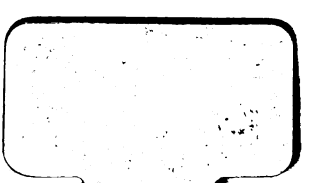


A SYSTEM OF

# PRACTICAL ARITHMETIC,

ADAPTED TO THE USE OF SCHOOLS;

CONTAINING

## THE FUNDAMENTAL RULES,

AND THEIR APPLICATION TO

MERCANTILE, COTTON SPINNING, MANUFACTURING, AND MECHANICAL CALCULATIONS.

ALSO COMPREHENDING

NUMEROUS RULES AND EXAMPLES

IN THE VARIOUS DEPARTMENTS OF

*COTTON SPINNING AND MECHANICS;*

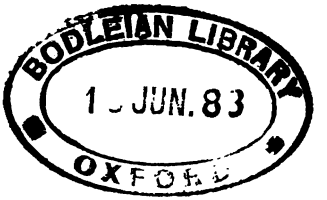
USEFUL TO

COTTON SPINNERS, MILLWRIGHTS, ENGINEERS, AND ARTISANS IN GENERAL.

CONTAINING CONSIDERABLY MORE INFORMATION UPON THOSE SUBJECTS THAN HAS EVER BEFORE BEEN PUBLISHED IN ANY TREATISE ON ARITHMETIC.

BY SAMUEL YOUNG.

DERBY:
Printed for the Author by
HENRY MOZLEY AND SONS;
AND SOLD IN LONDON BY COWIE AND CO. POULTRY;
AND IN MANCHESTER BY W. AND W. CLARKE.
*Price Four Shillings and Sixpence.*
1833.




*ENTERED AT STATIONERS' HALL.*

# PREFACE.

THE improvements in Cotton-spinning, Manufacture and Mechanics, have long required a change of Questions in Arithmetic, so as to connect the latter with a general information of the principles of the former; divested of technical terms and abstract matter, which often more obstruct than forward the acquirements of the Student.

A youth leaving school, and entering upon either a Cotton-spinning, Manufacturing or Mechanical situation, although a fair Arithmetician, often finds himself at a loss how to apply the Rules he has learned to the performance of Questions intimately connected with his employment; and few persons in either situation have the leisure, or the means of obtaining a Mathematical course of education, sufficient to enable them to study the more elaborate treatises on Mechanics.

The present Work has been compiled with a view to forward a general and practical information upon such subjects as are daily called for.

The elementary parts, Proportion, Fractions, Vulgar and Decimal, Partnership, Position, Progressions, Square and Cube Roots, are applied to Cotton-spinning, Manufacturing and Mechanical purposes.

The Rule for Proportion is that of *Cause* and *Effect*, and by it many apparently tedious Questions become easy; no distinction is made from Direct, Inverse, or Compound Proportion, the Rule of *Cause* and *Effect* rendering that distinction merely nominal, and Inverse Proportion is where four terms are given or implied to find a fifth.

In all cases the Rules are formed with as much brevity as is consistent with the nature of the Work: and it is presumed that the numerous Examples under each are so arranged as to convey systematic and very considerable practical informa-

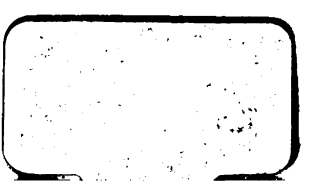
tion to the Student, whether intended for Commercial, Cotton-spinning, Manufacturing or Mechanical pursuits.

The kindness of several friends is here acknowledged, for their information on several subjects, but more particularly to Mr. J. Hill, the Architectural and Mechanical Drawing Master, London Road, for seventeen Questions connected with Mechanics; to several friends for their information in the Cotton-spinning department, and especially to Mr. J. Barnes, of Manchester, and Mr. G. Mellor, of Hulme, for their generous assistance in the arrangement of the calculations.

61, *Lever Street*,
*Manchester*, 1833.

# CONTENTS.

## ON COTTON SPINNING.



## ON COTTON SPINNING.

## MECHANICS.

A

# SYSTEM

OF

# PRACTICAL ARITHMETIC.

## MARKS OF ABBREVIATION.

+ is the sign of Addition, and signifies *added to.*
— is the sign of Subtraction, and signifies *diminished* or *lessened by.*
× is the sign of Multiplication, and signifies *multiplied by.*
÷ is the sign of Division, and signifies *divided by.*
= is the sign of Equality, and signifies *equal to.*
$\sqrt{}$ is the sign of the Square Root.
$\sqrt[3]{}$ is the sign of the Cube Root.
$\sqrt[4]{}$ is the sign of the Fourth Root.

## TABLES OF MONEY, WEIGHTS AND MEASURES.

### MONEY TABLE.

| | | | |
|---|---|---|---|
| 4 farthings | make | 1 penny, | marked *d.* |
| 12 pence . . . | | 1 shilling, . . | *s.* |
| 20 shillings . . | | 1 pound, . . . | £. |

Standard, or sterling gold, contains eleven-twelfths of pure gold and one-twelfth part of alloy. The alloy for gold coins is composed of equal parts of fine silver and copper. Hence a pound troy weight of gold contains 5280 grains of pure gold, 240 grains of fine silver and 240 grains of fine copper.

Standard, or sterling silver, contains eleven ounces two pennyweights of fine silver, and eighteen pennyweights of fine copper for the alloy. Hence one pound troy of standard silver contains 5328 grains of pure silver and 432 grains of fine copper.

The value and weight of gold and silver coin of Great Britain is

| Gold. | Value. | Weight. |
|---|---|---|
| A sovereign = | £1 0 0 ..... | 5 *dwts.* $3\frac{5}{11}$ *grs.* |
| Half sovereign = | 0 10 0 ..... | 2 *dwts.* $13\frac{7}{11}$ *grs.* |
| **Silver.** | | |
| A crown . . = | 0 5 0 ..... | 18 *dwts.* $4\frac{4}{11}$ *grs.* |
| Half crown . = | 0 2 6 ..... | 9 *dwts.* $2\frac{2}{11}$ *grs.* |
| Shilling . . = | 0 1 0 ..... | 3 *dwts.* $15\frac{5}{11}$ *grs.* |
| Sixpence . . = | 0 0 6 ..... | 1 *dwt.* $19\frac{7}{11}$ *grs.* |

Coins of foreign nations are considered merely as bullion, and are bought and sold accordingly.

### TROY WEIGHT.

24 grains, *gr.* = 1 pennyweight, marked *dwt.*
480 grains . = 20 pennyweights = 1 ounce, *oz.*
5760 grains . = 240 pennyweights = 12 *oz.* = 1 pound, *lb.*

The unit of all weights used in England is a grain of wheat, taken out of the middle of the ear and thoroughly dried.

By this weight gold, silver, jewels, &c. are weighed: the strength of spirituous liquors and philosophical experiments, and the number of hanks of yarn in one pound are ascertained.

### DIAMOND WEIGHT.

4 troy grains . . = 1 carat.
5 diamond grains = 4 troy grains.
150 diamond carats = 1 ounce troy.

### APOTHECARIES' WEIGHT,

*Used in Medical prescriptions only.*

20 troy *grs.* . . . make 1 scruple, marked . . ℈
60 troy *grs.* 3 scruples = 1 dram, . . . . . ʒ
480 troy *grs.* 24 scruples = 8 drams = 1 ounce, . ℥
5760 troy *grs.* 288 scruples = 96 drams = 12 ounces = 1 *lb.*

### APOTHECARIES' FLUID MEASURE.

| | | | Cubic Inches. |
|---|---|---|---|
| 1 fluid minim . . = | | marked *M.*= | |
| 60 flu.m.= | 1 dram = | . . *F.* ʒ.= | |
| 480 flu.m.= | 8 drams= | 1 ounce *F.* ℥.= | |
| 7680 flu.m.= | 128 drams= | 16*oz.*=1 fl.pt ⊖= | |
| 61440 flu.m.= | 1024 drams= | 128*oz.*=8 flu.pts.=1 gal. | 277·274. |

### AVOIRDUPOIS WEIGHT,

*Used for all purposes except those beforementioned.*

| | | | | | | |
|---|---|---|---|---|---|---|
| Grains. $27\frac{11}{32}$ | = | 1 dram. | | | | |
| $437\frac{1}{2}$ | = | 16 = | 1 ounce. | | | |
| 7000 | = | 256 = | 16 = | 1 pound. | | |
| 196000 | = | 7168 = | 448 = | 28 = | 1 quarter. | |
| 784000 | = | 28672 = | 1792 = | 112 = | 4 = | 1 cwt. |
| 15680000 | = | 573440 = | 35840 = | 2240 = | 80 = | 20 = 1 ton. |

### HAY AND STRAW WEIGHT.

36 *lbs.* of straw make 1 truss.
56 *lbs.* of old hay . . 1 truss.
60 *lbs.* of new hay . 1 truss.
36 trusses . . . . 1 load.*

### WOOL WEIGHT.

7 *lbs.* make 1 clove.
14 *lbs.* . . 2 cloves = 1 stone.
240 *lbs.* . . . . . = 1 pack.

### LINEAL MEASURE.

| | | | | | |
|---|---|---|---|---|---|
| Barley corns. 3 = | 1 inch. | | | | |
| 36 = | 12 = | 1 foot. | | | |
| 108 = | 36 = | 3 = | 1 yard. | | |
| 594 = | 198 = | $16\frac{1}{2}$ = | $5\frac{1}{2}$ = | 1 perch. | |
| 23760 = | 7920 = | 660 = | 220 = | 40 = | 1 furlong. |
| 190080 = | 63360 = | 5280 = | 1760 = | 320 = | 8 = 1 mile. |

A hand, in estimating the height of horses, is 4 inches. A pace = 5 feet. A fathom = 6 feet. A chain = 66 feet = 100 links: and a link = 7·92 inches. A mile in Russia = 1100 yards; in Italy, 1467; in Scotland and Ireland, 2200; in Poland, 4400; in Spain, 5028; in Germany, 5866; in Sweden, 7233; in Denmark, 7233; in Hungary, 8800. A small league in France is 2933 yards; mean league, 3666; and great league, 4400.

### GEOGRAPHICAL, OR NAUTICAL MEASURE.

A nautical mile = 6075·81 feet.
3 miles = 1 league.
20 leagues = 1 degree.
360 degrees = the earth's circumference.

---

* Hay sold between the 1st. of June and the 31st. of August, being new hay, must weigh 60 *lbs.* per truss: all other, 56 *lbs.* per truss.

The earth's circumference is equal to 131237500 feet, or 24855 miles and a half, very nearly.

