are used for each book. The price is $1.00 a bundle.

The cases are made up on a case-making machine, which glues the cloth to the two boards and also glues a strip of lining paper to the back. The charge is $3.00 a thousand.

The cases are stamped in ink, one color, on a stamping press, with two impressions, at $1.25 a thousand.

The cases are now ready for the casing-in machine, which fastens the cases to the volumes by pasting the end sheets to the inside of the cases, and is the last operation of actual binding. The charge is $3.00 a thousand.

The volumes are then placed in presses between brass bound boards, to make the joints, and remain in the presses from 12 to 36 hours, and are then released, examined and wrapped.

The examining and wrapping cost, respectively, $1.50 and $2.50 a thousand. These operations complete the bindery work on these or similar books. Find the cost of binding with the data given.

Folding at 60¢ a thousand signatures.

256÷32 pages to a signature equals 8 signatures to a book.

5,000×8=40,000 signatures in 5,000 books.

40×$.60=$24.00—cost of folding.

Tipping end sheets on first and last signatures at 80¢ a thousand.

5×2×80¢=$8.00—cost of tipping.

Gathering signatures at 25¢ a thousand.

5×8×25¢=$10.00—cost of gathering.

Smashing at 75¢ a thousand.

5×75¢=$3.75—cost of smashing.

Sewing with linen thread at $4.00 a thousand.

5×$4.00=$20.00—cost of sewing.

Trimming at $1.00 a thousand.

5×$1.00=$5.00—cost of trimming.

Rounding and backing at $2.00 a thousand.

5×$2.00=$10.00—cost of rounding and backing.

Headbanding and lining at $4.00 a thousand.

5×$4.00=$20.00—cost of headbanding and lining.

Cutting and preparing material used at $1.50 a thousand.

5×$1.50=$7.50—cost of cutting and preparing material.

12 cases to a yard of cloth at $.12 a yard.

5000÷12×$.12=$50.04—cost of cloth.

16 pieces or 8 covers can be cut from each board and there are 35 boards to a bundle at $1.00 each.

$8 \times 35 = 280$ covers that can be cut from one bundle.

$5{,}000 \div 280 \times \$1.00 = \$18.00$—cost of board.

Case-making at $3.00 a thousand.

$5 \times \$3.00 = \$15.00$—cost of case-making.

Printing covers at $1.25 a thousand.

$5 \times \$1.25 = \$6.25$—cost of printing covers.

Casing-in at $3.00 a thousand.

$5 \times \$3.00 = \$15.00$—cost of casing-in.

Examining at $1.50 a thousand.

$5 \times \$1.50 = \$7.50$—cost of examining.

Wrapping at $2.50 a thousand.

$5 \times \$2.50 = \$12.50$—cost of wrapping.

40×	$ .60=	$24.00—	Cost of folding.
10×	.80=	8.00—	" " tipping.
40×	.25=	10.00—	" " gathering.
5×	.75=	3.75—	" " smashing.
5×	4.00=	20.00—	" " sewing.
5×	1.00=	5.00—	" " trimming.
5×	2.00=	10.00—	" " rounding and backing.
5×	4.00=	20.00—	" " headbanding and lining.
5×	1.50=	7.50—	" " preparing material.
417×	.12=	50.04—	" " cloth.
18×	1.00=	18.00—	" " board.
5×	3.00=	15.00—	" " case-making.
5×	1.25=	6.25—	" " printing covers.
5×	3.00=	15.00—	" " casing-in.
5×	1.50=	7.50—	" " examining.
5×	2.50=	12.50—	" " wrapping.
		10.00—	allowance for dies.

$\$242.54 \times 2\frac{1}{2}\% = \$6.06$ factory waste.

$\$242.54 + \$6.06 = \$248.60$—total bindery cost.

EXERCISE XLIV

1. Ooze leather costs 27¢ per sq. foot. How much will it cost to cover 1000 books, size of cover allowing $\frac{1}{8}$ inch turn in at each edge, 7×10 inches. Allow 50% for waste in cutting leather.

2. If a book covering is $12\times18''$ flat, how much will 2500 copies cost bound in calf at 16¢ per square foot? Allow 50% for waste in cutting.

3. Buckram comes in rolls 40 yards long, 38 inches wide, at $12\frac{1}{2}$¢ per yard. It is to be used for covering an edition of 10,000 school books. Size of cover, including turn-in, flat, 9×11 inches. Find the cost of the buckram.

BINDERY WORK ON JOBS OTHER THAN BOOKS

There are two great classes of bindery work. Bound books, with the various stages of work leading up to the actual casing; and work on pamphlets, folders, and magazines, which is a purely modern development of this art. Take, for instance, an eight-page folder without cover. It has been printed in the job room with two forms, sheetwise, delivered to the bindery in flat sheets, size seventeen by twelve inches on sized and super-calendered stock. In the bindery it is called an eight page form. There are to be five thousand folders, so the pressroom delivers fifty-one hundred sheets, which allows two per cent for spoilage. On a large, more complicated job, the spoilage would be greater. The first operation is folding. This particular job will be run on a folder and be folded twice. At the rate of eight hundred per hour, it will take six and one-half hours to fold this job. The cost of this kind of folding is thirty-five cents per hour. The next step is stitching.