### LIQUID MEASURE.

Cubic inches. $34\frac{2}{3}$ = 1 pint = 20*oz.* of water, avoirdupois.
$69\frac{1}{3}$ = 2 = 1 quart.
277·274 = 8 = 4 = 1 gallon = 10 *lbs.*

The undermentioned are merely nominal.—A firkin, 9 gallons; a kilderkin, 18 gallons; a barrel, 36 gallons; a tierce, 42 gallons; a hogshead, 63 gallons; a pipe, 126 gallons. All casks being guaged, and the contents charged to the purchaser by the number of gallons contained in them.

### MEASURE OF CAPACITY.

*The gallon is the same as Liquid Measure.*

Gallons. 2 = 1 peck.
8 = 4 = 1 bushel.
64 = 32 = 8 = 1 quarter.

Other terms are merely nominal.

### COTTON-YARN MEASURE.

Inches. 54 = 1 thread.
4320 = 80 = 1 lea, or rap.
30240 = 560 = 7 = 1 hank, or 840 yards.

### LINEN-YARN MEASURE.

Inches. 90 = 1 thread.
10800 = 120 = 1 lea, or rap.
108000 = 1200 = 10 = 1 slip.
2160000 = 24000 = 200 = 20 = 1 bundle.

Ermland yarn is $85\frac{1}{2}$ inches to one thread, and 40 threads to one lea. Hamburgh yarn is 80 inches to one thread, and 90 threads to one lea.

### WORSTED-YARN MEASURE.

Inches. 36 = 1 thread.
2880 = 80 = 1 lea, or rap.
20160 = 560 = 7 = 1 hank, or 560 yards.

The cotton-reel is 54 inches in circuit; the linen-reel is 90 inches in circuit; the worsted-reel is 30 inches in circuit; the ounce thread-reel is 30 inches in circuit: and a hank of this yarn is 30 threads.

### CLOTH MEASURE.

Inches. $2\frac{1}{4}$ = 1 nail.
9 = 4 = 1 quarter of a yard.
36 = 16 = 4 = 1 yard.
45 = 20 = 5 = 1 ell.

The breadth of cloth is ascertained by the number of inches broad.

### SQUARE, OR SUPERFICIAL MEASURE.

144 square inches, or 12 inches multiplied by 12 in. = 1 square foot.

Inches. 1296 = 9 = 1 square yard.
39204 = $272\frac{1}{4}$ = $30\frac{1}{4}$ = 1 square perch.
1568160 = 10890 = 1210 = 40 = 1 square rood.
6272640 = 43560 = 4840 = 160 = 4 = 1 squareacre.

36 square yards of stone, or brick-work, are termed a rood; 100 superficial feet, one square of flooring; 640 acres, one square mile.

| | *ft.* | *in.* |
|---|---|---|
| The statute perch for measuring land .... = | 16 | 6 |
| The customary perch in Dorsetshire..... = | 15 | 1 |
| Ditto, in Devonshire ... ..... = | 15 | 0 |
| Ditto, in Cornwall ..... = | 18 | 0 |
| Ditto, in Lancashire ..... = | 21 | 0 |
| Ditto, in Cheshire ..... = | 24 | 0 |
| The standard perch in Scotland..... = | 18 | 6 |
| Ditto, in Ireland ..... = | 21 | 0 |

160 of such perches respectively make an acre standard or customary.

### CUBIC, OR SOLID MEASURE.

1728 inches make 1 cubic foot.
46656 inches, or 27 cubic feet = 1 cubic yard.
40 cubic feet of rough timber
50 cubic feet of hewn timber } = 1 load.
42 cubic feet = 1 ton of shipping.
24 cubic feet of sand
18 cubic feet of earth } = 1 ton.
17 cubic feet of clay
64 cubic feet of fir
39 cubic feet of oak
60 cubic feet of elm } = 1 ton.
45 cubic feet of ash

16 cubic feet of Portland stone
17 cubic feet of Bath stone
15 cubic feet of Yorkshire stone
13½ cubic feet of granite stone
13 cubic feet of marble
} = 1 ton.

TIME.

Seconds. 60 = 1 minute.
3600 = 60 = 1 hour.
86400 = 1440 = 24 = 1 day.
604800 = 10080 = 168 = 7 = 1 week.
2419200 = 40320 = 672 = 28 = 4 = 1 month.

12 calendar months, or 13 common months and 1 day, or 52 weeks and 1 day, or 365 days, make 1 common year; 365¼ days make 1 Julian year; 366 days make 1 Bissextile, or leap year.

The Tropical, or true Solar year, as determined by astronomical observations, is 365 days, 5 hours, 48 minutes and 48 seconds; the Julian year is 365 days, 6 hours. The annual excess of the Julian year is 11 minutes, 12 seconds, which in 400 years amounts to 3 days, 2 hours and 40 minutes. This is regulated by the Gregorian calendar and the British Legislature: so that when a number denoting a complete century is not divisible by 4, as the 19th. 21st. 22nd. 23rd. 25th. and so on, such years should be reckoned common years, not leap years. By this regulation the calendar will exceed the true Solar year by 2 hours and 40 minutes only in 400 years, which is exactly 1 day in 3600 years.

*The Calendar Months, and number of Days in each.*

January, 31 days; February, 28 days, leap year, 29 days; March, 31 days; April, 30 days; May, 31 days; June, 30 days; July, 31 days; August, 31 days; September, 30 days; October, 31 days; November, 30 days; December, 31 days.

*The Quarterly terms.*

Lady-day..... 25th. of March.
Midsummer..... 24th. of June.
Michaelmas ..... 29th. of September.
Christmas..... 25th. of December.

MOTION.

Seconds. 60 = 1 minute.
3600 = 60 = 1 degree.
108000 = 1800 = 30 = 1 sign.
1296000 = 21600 = 360 = 12 = 1 circle of the Zodiac.

### PAPER.

Sheets. 24 = 1 quire.
480 = 20 = 1 ream.
960 = 40 = 2 = 1 bundle.

12 skins of parchment make 1 roll; 72 words, 1 common Law folio; 80 words, 1 Exchequer folio; 90 words, 1 Chancery folio; 4 pages, 1 sheet folio; 8 pages, 1 sheet quarto; 16 pages, 1 sheet octavo; 24 pages, 1 sheet duodecimo.

### MISCELLANEOUS INFORMATION.

12 units . . . = 1 dozen.
12 dozen . . = 1 gross.
12 gross . . . = 1 great gross.
20 units . . . = 1 score.
5 score . . . = 1 common hundred.
6 score . . . = 1 long hundred.
12 score of flour = 240 *lbs.*
14 score of flour = 280 *lbs.*
5 *lbs.* . . . = 1 stone of glass.
14 *lbs.* . . . = 1 stone, horseman's weight.
8 *lbs.* . . . = 1 stone of wire.
20 hanks . . = 1 doffing.

*Counts of yarn* signify the number of hanks in one pound.

*Hank roving,* the same *draft of cotton,* the increase in length by being drawn through certain parts of machinery.

*Stretch,* the length of yarn delivered from the rollers to the spindle end, when the carriage containing the spindles is drawn out at full length.

*Stretching* is the length the thread is drawn out by the carriage after the rollers have ceased to act.

*Gaining* is the length of yarn gained by the carriage moving faster than the rollers deliver the yarn.

A *set of yarn,* the number of cops spun on one mule.

*Twist,* yarn spun for the purpose of making warps, or web of cloth.

*Weft,* yarn not so much twisted as the former, and intended for the shuttle.

*Warp,* a number of ends of yarn, made certain lengths, prepared for the loom.

*Blower,* the first piece of machinery used for cleansing and loosening cotton.

*Carding engine,* used for laying the fibres of cotton in regular order.

*Feeding rollers,* the rollers which first receive the cotton.

*Main cylinder,* the largest in the carding engine, and which goes the quickest.

*Doffing cylinder,* receives the cotton from the main cylinder; the cotton is taken from the doffing cylinder by the *doffer,* a comb of steel plate, worked by a crank.

*Delivery rollers,* the rollers which deliver cotton from any piece of machinery.

*Drawing frame,* a frame where several ends of cotton pass through rollers and are considerably increased in length.

*Slubbing frame,* the cotton passes through rollers on to bobbins.

*Jack frame,* or *roving frame,* the machine which prepares the cotton for the stretcher or mule, according to the fineness of the yarn required.

*Stretching frame* prepares the yarn for the mules; the spindles are placed in a carriage, which moves.

*Mule,* the last spinning machine, where the yarn is formed into the cop.

*Throstle,* a machine for making twist only, on small bobbins.

*Reel,* the frame for making the yarn into leas and hanks.

*Drum,* a cylindrical piece of wood or iron, fastened on a shaft, over which the strap moves.

*Pulley,* a small-sized drum, over which the strap runs to turn the machine.

*Warve,* a small pulley fastened on a spindle.

*Mendoza wheel,* a wheel working with the rollers, and moves the carriage by a pulley attached to the wheel.

*Single speed,* twists the yarn as it is drawn out from the rollers.

*Double speed,* twists the yarn when the rollers have ceased to act.

*Stud wheel,* receives motion from the front roller, on the axis of which is fixed the altering pinion.

*Altering,* or *change pinion,* gives motion to the back roller; by this pinion the drafts are regulated.

*Twist pulley,* has several grooves in it, to regulate the twist necessary for the yarn.

*Saddle, bridle* and *lever.* The saddle is placed on the rollers, the bridle connects the saddle and lever, to which a weight is hung, to give the requisite pressure on the rollers in drawing out the cotton.

Three cops out of every set are reeled; the hanks and leas

produced from each cop are weighed by Troy weight; from the average weight the counts or number of hanks of yarn in the pound Avoirdupois is ascertained.

### REEDS.

Manchester and Stockport count by the number of dents or teeth in the reed, in $24\frac{1}{4}$ inches. Bolton counts the number of warp threads in one inch. A 1400 Scotch reed is equal to 76 Manchester and Stockport and 46 Bolton. The ratio of reeds is 5 to 3 between the Manchester and Stockport and the Bolton counts.

### BRICK WORK.

16 bricks, with the mortar, weigh 112 *lbs.* and make 1 cubic foot.

1000 bricks will build a wall $11\frac{1}{4}$ square yards, 9 inches thick, including waste.

### CARPENTRY.

600 superficial feet of 1 inch plank, or deal
400 superficial feet of $1\frac{1}{2}$ inch plank, or deal
300 superficial feet of 2 inch plank, or deal
240 superficial feet of $2\frac{1}{2}$ inch plank, or deal
200 superficial feet of 3 inch plank, or deal
170 superficial feet of $3\frac{1}{2}$ inch plank, or deal
150 superficial feet of 4 inch plank, or deal
} make 1 load.

Battens are 7 inches wide.
Deals are 9 inches wide.
Planks are 11 inches wide.

120 deals, 12 *ft.* long, $2\frac{1}{2}$ *in.* thick, 9 *in.* wide, each containing 1 *ft.* $10\frac{1}{2}$ *in.* solid $= 4\frac{1}{2}$ loads.

120 deals, 12 *ft.* long, 3 *in.* thick, 9 *in.* wide, each containing 2 *ft.* 3 *in.* solid $= 5\frac{2}{3}$ loads.

24 ten-feet boards, 5 inch guage
20 ten-feet boards, 6 inch guage
17 ten-feet boards, 7 inch guage
15 ten-feet boards, 8 inch guage
13 ten-feet boards, 9 inch guage
12 ten-feet boards, 10 inch guage
} will finish 1 square.

20 twelve-ft. boards, . . . . . 5 *in.* guage
16 twelve-ft. boards, 4 *ft.* superficial, 6 *in.* guage
14 twelve-ft. boards, 2 *ft.* superficial, 7 *in.* guage
12 twelve-ft. boards, 4 *ft.* superficial, 8 *in.* guage
11 twelve-ft. boards, 1 *ft.* superficial, 9 *in.* guage
10 twelve-ft. boards, . . . . . 10 *in.* guage
} will finish 1 square.

13 twelve-feet deals to 1 square of wrought flooring.
12½ twelve-feet deals to 1 square of rough boarding.
17 twelve-feet deals to 1 square of wrought boarding.
35 deals, 12 feet long, 2½ inches thick, weigh 1 ton.

### SLATING.

120 slates make 1 hundred.

| Names. | Size, nearly. | |
|---|---|---|
| | *ft. in.* | *ft. in.* |
| Doubles . . . . | 1 2 | by 0 6 |
| Ladies . . . . . | 1 3 | by 0 8 |
| Countess . . . . | 1 10 | by 0 11 |
| Duchess . . . . | 2 2 | by 1 3 |
| Rags and Queens . | 3 3 | by 2 3 |
| Imperial and Patent | 2 8 | by 2 2 |

1 square of slating = 100 superficial feet, will require of Westmoreland slates half a ton; of Welsh rags, from ¾ of a ton to a ton; of Tavistock slates, about 360; of Ladies slates, 308; of Countess slates, 200; and of Duchess slates, 110. The last three will weigh from 6 to 6½ *cwt.*

### PAVING.

1 ton of paving-stones will average 5½ yards square.
1 ton of square sets will average 3¼ yards square.

### IRON.

430·25 cubic inches of cast iron
397·60 cubic inches of bar iron
368·88 cubic inches of cast brass
352·41 cubic inches of cast copper
372·8 cubic inches of cast lead
} = 1 *cwt.*

Inch square, 9 feet long, cast iron . . . } = 28 *lbs.*
Inch square, 100 inches long, wrought iron }
Cohesion of a cubic inch of cast iron = 18000 *lbs.*
The weight of cast iron pipes, to leaden pipes of the same dimensions, are nearly as 7 to 11.

### WATER.

Water boils at 212 degrees of Fahrenheit, or 100 degrees by the centigrade.
1 gallon = 10 *lbs.*
A column of water, 33 feet high, 1 inch square, will press with a force of nearly 15 *lbs.* Another, 1 foot square, 36 feet high, will press with a force of nearly 1 ton.

A cast iron pipe, 15 inches diameter, $\frac{3}{4}$ of an inch thick, is sufficient for a head of water 600 feet high. A pipe 1 foot long, 1 inch diameter, will discharge 7070 cubic inches of water in 1 minute, from a head of water 4 feet above the pipe.

### AIR.

One cubic foot of atmospheric air weighs *525 grs.* at the surface of the earth.

### SOUND.

Sound passes through 1142 feet in 1 second of time.

### LIGHT.

Light passes through 1010771520 feet, or 191434 miles in 1 second of time; 1553 cubic feet of light weigh 1 *gr.*

### A TABLE SHOWING THE RELATIVE VALUE OF TROY AND AVOIRDUPOIS POUNDS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Troy | 1 | 2 | 3 | 4 | 5 | |
| Avoir. | 0·823 | 1·646 | 2·469 | 3·291 | 4·114 | |
| Troy | 6 | 7 | 8 | 9 | | |
| Avoir. | 4·937 | 5·760 | 6·583 | 7·406 | | |
| Avoir. | 1 | 2 | 3 | 4 | 5 | 6 |
| Troy | 1·215 | 2·431 | 3·646 | 4·861 | 6·076 | 7·292 |
| Avoir. | 7 | 8 | 9 | | | |
| Troy | 8·507 | 9·722 | 10·937. | | | |

---

## ARITHMETIC

Is the science of numbers; it explains their properties and the art of computing by them.

All numbers are expressed by the ten following figures:

One, or unit, two, three, four, five, six, seven, eight, nine, cipher.

1 2 3 4 5 6 7 8 9 0

Notation is the method of writing down a number in figures; Numeration is the art of reading a number expressed in figures.

A single figure, placed on the right hand of other figures, signifies so many units; in the second place, so many tens; and in the third place, so many hundreds.

The cipher serves to bring figures to their proper places, by supplying vacant places; thus, 8, eight; 80, eighty; 800, eight hundred; 850, eight hundred and fifty; 806, eight hundred and six.

NUMERATION TABLE.

| C. of M. of Millions. | X. of M. of Millions. | M. of Millions. | C. of Millions. | X. of Millions. | Millions. | C. of Thousands. | X. of Thousands. | Thousands. | Hundreds. | Tens. | Units. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 7 | 8, | 9 | 8 | 7. | 6 | 5 | 4, | 3 | 2 | 1 |

This table may be extended, as under:

| Nonillions. | Octillions. | Septillions. | Sextillions. | Quintillions. |
|---|---|---|---|---|
| 897,654 | 375,486 | 854,123 | 375,406 | 467,589 |
| **Quadrillions.** | **Trillions.** | **Billions.** | **Millions.** | **Units.** |
| 859,763 | 689,754 | 374,582 | 764,539 | 865,478 |

*Read and write in words the following:*

48, 75, 60, 104, 720, 834, 158, 16, 76, 604, 197, 514.

*Write in figures the following:*

Twenty-four; sixty-eight; one hundred and eight; six hundred and forty-seven; nine hundred and forty-three; five hundred and ten; three hundred and three.

When the number consists of more than three places,

RULE. Divide it from the right hand into parcels of three figures, by placing a comma at the left hand of the first three, a period after the next three, and so on alternately. Then beginning at the left hand, read each parcel by itself, as before, and call the periods millions and the commas thousands. Thus, 42.706,835. Forty-two millions, seven hundred and six thousand, eight hundred and thirty-five.

EXAMPLES. Write or read the following: 8,346; 4,706; 78,900; 175,642; 107,000; 200,500; 300,070; 608,004; 4.587,639; 75.849,047; 678.954,348; 5,407.065,407; 28,064.375,500.

To write a number in figures. Write down a sufficient number of ciphers, and point them, in order to determine their places; then observe what place every figure in the given number should occupy; erase the cipher there, and place the figure in its room.

Eighty thousand, five hundred and four. } 00,000 / 80,504

### EXAMPLES.

Write down in figures six hundred and forty-eight; two thousand and one; thirty-five thousand and twenty-eight; three hundred and twenty-six thousand; two hundred thousand, six hundred and four.

### EXERCISES.

(1) A year contains three hundred and sixty-five days; put the same down in figures.

(2) The world was created four thousand and four years before the birth of Christ; express the same in figures.

(3) The Deluge happened in the year of the world 2,348; write the same in words.

(4) William the Fourth ascended the English throne in 1830; write the same in words.

(5) A rood of land contains ten thousand, eight hundred and ninety feet; write the same in figures.

(6) There are 40320 minutes in one month; write the same in words.

(7) Thirty-one millions, five hundred and fifty-six thousand, nine hundred and twenty-eight seconds, make one solar year; put the same down in figures.

(8) There are one hundred and ninety thousand, and eighty barley corns in one mile; write the same in figures.

(9) There are 5322240 inches in one pound of No. one hundred and seventy-six hanks yarn; write the same in words.

(10) Ten millions, four hundred and thirty-two thousand inches are contained in one pound of No. 345 hanks yarn; put the same in figures.

(11) The population of Manchester, in 1831, amounted to 142026; write the same in words.

(12) The earth is computed to be ninety-five millions of miles from the sun; put the same down in figures.

(13) The circumference of the earth is 1,603.745,280 inches; write the same in words.

(14) There are 73.334,400 acres of land in England; write the same in words.

## ADDITION.

ADDITION is the method of finding one number equal to two or more numbers. The number found is called the sum.

RULE. Begin at the right hand, write the figures of the given numbers below one another, in their order, so that the vacancies, if any, may fall on the left side.

Draw a line under the number; add up the right hand column; and if the sum be one figure, write it under the added column; but if it consists of two figures, write only the right hand figure under the column, and carry the other to the next column.

Add all the other columns in the same manner, and under the left hand column write down the full sum.

PROOF. Repeat the operation, beginning at the top; or, add first so many of the given numbers, and to the sum add the rest.

*Addition and Subtraction Table.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 3 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 4 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 6 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 7 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 8 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 9 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |

| | | |
|---|---|---|
| 43856 | | |
| 80794 | | |
| 65807 | | |
| 59470 | | |
| 73845 | | |
| 90786 | | |
| 85064 | | |
| 499622 | | |

| | | |
|---|---|---|
| (1) 529374 | (2) 89704 | (3) 13507 |
| 487563 | 7850 | 2759 |
| 806759 | 45673 | 364 |
| 695473 | 296 | 89073 |
| 836795 | 4785 | 5682 |
| 384506 | 98432 | 73456 |
| 460370 | 4075 | 928 |
| (4) 843297 | (5) 1 | (6) 6804 |
| 56435 | 43 | 79365 |
| 8796 | 568 | 40570 |
| 473 | 4839 | 8394 |
| 58 | 76584 | 56073 |
| 694 | 8376 | 947 |
| 76587 | 39842 | 62389 |

(7) 4859 + 765432 + 7489 + 4080 + 75832 + 56073 + 94760 + 327 + 59478 + 3284 =

(8) 947365 + 207 + 59443 + 29456 + 7654 + 12345678 + 9874 + 32579 + 4004 =

(9) 6584732 + 480765 + 54869 + 4607 + 403078 + 93205 + 76945623 =

(10) 23 + 475 + 948760 + 37546 + 5074 + 29865432 + 73694 + 62796 + 37594 =

### EXERCISES IN ADDITION.

(1) One year contains 12 calendar months; the names and number of days assigned to each are as follow: January, 31 days; February, 28* days; March, 31 days; April, 30 days, May, 31 days; June, 30 days; July, 31 days; August, 31 days; September, 30 days; October, 31 days; November, 30 days; December, 31 days. How many days in a year?

(2) Iron was found in Greece, from the accidental burning of the woods, 1406 years before Christ. How many years is it since, this being 1833.