It will be saddle stitched with wire, on a wire stitcher, at the rate of one thousand per hour, and can be stitched in five hours, at the cost of forty cents per thousand. It is now ready for trimming. This single operation can be performed in three and a quarter hours, cutting fifteen hundred an hour at forty cents per thousand. The job can then be delivered to the shipper for packing.

If a smaller number is ordered, the job can be folded by hand, but the other operations are the same as above. If a thicker pamphlet is required, it will be side stitched, but it is then generally inserted within a cover. A covered pamphlet requires more operations, for the cover must be folded separately from the body, but when the job is stitched and inserted, the body and cover are trimmed together, as a rule.

Fold 3,000 sheets, 12×17", delivered from job pressroom to the bindery, into an 8-page pamphlet without cover. Allow 2% for spoilage. Hand folded at rate of 500 per hour, at a cost of 30¢ per thousand; stitched at 900 an hour, at the cost of 40¢ per thousand; trimmed at 1500 per hour, at 30¢ per thousand. If there is one half hour between each operation, what was the time occupied by the job in the bindery? What was the cost?

3,000 – 1.02 = 3060 sheets, press count.
500 per hour folded by hand.
3060 ÷ 500 = 6.12 hours folding.
30¢ per thousand cost of folding.
30¢ × 3.06 = \$.918 or \$.92 cost of folding 3060 sheets.
3060 ÷ 900 = 3.3 hours required for stitching.
40 per 1000 cost of stitching.
40 × 3.06 – \$1.22, cost of stitching.
1,500 trimmed per hour.
Drop spoilage after stitching.
3000 ÷ 1500 = 2 hrs. required for trimming.

30¢ per 1,000, cost of trimming.
$\frac{1}{2}$ hour delay between operations.
3.3+6.12+2, −1=12.42 hours in the bindery.
\$.92+1.22+.90=\$3.04=cost of bindery work.

EXERCISE XLV

1. A sixteen page pamphlet, without cover, is to be folded from 5100 sheets allowing 2% spoilage. Printed from 2 forms, sheetwise, in the cylinder pressroom. Size of sheet 25×38″, size of page, 9×12″. Three folds on Dexter Folder at 1000 per hour, at 25¢ per 1000. Saddle wire stitched at 1200 an hour, at 45¢ per 1000. Trimmed at the rate of 1500 per hour, at 40¢ per hour. Make layout. What was the cost of bindery work?

2. A man at a Sheridan Cutter can trim 10 magazines in 20 seconds. Allowing 40 minutes for adjusting machine, how many magazines can he trim in 9 hours, if he is 89% efficient.

3. If a Dexter Feeder can run off 2000 signatures per hour, how long will it take to run off 2000 complete books counting 24 signatures to a book? Allow $\frac{1}{2}$ hour for adjusting machine.

4. Fold 12,360 sheets, 32″×44″, delivered from cylinder pressroom to bindery. Two 16-page forms, or 32 sheetwise. 32 pages and cover, saddle wire stitched and trimmed. Cover delivered from Gordon room. Insert 32's into cover. Folded as one 8-page on Dexter Feeder, 1200 an hour, at 45¢ per 1000. Cover, 1 fold, 1000 an hour at 15¢ per 1000. One insert, 1000 per hour, at 15¢ per 1000. Wire stitched at 45¢ per 1000, at the rate of 1200 per hour. Drop spoilage after stitching. Trimming 1000 per hour, at 40¢ per 1000. Find length of time in bindery, allowing 1 hour delay and cost.

5. A Dexter Folding Machine can fold at the rate of 2500 per hour. Allowing 5% make-ready at the beginning, and 3% spoilage at end of the run, how many signatures will there be at the end of a 3½ hour run?

6. The press count of a job is 10, 250. Delivered to the bindery in sheets 25″×38″, to be folded into a booklet and inserted within a cover. If it was printed in two 8-page forms, sheetwise, how many pages will there be in the booklet? Folded at the rate of 1000 per hour; stitched at 1800 per hour; inserted at 1200 per hour; and trimmed at 1200 per hour; how long was the job in operation?

7. What is the cost of side stitching a job of 20,600 sheets folded into 32-page booklets at 2000 per hour; 3% allowed for spoilage; charged at the rate of 50¢ per hour?

8. How long will it take to insert the same job within a cover at the rate of 1000 an hour if 3% is deducted after the stitcher's spoilage?

9. A Dexter Folder folds 2100 sheets per hour. If 10% is spoiled (enameled stock), and 40 minutes are lost setting the machine, how many sheets will be folded at the end of a 9-hour day?

10. A Boston Wire Stitcher can side stitch 7200 pamphlets in a 9-hour day. If there is 5% spoilage and 30 minutes delay, how much is the average output per hour, if the machine is running at 92% capacity?

11. What is the cost of an 8-page pamphlet, without cover, folded at the rate of 1000 per hour, at 45¢ per hour; stitched at 30¢ per 1000; trimmed at 35¢ per 1000; 20,500 sheets delivered from Gordon room; allow 2½% spoilage, which is dropped after stitching?

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