(3) Julius Cæsar made his first expedition into Great Britain 52 years before the birth of Christ; St. Paul introduced christianity in this island 63 years after the birth of Christ; the power of the Popes commenced 543 years after, being 290 years before the reign of Alfred the Great, which was 170 years before the battle of Hastings, between Harold and William the Conqueror. How many years from the invasion by Julius Cæsar to the battle of Hastings?

(4) The art of printing with wooden types was invented by Laurentius, of Haerlem, in 1430. Thirty years after, engraving and etching on copper was invented; this was 61 years before the first English edition of the Bible was authorized to be made, and 72 years were occupied in the translation. What year of our Lord was the translation of the Bible completed?

(5) The present method of calculating the year was instituted by Pope Gregory, in 1582, but was not adopted in England until 170 years after. What was the year?

(6) The first artificial globe was constructed by Anaximander, a philosopher of Miletus, 610 years before Christ; and maps were first brought to England in the year 1489. How many years elapsed from the first construction of globes to the introduction of maps into England?

---

* In leap year February has 29 days.

(7) Euclid, the astronomer, flourished 277 years before Christ: and Sir Isaac Newton was born in the year 1642. How many years from the time of Euclid to that of Sir Isaac Newton?

(8) From the Creation, to the departure from Egypt, was 2513 years; thence to the building of Solomon's temple, 487; to the Jewish captivity, 398; to their return, 70; to the Christian era, 536; to the revolution, 1688; to the present year,* 145. Required the time from the Creation.

(9) How many days from the 1st. of January, 1832, to the 28th. of July in the same year?

(10) Received from *A.* eight hundred and seventy-eight pounds; from *B.* three thousand; from *C.* sixty-four; from *D.* six hundred and one; from *E.* eleven thousand, eleven hundred and eleven; from *F.* ten thousand, two hundred and seven; from *G.* four hundred and seventy-eight pounds. How much did I receive in all?

(11) From Manchester to Stockport is 6 miles; from Stockport to Macclesfield, 13; from Macclesfield to Leek, 13; from Leek to Ashbourn, 17; from Ashbourn to Derby, 13 miles. Required the distance from Manchester to Derby.

(12) Bought 104 bundles of twenty hanks twist; 176, twenty-two hanks; 260, twenty-four's; 89, twenty-six's; 304, twenty-eight's; 289, thirty's. How many bundles in the whole?

---

## SUBTRACTION.

SUBTRACTION is the method of finding the difference of two numbers, by taking the less from the greater.

The greater number is called the *Minuend;* the less, the *Subtrahend;* and the number found is called the *Difference,* or *Remainder.*

RULE. Place the less number below the other, and draw a line under it. Commence at the right hand; take each figure in the lower line from that above it, and set down the remainder under it. If the upper figure be less than the under, take the under figure from ten, and to the remainder add the upper figure; carry one to the next lower figure, with which proceed as before.

---

* 1833.

PROOF. If the work be right, the sum of the *Subtrahend* and *Remainder* will be equal to the *Minuend.*

From 85476 minuend.
Take 48793 subtrahend.

36683 remainder.

85476 *Proof.*

| | | | | | |
|---|---|---|---|---|---|
| (1) | 258392417<br>235430765 | (2) | 4073645<br>2857849 | (3) | 113407694<br>28604978 |
| (4) | 30076945<br>96978 | (5) | 9876043<br>9787062 | (6) | 18049627<br>18038798 |
| (7) | 12347689<br>856798 | (8) | 4709365<br>2036748 | (9) | 170909009<br>24710905 |
| (10) | 94286730<br>32199739 | (11) | 8111118<br>1600809 | (12) | 111347640<br>386938 |
| (13) | 10042793<br>9941876 | (14) | 2449734<br>1742693 | (15) | 30921098<br>1870189 |

EXERCISES.

(1) By a late census, the population of the parish of Manchester amounts to 232578; and that of the township amounts to 142026. How much does the parish population exceed the township?

(2) Although glass was invented in England in 664, yet it only began to be used in windows in 1180. How many years elapsed from its discovery to its use in windows?

(3) It is now (1833) 493 years since painting in oil was first made use of, by John Vaneck. What was the year?

(4) It is now 531 years since gunpowder was invented, by one Swartz, of Cologne. Required the year of our Lord.

(5) Coals were first brought to London in the year 1357. How many years is it since?

(6) Borrowed from *A* 407; from *B* 126; from *C* 359; from *D* 84; from *E* 70. Paid *A* 98; *B* 75; *C* 108; *D* 27; *E* 36. How much remains to pay?

(7) Paper was originally made of cotton rags; and the first English manufactory of it was established at Dartford, in Kent, in 1588. Glass was invented in England, by a

Monk, in 664. How many years elapsed from the discovery of glass to paper-making at Dartford?

(8) What is the difference between one million and 110479?

(9) Required answers to the following: 26073 — 9876; 103470 — 48937; and 38764 — 38695.

(10) A person collected as follow: from *A* £143 — 47.; *B* £204 — 65.; *C* £300 — 109.; *D* £436 — 298. How much did he collect from each person?

(11) Received in rents £126. + £79. + £38. and paid in chief rent and repairs £174. — £95. What is the nett amount of receipts?

(12) How much does fourteen thousand and four want of twenty-one thousand?

---

## MULTIPLICATION.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 |
| 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 |
| 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 | 84 |
| 8 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 |
| 9 | 18 | 27 | 36 | 45 | 54 | 63 | 72 | 81 | 90 | 99 | 108 |
| 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 11 | 22 | 33 | 44 | 55 | 66 | 77 | 88 | 99 | 110 | 121 | 132 |
| 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 | 132 | 144 |

MULTIPLICATION is the method of finding the amount of a number repeated as many times as there are units in another number.

The two numbers are called *Factors;* the first the *Multiplicand,* the other the *Multiplier;* and the amount is called the *Product.*

RULE. Place the Multiplier under the Multiplicand, and draw a line below. Multiply the right hand figure of the Multiplicand by that of the Multiplier; write the right hand figure of the Product below, and carry the second figure to the next Product. In like manner, multiply every figure of the Multiplicand by this figure of the Multiplier.

Where the Multiplier consists of several figures, multiply

in the same manner by each of them, taking care to write the right hand figure of each of the Products directly under the figure of the Multiplier which produces it.

Add the lines thus produced, and the sum will be the product required.

NOTE. To multiply by 10, 100, 1000, &c. annex ciphers to the Multiplicand.

2. When there are ciphers annexed to either, or both Factors, multiply by the figures, and annex the ciphers to the Product.

PROOF. Make the Multiplicand the Multiplier, and the Multiplier the Multiplicand, and repeat the operation; the Product should be the same as before.

EXAMPLES.

Multiply 876093456738487 by 4, 5, 6, 7, 8, 9, 10, 11, 12.

(1) 84790632 × 22.
(2) 60975843 × 34.
(3) 7540096[illegible] × 47.
(4) 9485379 × 59.
(5) 3478596 × 68.
(6) 2875943 × 76.
(7) 5463759 × 87.
(8) 3459376 × 100.
(9) 8594863 × 406.
(10) 4785932 × 610.
(11) 4893546 × 726.
(12) 91463897 × 4875.
(13) 7149603 × 64963.
(14) 6004379 × 9430.
(15) 438900 × 78080.
(16) 586540 × 46700.
(17) 9658730 × 80000.
(18) 8745639 × 14963.
(19) 1342579 × 87600.
(20) 640795 × 9307.
(21) 850304 × 5060.
(22) 948627 × 12345.
(23) 548593 × 5423.
(24) 469843 × 469843.

RULE. When the Multiplier is the Product of any two or more Factors, none of which exceeds 12, multiply successively by these Factors.

(1) 7896437 × 15.
(2) 8417653 × 24.
(3) 9346803 × 32.
(4) 7385496 × 54.
(5) 487596 × 48.
(6) 897146 × 72.
(7) 956784 × 81.
(8) 649538 × 88.
(9) 7209864 × 96.
(10) 8765940 × 108.
(11) 3572635 × 112.
(12) 4839786 × 168.

EXERCISES.

(1) How many farthings are there in 240 pence?
(2) How many pence in 20 shillings?
(3) How many strokes does the hammer of a clock strike, in a year of 365 days, at 156 strokes in a day?

dend. Or, subtract the Remainder from the Dividend, and divide by the Quotient; then the new Quotient should be the Divisor. Or, add the Remainder and all the partial Products, retaining the places in which they stand in the operation, the sum is the Dividend.

(1) 23)63758946.
(2) 19)48359847.
(3) 17)12345678.
(4) 29)8476593.
(5) 38)20730048.
(6) 47)32780350.
(7) 59)83749638.
(8) 68)54863752.
(9) 87)59476348.
(10) 94)67859436.
(11) 123)65987635.
(12) 278)34759630.
(13) 397)27869438.
(14) 5486)18675943.
(15) 8943)37800764.
(16) 9876)48394760.

EXERCISES.

(1) There are 1000 ounces in a cubical foot of water. How many pounds of 16 ounces each, are there?

(2) There are 30240 inches in one hank of cotton yarn. How many yards of 36 inches each?

(3) How many stretches of 54 inches each, in one hank of yarn containing 30240 inches?

(4) In 2160000 inches of linen yarn, how many threads of 90 inches each?

(5) What number multiplied by 49 will produce 18375?

(6) Suppose I lease 780 square yards of land to build upon, the front of which is 20 yards. How many yards in depth must be fenced out to make up the exact complement of square yards?

(7) In a set of yarn weighing 6 *lbs.* and containing 1920 hanks; how many hanks in one pound?

(8) What will be the counts of a set of yarn containing 1480 hanks, and weighing 5 *lbs.*?

(9) A cubical foot of air weighs one ounce and a quarter; how many pounds avoirdupois does a room contain, 12 feet high, 16 feet wide and 20 feet long?

(10) How many warp threads of 120 yards each, can be made from 302400 yards of twist?

(11) How many hanks of yarn 840 yards each, are contained in 604800 yards?

(12) How many miles is a person at Manchester carried eastward in an hour in consequence of the earth's diurnal revolution, supposing it performed in 24 hours, and that the parallel of Manchester is 14952 miles?

(13) Supposing the number of persons alive at once upon the earth to be twelve hundred and fifty-four millions, and one out of 33 die annually, how many deaths happen in a year?

### SUPPLEMENT TO MULTIPLICATION AND DIVISION.

1. WHEN the Multiplier contains a fraction.

First multiply by the upper figure of the fraction, and divide by the under figure; then multiply by the integer, and add the product to the Quotient.

NOTE. For $\frac{3}{4}$ take $\frac{1}{4}$, and $\frac{1}{3}$ of that half; for $\frac{5}{8}$ take $\frac{1}{8}$, and $\frac{1}{5}$ of that quarter; and for $\frac{4}{5}$ take $\frac{1}{5}$, and $\frac{1}{4}$ of that half.

(1) $6484\times3\frac{1}{2}$.
(2) $3488\times5\frac{1}{4}$.
(3) $5616\times6\frac{1}{3}$.
(4) $798\times8\frac{2}{3}$.
(5) $875\times5\frac{1}{2}$.
(6) $458\times7\frac{1}{4}$.
(7) $6834\times9\frac{5}{6}$.
(8) $9543\times11\frac{5}{8}$.
(9) $4736\times12\frac{7}{8}$.
(10) $3485\times10\frac{5}{6}$.
(11) $4836\times\frac{7}{8}$.
(12) $9436\times4_{1}\frac{5}{2}$.

2. To Divide when the Divisor contains a fraction.

Multiply both the Dividend and Divisor by the under figure of the fraction, taking in the upper figure to the product of the Divisor; then divide.

(1) $2\frac{1}{2})47856$.
(2) $5\frac{1}{4})59648$.
(3) $6\frac{2}{3})84376$.
(4) $7\frac{3}{5})98473$.
(5) $8\frac{1}{8})35946$.
(6) $9\frac{1}{3})38759$.
(7) $28\frac{6}{7})94863$.
(8) $365\frac{1}{4})587934$.
(9) $29\frac{5}{8})876923$.

### CONTRACTIONS IN MULTIPLICATION AND DIVISION.

1. To multiply by 5; annex a cipher to the Multiplicand, and divide by 2.

2. To multiply by 15; proceed in the same way and then add the Quotient to the Dividend.

3. To multiply by 25; annex two ciphers to the Multiplicand, and divide by 4.

4. To multiply by 75; proceed in the same way and then subtract the Quotient from the Dividend.

(1) $48753\times5$.
(2) $58794\times50$.
(3) $87385\times500$.
(4) $68947\times15$.
(5) $34509\times150$.
(6) $75038\times1500$.
(7) $89734\times25$.
(8) $27854\times250$.
(9) $6759\times75$.
(10) $7948\times750$.
(11) $8453\times2500$.
(12) $12345\times7500$.

5. To multiply by any number between 10 and 20; multiply by the Units and add in the back figure.

6. To multiply by any number between 100 and 110; multiply by the Units and take in the second back figure.

7. To multiply by any number between 110 and 120; multiply by the Units and take in the two back figures.

| | | |
|---|---|---|
| (1) 4786×13. | (4) 5496×104. | (7) 31416×119. |
| (2) 8754×17. | (5) 2573×107. | (8) 8597×113. |
| (3) 7856×14. | (6) 4395×114. | (9) 6748×106. |

8. To multiply by a number consisting entirely of Units; add together as many figures of the Multiplicand as there are Units, as in the preceding.

9. To multiply by a number consisting of the same figure; find the product by as many Units, and multiply it by that figure.

10. To multiply by a number of nines; annex as many ciphers to the Multiplicand, then subtract the Multiplicand.

| | | |
|---|---|---|
| (1) 7854×111. | (5) 9085×777. | (9) 7489×9999. |
| (2) 8976×1111. | (6) 4763×99. | (10) 6358×555. |
| (3) 487×444. | (7) 8394×999. | (11) 8973×99999. |
| (4) 598×66. | (8) 3584×888. | (12) 6478×333. |

11. After finding a line of the Product, other lines may be found by adding or subtracting the Multiplicand, or by multiplying the line found, thus to multiply by 89; multiply by 8, and for the Product by 9 add the line found to the Multiplicand. To multiply by 287; multiply by 7 and the Product by 4 for the sum of the other two lines.

| | | |
|---|---|---|
| (1) 47536×48164. | (4) 4897×84287. | (7) 28407×96328. |
| (2) 59387×72246. | (5) 6735×64164. | (8) 12345×150255. |
| (3) 56473×1728. | (6) 4538×56147. | (9) 47356×75255. |

12. To divide by 5; multiply by 2 and divide by 10. And in every case in which the Unit's place is 5 the operation may be shortened by multiplying both Divisor and Dividend by 2, 4, 8, &c. and then dividing the Products.

| | | |
|---|---|---|
| (1) 5)473025. | (5) 75)98765. | (9) 250)784396. |
| (2) 15)895632. | (6) 55)48327. | (10) 750)468972. |
| (3) 25)48739. | (7) 125)79643. | (11) 155)830473. |
| (4) 35)64387. | (8) 425)30000. | (12) 45)496827. |

13. The operation may also be shortened by dividing the Divisor and Dividend by any number which divides both without a remainder. Thus, to divide 287496 by 576; divide both by 6 and they become 47916 by 96.

246)144886936( 369)50243409( 819)549353259(

14. To divide by a number consisting of nines: from the right of the Dividend point off as many figures as there are

nines, then write the figures not cut off below it, cutting off and writing in the same manner till all the figures are cut off; then add, and the figures cut off make the Remainder, and those not cut off the Quotient.

999)473586476 9999)485763257

99999)83457685946

15. The operation may always be contracted by subtracting the figures of the product as they arise in multiplying, and writing down only the Remainder.

16. The operation may be rendered very easy, by making a table of the Divisor multiplied by the nine digits, by which means the figure to be put in the Quotient and the Product to be subtracted, are seen by inspecting the table.

347)859638. 2438)95763275.

4586)1234567. 6789)35786423.

75439)48576938425.

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## REDUCTION

TEACHES to change one denomination into another without altering its value, and is performed by multiplication and division.

RULE. To bring a greater name into a less—Multiply.

To bring a less name into a greater—Divide.

Always multiply and divide by the number of times the less name is contained in the greater.

### EXAMPLES.

(1) In £3768. how many shillings, pence and farthings?

(2) In 4873 crowns, how many sixpences and three-pences?

(3) In £5486. how many crowns and sixpences.

(4) In £124..17..9. how many pence and farthings?

(5) In 18*s*. 0½*d*. how many farthings?

(6) In £1024..15..7¾. how many farthings?

(1) In 3617280 farthings, how many pounds?

(2) In 97460 three-pences, how many crowns?

(3) In 219440 sixpences, how many crowns and pounds?

(4) In 119892 farthings, how many pence, shillings and pounds?

(5) In 866 farthings, how many shillings?

(6) In 983791 farthings, how many shillings and pounds?

RULE 2. When one of the Denominations is not contained exactly in the other, bring down the given number to a name which is contained exactly in that required; then bring it up the required name.

EXAMPLES.

(1) In 4768 guineas, how many crowns and pounds?

(2) In £41978. how many crowns, shillings and guineas?

(3) In 57800 crowns, how many pounds, shillings and guineas?

(4) In £1784. how many crowns, half-crowns and shillings, and of each an equal number?

(5) How many pounds troy, are there in a million of grains?

(6) In 484 *lbs.* 11 *oz.* 19 *dwts.* 23 *grs.* how many grains?

(7) In 7000 grains, how many pennyweights, ounces and pounds?

(8) In one pound, how many grains?

(9) In 46080 *dwts.* how many ounces and pounds?

(10) In 11 *oz.* 23 *grs.* how many grains?

(11) In 16 *lbs.* 3 *dwts.* how many grains?

(12) In 68394 *dwts.* how many ounces and pounds?

(13) In 4759673 grains, how many pennyweights, ounces and pounds?

(14) In 8594763 grains, how many ounces?

(15) In 4738594 ounces, how many pounds?

(16) In 12345678 grains, how many pounds?

(17) In one ton, how many hundreds, quarters, pounds, ounces and drams?

(18) In 24 *tons,* 16 *cwts.* 2 *qrs.* 15 *lbs.* 9 *oz.* 14 *drs.* how many drams?

(19) In 32 *cwts.* 3 *lbs.* 15 *drs.* how many drams?

(20) In 2 *tons,* 3 *qrs.* 16 *lbs.* how many ounces?

(21) In 25 *lbs.* 12 *drs.* how many drams?

(22) In 12 *tons,* 14 *oz.* how many ounces?

(23) In 49687325 ounces, how many pounds, quarters, hundreds and tons?

(24) In 4865392 drams, how many ounces, pounds, quarters and hundreds?

(25) In 8947568 ounces, how many pounds and quarters?

(26) In 647895 drams, how many ounces and pounds?

(27) In 8594367 drams, how many tons?

(28) In 1 pound, how many ounces, drams, scruples and grains?

(29) In 438 pounds, 18 grains, how many grains?

(30) In 276 pounds, 9 ounces, how many scruples?

(31) In 43567 scruples, how many pounds?

(32) In 84936 grains, how many pounds?

(33) In 954736 drams, how many pounds?

(34) In 248 yards, 3 quarters, how many nails?

(35) In 20704 yards, 2 quarters, how many inches?

(36) In 6 yards, 2 quarters, 3 nails, how many half nails?

(37) In 8652 nails, how many yards?

(38) In 547968 inches, how many yards?

(39) In 74586 ells, how many yards?

(40) In 43759 yards, how many ells?

(41) In 12345 quarters, how many ells?

(42) In 1 hank, how many leas, threads and inches?

(43) In 27 hanks, 4 leas, 56 threads, how many inches?

(44) In 745068 inches, how many threads, leas and hanks?

(45) In 5496785 threads, how many hanks?

(46) In 43876 hanks, how many leas?

(47) In 6458694 leas, how many hanks?

(48) In 75946785 inches, how many hanks?

(49) In 1 bundle of linen yarn, how many slips, leas, threads, yards and inches?

(50) In 30 slips, how many leas, threads and yards?

(51) In 4 bundles, 16 slips and 18 threads, how many threads?

(52) In 6 bundles, 8 leas, how many yards?

(53) In 43275 leas, how many bundles?

(54) In 758946 threads, how many slips?

(55) In 78493758694 inches, how many bundles?

(56) In 5947865 yards, how many slips?

(57) In a cotton warp 120 yards long, 2520 ends, how many hanks?

(58) In 10886400 inches of yarn, what length of a warp may be made containing 2160 ends?

(59) What length of a warp in yards, containing 1800 ends, may be made from 246 hanks, 3 leas of twist?

(60) A warp containing 3360 ends and 80 yards long, how many hanks?

(61) 360 hanks are made into a warp containing 2520 threads, required the length in yards?

(62) In one hank of worsted, how many inches?

(63) In 43 hanks of worsted, how many inches?

(64) In 27 hanks, 3 leas, 46 threads, 18 inches, how many inches?

(65) In 12345678 inches, how many hanks?

(66) In 463594 threads, how many leas and hanks?

(67) In 548634 hanks, how many leas?

(68) In 473692 leas, how many hanks?

(69) In 6487596 inches, how many threads, leas and hanks?

(70) In 1 league, how many miles, furlongs, poles, yards, inches and barley-corns?

(71) In 4 leagues, 2 miles, 7 furlongs, 9 inches, how many barley-corns?

(72) In 569473865 barley-corns, how many miles?

(73) In 865947386 yards, how many leagues?

(74) In 38947365 inches, how many miles?

(75) In 365 acres, how many roods and perches?

(76) In 144 acres, 3 roods, 24 perches, how many perches?

(77) In 278 acres, 32 perches, how many yards?

(78) In 54786943 perches, how many roods?

(79) In 4389546 perches, how many acres?

(80) In 5738459 yards, how many perches and roods?

(81) In 1 square yard, how many feet and inches?

(82) In 287 yards, 8 feet, 132 inches, how many inches?

(83) In 26 yards, 42 inches, how many inches?

(84) In 347694 inches, how many feet?

(85) In 12345678 inches, how many yards?

(86) In one solid yard, how many feet and inches?

(87) In 43765947 inches, how many feet and yards solid?

(88) In 9 pipes, how many gallons and pints?

(89) In 6 tuns, 1 hogshead, 17 gallons, how many quarts?

(90) In 432 butts of wine, how many pints?

(91) In 64 hogsheads, how many quarts?

(92) In 3768 quarts, how many barrels?

(93) In 48 quarters, 3 pecks, how many quarts?

(94) In 386944 gallons, how many quarters?

(95) In 24 quarters, 6 bushels, 3 pecks, 1 gallon, 3 quarts, 1 pint, how many pints?

(96) In 487356 pints, how many quarters?

(97) In one year consisting of 365 days, 5 hours, 48 minutes and 49 seconds, how many seconds?

(98) How many days from the 24th. of May to the 24th. of November?

(99) How many days from the 25th. of March to the 24th. of June?

(100) How many days from the 25th. of December to the 25th. of March in leap year?

(101) The pressure of air upon a person of moderate size is said to be about 324000 pounds, how many tons?

## COMPOUND ADDITION.

ARRANGE the numbers so that those of the same denomination may stand directly under each other, and draw a line under them.—Add the numbers in the lowest denomination together and find how many Units of the next higher denomination are contained in their sum. Write down the Remainder, and carry the Units to the next higher denomination, and proceed so to the end.

| | £. | s. | d. |
|---|---|---|---|
| (1) | 42 | 16 | 9 |
| | 37 | 15 | 11 |
| | 73 | 9 | 9 |
| | 62 | 10 | 6 |
| | 29 | 4 | 3 |
| | 19 | 15 | 7 |

| | £. | s. | d. |
|---|---|---|---|
| (2) | 84 | 17 | $6\frac{1}{2}$ |
| | 93 | 8 | $10\frac{1}{4}$ |
| | 3 | 15 | $7\frac{3}{4}$ |
| | 25 | 10 | 8 |
| | 42 | 6 | $0\frac{1}{2}$ |
| | 30 | 19 | $11\frac{3}{4}$ |

| | £. | s. | d. |
|---|---|---|---|
| (3) | 124 | 15 | $8\frac{3}{4}$ |
| | 206 | 9 | 3 |
| | 73 | 0 | $9\frac{3}{4}$ |
| | 290 | 19 | 10 |
| | 3 | 8 | $6\frac{1}{4}$ |
| | 84 | 17 | $0\frac{1}{2}$ |

(1) £3495..14..9. + £376..13..$8\frac{1}{2}$. + £1000..19..$11\frac{3}{4}$. + £27..6..$7\frac{1}{2}$. + £2367..0..$9\frac{1}{2}$. + £6090..12..$3\frac{3}{4}$.

(2) £998..4..$0\frac{1}{2}$. + £1234..16..$7\frac{3}{4}$. + £56..17..$11\frac{1}{2}$. + £800..9..0. + £230..0..$11\frac{1}{2}$. + £6758..15..$10\frac{1}{2}$.

(3) £5768..19..$0\frac{3}{4}$. + £1006..8..$6\frac{1}{2}$. + £365..14..$8\frac{1}{4}$. + £27..16..3. + £0..17..$9\frac{1}{4}$. + £2765..17..$5\frac{1}{4}$.

| *lbs.* | *oz.* | *dwt.* | *gr.* |
|---|---|---|---|
| 58 | 11 | 15 | 23 |
| 47 | 3 | 5 | 19 |
| 8 | 10 | 16 | 8 |
| 26 | 0 | 12 | 0 |
| 6 | 7 | 13 | 14 |
| 0 | 9 | 19 | 17 |

| *tons.* | *cwt.* | *qrs.* | *lbs.* | *oz.* | *dr.* |
|---|---|---|---|---|---|
| 305 | 14 | 3 | 27 | 15 | 15 |
| 94 | 3 | 0 | 16 | 9 | 14 |
| 87 | 0 | 2 | 12 | 10 | 9 |
| 36 | 17 | 1 | 0 | 6 | 4 |
| 127 | 15 | 3 | 9 | 8 | 7 |
| 4 | 9 | 2 | 3 | 0 | 12 |

| *lbs.* | *oz.* | *drs.* | *sc.* | *gr.* |
|---|---|---|---|---|
| 47 | 11 | 7 | 2 | 19 |
| 94 | 10 | 6 | 2 | 0 |
| 74 | 10 | 4 | 1 | 12 |
| 69 | 0 | 2 | 0 | 1 |
| 20 | 9 | 3 | 1 | 14 |
| 17 | 8 | 5 | 0 | 17 |

| *yds.* | *qrs.* | *nl.* |
|---|---|---|
| 434 | 3 | 3 |
| 107 | 1 | 2 |
| 36 | 0 | 2 |
| 0 | 3 | 1 |
| 64 | 1 | 3 |
| 276 | 2 | 2 |

| *hanks.* | *leas.* | *thrs.* | *inches.* |
|---|---|---|---|
| 267 | 6 | 79 | 53 |
| 1078 | 5 | 64 | 26 |
| 546 | 3. | 0 | 32 |
| 850 | 6 | 58 | 29 |
| 673 | 3 | 49 | 26 |
| 85 | 0 | 74 | 20 |

| *bundles.* | *slips.* | *leas.* | *thr.* | *inches.* |
|---|---|---|---|---|
| 240 | 19 | 9 | 119 | 89 |
| 3476 | 18 | 7 | 110 | 65 |
| 108 | 0 | 6 | 100 | 30 |
| 59 | 17 | 4 | 86 | 9 |
| 1000 | 5 | 8 | 7 | 46 |
| 589 | 14 | 3 | 50 | 27 |

*Worsted*

| *hks.* | *l.* | *th.* | *in.* |
|---|---|---|---|
| 286 | 6 | 79 | 35 |
| 42 | 5 | 64 | 26 |
| 592 | 3 | 56 | 18 |
| 487 | 5 | 73 | 19 |
| 104 | 0 | 3 | 18 |
| 5 | 4 | 27 | 32 |

| *lea.* | *m.* | *fur.* | *p.* | *yds.* | *ft.* | *in.* | *bc.* |
|---|---|---|---|---|---|---|---|
| 476 | 2 | 7 | 39 | 4 | 2 | 11 | 2 |
| 300 | 1 | 6 | 24 | 0 | 2 | 9 | 1 |
| 10 | 2 | 3 | 6 | 2 | 1 | 7 | 2 |
| 8 | 2 | 5 | 19 | 3 | 0 | 10 | 1 |
| 100 | 0 | 6 | 9 | 2 | 1 | 0 | 0 |
| 97 | 2 | 4 | 32 | 0 | 2 | 6 | 1 |

| *a.* | *r.* | *p.* | *y.* | *ft.* | *in.* |
|---|---|---|---|---|---|
| 640 | 3 | 36 | 28 | 8 | 143 |
| 27 | 0 | 26 | 19 | 3 | 127 |
| 286 | 3 | 5 | 4 | 0 | 6 |
| 104 | 2 | 19 | 27 | 6 | 94 |
| 8 | 1 | 14 | 16 | 5 | 73 |
| 39 | 0 | 6 | 17 | 2 | 26 |

| *tuns.* | *hhds.* | *gal.* | *qt.* | *p.* |
|---|---|---|---|---|
| 706 | 3 | 62 | 3 | 1 |
| 384 | 2 | 58 | 2 | 0 |
| 145 | 0 | 7 | 0 | 1 |
| 4 | 3 | 46 | 1 | 0 |
| 375 | 2 | 27 | 3 | 1 |
| 82 | 0 | 4 | 0 | 1 |

| *qrs.* | *bu.* | *pec.* | *gal.* |
|---|---|---|---|
| 87 | 7 | 3 | 1 |
| 4 | 3 | 2 | 0 |
| 87 | 6 | 0 | 1 |
| 0 | 3 | 3 | 1 |
| 43 | 0 | 3 | 0 |
| 56 | 2 | 1 | 1 |

| *yrs.* | *m.* | *w.* | *d.* | *h.* | *m.* | *s.* |
|---|---|---|---|---|---|---|
| 1831 | 11 | 3 | 6 | 23 | 59 | 59 |
| 1790 | 8 | 2 | 4 | 19 | 40 | 27 |
| 864 | 5 | 1 | 3 | 15 | 24 | 16 |
| 4586 | 0 | 2 | 5 | 10 | 9 | 8 |
| 57 | 3 | 0 | 5 | 9 | 4 | 7 |
| 126 | 9 | 2 | 2 | 21 | 35 | 10 |

### EXERCISES.

(1) A person borrowed a certain sum of money and having paid in part thereof £502..5..6¼. the remainder to pay is £30..13..3¾. Required the sum borrowed?

(2) The deluge, or Noah's flood, happened 2356 years before Christ, how long is that ago, this present year 1833?

(3) *A* owes to *B* £384..16..9½. to *C* £103..19..0¾. to *D* £26..4..11¼. to *E* 18*s.* 4½*d.* to *F* £207..0..8½. to *G* £120..9..4½. to *H* £98..5..6¼. How much does *A* owe in the whole?

(4) Bought 6 bags of cotton, weight as follow, *3 cwt. 1 qr. 15 lbs. 3 cwt. 0 qrs. 22 lbs. 3 cwt. 2 qrs. 9 lb. 3 cwt. 0 qr 17 lbs. 2 cwt 2 qrs. 25 lbs. 3 cwt. 3 qrs. 14 lbs.* Required the whole weight.

(5) Paid to my Banker the following Bills, £1449..11..5. £2000..0..0. £449..17..6. £946..1..9. £556..10..10. £946..1..9. £1567..12..8. £833..6..8. How much in the whole?

(6) Bought 6 ends super black cloth, each 22 yards; 9 ends blue, each 26 yards; 8 ends brown, each 24¼ yards; 5 ends olive, each 21 yards; 6 ends brown, 24 yards each; 4 ends claret, 19 yards each; how much in the whole?

(7) The great bell at Moscow (the largest in the world) is said to weigh 198 *tons, 2 cwt.* In the city of Pekin there is one said to weigh 120000 *lbs.* The great bell at Oxford, the heaviest in England, weighs 7 *tons,* 11 *cwt. 3 qrs. 4 lbs.* St. Paul's bell, London, 4 *tons,* 16 *cwt. 3 qrs.* 18 *lbs.* Required the burden of a ship capable of conveying their united weight from one place to another?

(8) Number up the twelve Tribes of Israel (of those that were 20 years old and upwards able to go to war) mentioned in the 26th chapter of Numbers?

(9) Find how many years it was from the creation of Adam, to the universal deluge in the days of Noah, called Noah's flood, by the 5th. chapter, and 6th. verse of the 7th. chapter of Genesis?

(10) The ten commandments were delivered to Moses 1491 years before Christ, how long is that since, this being A. D. 1833?

(11) A youth having served 3 years, 7 months, 2 weeks, 5 days, 13 hours, found he had 2 years, 10 months, 1 week, 1 day, 11 hours to serve, how long did he engage for at first?

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## COMPOUND SUBTRACTION.

RULE. Write like names under one another. Begin at the right hand, and Subtract each number of the under line from that of the like name in the upper; but if it be too great Subtract it from the value of the next higher name, add the Remainder to the upper number and write the sum below, and in this case carry one to the under figure of the next name.

| | £. | s. | d. |
|---|---|---|---|
| From | 684 | 14 | 11 |
| Take | 253 | 8 | 5 |

| | £. | s. | d. |
|---|---|---|---|
| | 10476 | 8 | $4\frac{1}{2}$ |
| | 689 | 4 | 7 |

| | £. | s. | d. |
|---|---|---|---|
| Borrowed | 5976 | 3 | 8 |
| Paid | 846 | 5 | 7 |

| | £. | s. | d. |
|---|---|---|---|
| | 15694 | 0 | 0 |
| | 15693 | 19 | $11\frac{3}{4}$ |

| | £. | s. | d. |
|---|---|---|---|
| Lent | 1000 | 10 | 10 |
| Received | 101 | 9 | $11\frac{1}{2}$ |

| | £. | s. | d. |
|---|---|---|---|
| | 30076 | 13 | 6 |
| | 189 | 13 | 7 |

| lbs. | oz. | dwt. | gr. |
|---|---|---|---|
| 1547 | 6 | 9 | 20 |
| 608 | 9 | 11 | 23 |

| tons, | cwt. | qrs. | lbs. | oz. | drs. |
|---|---|---|---|---|---|
| 489 | 14 | 2 | 26 | 12 | 10 |
| 190 | 17 | 3 | 26 | 13 | 14 |

| yds. | qrs. | n. |
|---|---|---|
| 107 | 2 | 2 |
| 96 | 2 | 3 |

| hks. | leas | thr. | in. |
|---|---|---|---|
| 576 | 3 | 48 | 27 |
| 298 | 6 | 54 | 39 |

| bdles. | slips, | leas, | thr. | in. |
|---|---|---|---|---|
| 3685 | 14 | 8 | 100 | 84 |
| 947 | 17 | 9 | 47 | 89 |

*Worsted*

| hks. | l. | thr. | in. |
|---|---|---|---|
| 4835 | 0 | 74 | 14 |
| 97 | 4 | 78 | 32 |

| m. | fu. | p. | yd. | ft. | in. |
|---|---|---|---|---|---|
| 131 | 4 | 8 | 2 | 2 | 10 |
| 117 | 4 | 13 | 3 | 2 | 11 |

| a. | r. | p. | y. |
|---|---|---|---|
| 47 | 2 | 34 | 4 |
| 39 | 3 | 10 | 5 |

| tuns, | hhd. | gal. | pt. |
|---|---|---|---|
| 33 | 1 | 42 | 6 |
| 23 | 3 | 51 | 3 |

| yrs. | m. | w. | d. | h. | mi. | s. |
|---|---|---|---|---|---|---|
| 1831 | 6 | 3 | 4 | 19 | 43 | 15 |
| 1790 | 7 | 2 | 5 | 23 | 58 | 49 |

### EXERCISES.

(1) A Merchant has cash £584..16..9.; goods value £1264..0..$9\frac{1}{2}$.; a mill value £3785..16..0.; book debts due to him £864..15..7.; stock in the mill £4076..18. He owes to his machine maker £1087..6..4.; to his cotton dealer £735..9..8.; to a builder £698..19..6.; to sundry persons £125..19..$11\frac{1}{2}$. What is the neat amount of his stock?

(2) Almanacs were first published in their present form in 1474. How long is it since?

(3) Subtract £100000. from sixteen millions and thirty pounds?

(4) Required the difference between the money coined in the reign of George 1st. being £8725951. and of that coined by George 2nd. being £11966576.?

(5) Bought 10 bags of cotton, weight as under.

| *No.* | *cwt.* | *qrs.* | *lbs.* |
|---|---|---|---|
| 1. | 3 | 0 | 18 |
| 2. | 2 | 2 | 22 |
| 3. | 2 | 3 | 10 |
| 4. | 2 | 3 | 0 |
| 5. | 3 | 2 | 25 |
| 6. | 3 | 1 | 23 |
| 7. | 3 | 0 | 9 |
| 8. | 3 | 1 | 17 |
| 9. | 2 | 3 | 19 |
| 10. | 3 | 3 | 14 |

And sold Nos. 1, 3, 5, 6, 8, and 10. Required the gross weight remaining on hand?

(6) I have an estate in the country worth £200. per annum, but I pay for land tax 10 guineas, for superintending the estate and collecting the rent 1*s.* in the pound, and for repairs after the rate of 20 guineas yearly; how much is the clear yearly income of the estate?

(7) Telescopes were first used in Germany in 1621. How many years is it since, this being 1833?

(8) A nobleman left his oldest son fifteen thousand pounds, and to the youngest six hundred guineas and twenty-three pounds. How much had the oldest more than the youngest?

(9) Henry the Third of England reigned 56 years and 4 weeks; George the Third reigned 59 years, 13 weeks, 5 days. How much longer did George the Third reign than Henry the Third?

(10) England contains 10000 leagues of roads, 1500 leagues of canals, and 1200 leagues of rail roads; France has more than twice the extent of territory of England and contains 1500 leagues of roads, 5000 leagues of canals and 40 leagues of rail roads. How many leagues of conveyance does England contain more than France?

(11) An estate consists of 476 acres, 3 roods, 14 perches, three parts of it are sold, the first containing 104 acres, 3 roods, 26 perches; the second 63 acres, 2 roods, 15 perches; the third 87 acres, 2 roods, 29 perches. How much remains unsold?

(12) Sent a due bill of exchange value £43..14..9. to pay

an account of £28..15..10½. Required the amount of the change out?

(13) A youth bound an apprentice for seven years has served 4 years, 5 months, 3 weeks, 4 days and 16 hours. How much longer has he to serve?

(14) Required the difference in length of one pound each of No. 24 and 124 hanks of yarn?

(15) I am allowed one ounce per pound for winding, warping and weaving 640 *lbs.* of silk, what weight of manufactured silk ought I to return?

## COMPOUND MULTIPLICATION.

RULE 1. When the Multiplier is not greater than 12, write it under the lowest name of the Multiplicand, and in multiplying carry as in Addition of the same name.

EXAMPLES.

| | £. | s. | d. | |
|---|---|---|---|---|
| Multiply | 16 | 14 | 8½ | |
| by | | | 5 | |
| | £83 | 13 | 6½ | |

| | £. | s. | d. | |
|---|---|---|---|---|
| (1) | 6 | 4 | 9 | × 2 |
| (2) | 8 | 7 | 4½ | × 3 |
| (3) | 14 | 12 | 7¾ | × 4 |
| (4) | 52 | 9 | 0½ | × 5 |
| (5) | 0 | 18 | 0¾ | × 6 |
| (6) | 15 | 13 | 8¼ | × 7 |
| (7) | 8 | 0 | 11½ | × 8 |
| (8) | 26 | 0 | 0¾ | × 9 |
| (9) | 101 | 19 | 11¼ | × 10 |

| | lbs. | oz. | dwt. | gr. | |
|---|---|---|---|---|---|
| (19) | 8 | 9 | 16 | 19 | × 8 |

| | tons, | cwt. | qr. | lb. | oz | drs. | |
|---|---|---|---|---|---|---|---|
| (20) | 37 | 14 | 2 | 25 | 14 | 10 | ×9 |

| | lbs. | oz. | dr. | sc. | gr. | |
|---|---|---|---|---|---|---|
| (21) | 43 | 11 | 6 | 2 | 17 | × 12 |

| | yds. | qrs. | n. | |
|---|---|---|---|---|
| (22) | 26 | 3 | 2 | × 6 |

| | hk. | l. | th. | in. | |
|---|---|---|---|---|---|
| (23) | 43 | 4 | 39 | 46 | × 11 |

| | bd. | sl. | le. | thr. | in. | |
|---|---|---|---|---|---|---|
| (24) | 104 | 16 | 9 | 109 | 87 | × 6 |

| | hks. | l. | th. | in. | |
|---|---|---|---|---|---|
| Multiply | 26 | 6 | 76 | 28 | |
| by | | | | 7 | |
| | 188 | 6 | 55 | 34 | |

| | £. | s. | d. | |
|---|---|---|---|---|
| (10) | 76 | 4 | 8¼ | × 11 |
| (11) | 0 | 15 | 10½ | × 12 |
| (12) | 43 | 7 | 9 | × 7 |
| (13) | 60 | 0 | 10¾ | × 12 |
| (14) | 84 | 16 | 9 | × 9 |
| (15) | 78 | 15 | 0¼ | × 11 |
| (16) | 0 | 19 | 8½ | × 12 |
| (17) | 97 | 13 | 4¾ | × 10 |
| (18) | 26 | 0 | 7 | × 12 |

| | mi. | f. | p. | y. | ft. | in. | bc. | |
|---|---|---|---|---|---|---|---|---|
| (25) | 27 | 4 | 19 | 4 | 2 | 9 | 2 | × 7 |

| | a. | r. | p. | yd. | ft. | in. | |
|---|---|---|---|---|---|---|---|
| (26) | 127 | 3 | 27 | 4 | 2 | 8 | × 8 |

| | t. | hhd. | g. | qt. | p. | |
|---|---|---|---|---|---|---|
| (27) | 7 | 3 | 56 | 3 | 1 | × 9 |

| | bar. | gal. | qt. | p. | |
|---|---|---|---|---|---|
| (28) | 43 | 33 | 2 | 1 | × 11 |

| | qr. | bu. | p. | gal. | |
|---|---|---|---|---|---|
| (29) | 47 | 6 | 3 | 1 | × 12 |

| | yrs | m. | w. | d. | h. | m. | s. | |
|---|---|---|---|---|---|---|---|---|
| (30) | 41 | 3 | 2 | 6 | 19 | 43 | 25 | ×11 |

RULE 2. When the Multiplier is the Product of two or more numbers, not exceeding 12, multiply by one of them, and the Product by another, and so on.

| | £. | s. | d. |
|---|---|---|---|
| (1) Multiply | 12 | 9 | $5\frac{3}{4}$ |
| by 42=7×6. | | | 7 |
| | 87 | 6 | $4\frac{1}{4}$ |
| | | | 6 |
| | £523 | 18 | $1\frac{1}{2}$ |

| | cwt. | qrs. | lbs. | oz. | dr. |
|---|---|---|---|---|---|
| (2) Multiply | 53 | 2 | 18 | 9 | 6 |
| by 84=12×7. | | | | | 12 |
| | 643 | 3 | 27 | 0 | 8 |
| | | | | | 7 |
| cwt. | 4507 | 3 | 21 | 3 | 8 |

| | £. | s. | d. | |
|---|---|---|---|---|
| (3) | 14 | 17 | 8 | × 18. |
| (4) | 15 | 0 | $9\frac{1}{4}$ | × 21. |
| (5) | 36 | 7 | $11\frac{1}{4}$ | × 22. |
| (6) | 0 | 14 | $3\frac{3}{4}$ | × 24. |
| (7) | 100 | 15 | $0\frac{1}{4}$ | × 25. |
| (8) | 97 | 0 | $4\frac{1}{2}$ | × 54. |
| (9) | 104 | 17 | 3 | × 63. |
| (10) | 59 | 8 | $11\frac{1}{2}$ | × 77. |
| (11) | 24 | 17 | 0 | × 27. |
| (12) | 36 | 0 | $7\frac{3}{4}$ | × 32. |
| (13) | 50 | 6 | $4\frac{1}{4}$ | × 45. |
| (14) | 93 | 14 | 8 | × 66. |
| (15) | 0 | 19 | $11\frac{3}{4}$ | × 72. |

| | £. | s. | d. | |
|---|---|---|---|---|
| (16) | 18 | 0 | $4\frac{1}{2}$ | × 56. |
| (17) | 13 | 8 | 5 | × 108. |
| (18) | 7 | 9 | $3\frac{1}{2}$ | × 144. |
| | lbs. | oz. | dwt. | gr. |
| (19) | 7 | 9 | 14 | 17 × 48. |
| | cwt. | qrs. | lbs. | oz. |
| (20) | 9 | 3 | 15 | 11 × 132. |
| | hks. | l. | th. | in. |
| (21) | 95 | 4 | 79 | 52 × 60. |
| | m. | fur. | p. | yds. |
| (22) | 93 | 4 | 26 | 3 × 168. |
| | yrs. | m. | w. | d. |
| (23) | 34 | 8 | 3 | 4 × 75. |

RULE 3. When the Multiplier is not the product of two or more numbers, take the nearest product, and multiply by its factors and then by the difference; if the assumed number be less than the Multiplier add the products; if greater, subtract them.

(1) Multiply £. 6, s. 15, d. $4\frac{3}{4}$ by $38 = 9 \times 4 + 2$.

| | | |
|---|---|---|
| | | 9 |
| 60 | 18 | $6\frac{3}{4}$ |
| | | 4 |
| 243 | 14 | 3 |
| 13 | 10 | $9\frac{1}{2}$ = top line by 2 add. |
| £257 | 5 | $0\frac{1}{2}$ |

(2) Multiply £. 77 s. 14 d. 3 by 106 = 12 × 9 − 2.

| £. | s. | d. | |
|---|---|---|---|
| | | 12 | |
| 932 | 11 | 0 | |
| | | 9 | |
| 8392 | 19 | 0 | |
| 155 | 8 | 6 | = top line by 2 subtract. |
| £8237 | 10 | 6 | |

| | £. | s. | d. | | | £. | s. | d. | |
|---|---|---|---|---|---|---|---|---|---|
| (3) | 13 | 6 | $0\frac{1}{2}$ | × 17. | (11) | 85 | 0 | $7\frac{3}{4}$ | × 95. |
| (4) | 5 | 0 | $7\frac{3}{4}$ | × 23. | (12) | 17 | 8 | $6\frac{1}{2}$ | × 106. |
| (5) | 6 | 0 | $0\frac{1}{2}$ | × 38. | (13) | 147 | 6 | 0 | × 74. |
| (6) | 17 | 4 | $9\frac{1}{4}$ | × 39. | (14) | 53 | 8 | $5\frac{1}{2}$ | × 142. |
| (7) | 0 | 12 | $10\frac{3}{4}$ | × 62. | (15) | 8 | 0 | $11\frac{1}{2}$ | × 82. |
| (8) | 27 | 9 | $4\frac{1}{2}$ | × 59. | (16) | 34 | 19 | $0\frac{3}{4}$ | × 53. |
| (9) | 63 | 14 | $9\frac{1}{4}$ | × 47. | (17) | 126 | 0 | $7\frac{1}{2}$ | × 79. |
| (10) | 107 | 6 | $3\frac{1}{2}$ | × 83. | | | | | |

RULE 4. When the Multiplier is large multiply it by 10, and the Product by 10, and so on till the Multiplicand and the Products make as many lines as there are figures in the Multiplier; then multiply the first line by the right hand figure, the next line by the second figure, and so on; add the Products thus obtained.

Multiply £. 4 s. 16 d. $9\frac{1}{2}$ by 4567.

| £. | s. | d. | | £. | s. | d. |
|---|---|---|---|---|---|---|
| | | 10 | | | | |
| 48 | 7 | 11 | × 6 = | 290 | 7 | 6 |
| | | 10 | | | | |
| 483 | 19 | 2 | × 5 = | 2419 | 15 | 10 |
| | | 10 | | | | |
| 4839 | 11 | 8 | × 4 = | | | |
| | | 4 | | | | |
| 19358 | 6 | 8 | | | | |
| 2419 | 15 | 10 | | | | |
| 290 | 7 | 6 | | | | |
| 33 | 17 | $6\frac{1}{2}$ | | | | |
| £22102 | 7 | $6\frac{1}{2}$ | | | | |

### EXERCISES.

1. When the value, weight, measure, &c. of an article is given, to find the value of any number of articles.

RULE. Multiply by the number of articles.

2. To find the amount of wages, or any thing that is increased by length of time.

RULE. Multiply by the time.

What is the price of

(1) 16 *cwt.* of indigo, at £19..7..4½. per *cwt.*?
(2) 8 stone of wool, at 19*s.* 7¾*d.* per stone?
(3) 11 *lbs* of coffee, at 2*s.* 9½*d.* per *lb*?
(4) 9 yards of blue cloth, at 8*s.* 6*d.* per yard?
(5) 15 gross of tape, at 6*s.* 7½*d.* per gross?
(6) 42 umbrellas, at 5*s.* 9*d.* each?
(7) 18 reams of paper, at 17*s.* 6*d.* per ream?
(8) 27 square yards of flags, at 2*s.* 3½*d.* per yard?
(9) 84 *lbs.* of flooring nails, at 4¾*d.* per *lb.*?
(10) 35 crates of earthenware, at £4..18..6. per crate?
(11) 63 dozen cans of milk, at 2*s.* 5½*d.* per can?
(12) 37 *oz.* of silver, at 5*s.* 4¾*d.* per *oz.*?
(13) 29 sets of china, at £3..17..9½. per set?
(14) 53 barrels of ale, at £2..12..7. per barrel?
(15) 74 oxen, at £12..9..6. per head?
(16) 87 *lbs.* of brevier type, at 3*s.* 7½*d.* per *lb.*?
(17) 240 bundles of twist, 10 *lbs.* each, at 4*s.* 3½*d.* per *lb.*?
(18) 94 demies of muslin, at £2..17..6½. per demy?
(19) 38 gross of bobbins, at 8*s.* 7¾*d.* per gross?
(20) 69 thousand bricks, at 24*s.* 7*d.* per thousand?
(21) 160,000 laths, at 16*s.* 9½*d.* per 1000?
(22) 56 weeks' wages, at 18*s* 7½*d.* per week?
(23) 94 dozen of wine, at 36*s.* 4½*d.* per dozen?
(24) 146 gross of corks, at 4*s.* 3¾*d.* per gross?
(25) 186 yards of gas-piping, at 3*s.* 4½*d.* per yard?
(26) 423 tons of coal, at £1..6. 8½. per ton?
(27) 108 loads of lime, at 1*s.* 1¾*d.* per load?
(28) 1728 cubic feet of gas, at 2*s.* 3½*d.* per foot?
(29) 78 chronometers, at £5..17..8. each?
(30) 525 *lbs.* of brass castings, at 14¾*d.* per *lb.*?
(31) 468 yards of muslin, at 1*s.* 10½*d.* per yard?
(32) 375 cubic feet of stone, at 4*s.* 10¾*d.* per foot?

(33) 156 dozen of Pullicat handkerchiefs, at 7*s.* 9¾*d.* per dozen?

(34) 56 pieces of cord gingham, at 11*s.* 9*d.* per piece?

(35) 8 Cheshire cheeses, each containing 25¾ *lbs.* at 6*d.* per *lb.*?

(36) 500 pieces of super calico's, at 6*s.* 4*d.* per piece?

(37) 347 score of doffings, reeled at 1*s.* 4¾*d.* per score?

(38) 487 *lbs.* of cotton yarn, dyed blue at 7¾*d.* per *lb.*?

(39) 146 *lbs.* of lead, at 2¾*d.* per *lb.*?

(40) 3 sugar loaves, weight 54½ *lbs.* at 7¾*d.* per *lb.*?

(41) 63 dozen of candles, at 5¾*d.* per *lb.*?

(42) 144 sacks of flour, at 43*s.* 9*d.* per sack?

(43) 56 loads of meal, at 34*s.* 10½*d.* per load?

(44) 38 weeks' rent, at 5*s.* 9½*d.* per week?

(45) 1520 spindles, turned by power at 1*s.* 1½*d.* per spindle?

(46) 19 feet of filletting, at 10¾*d.* per foot?

(47) 136 sheet cards, at 2*s.* 3½*d.* per sheet?

(48) 94 *lbs.* of bell-metal castings, at 1*s.* 2½*d.* per *lb.*?

(1) What is the weight of 49 bales of Surat cotton, each weighing 4 *cwt.* 1 *qr.* 26 *lbs.* per bale?

(2) What will the spinning of 11 sets of yarn, each weighing 6 *lbs.* 10 *oz.* 12 *dr.* come to, at 9½*d.* per *lb.*?

(3) A very violent hurricane goes at the rate of 146¾ feet in one second of time. What is the hourly motion in miles?

(4) The pressure of the atmosphere upon a square inch of the earth's surface is 14 *lbs.* 6 *oz.* 6 *dr.* What is that upon an acre of land?

(5) Suppose there are 1756 stretches, of 54 inches each, on one cop. How many hanks, leas and threads?

(6) If there are 1680 stretches, of 54 inches, on one cop, what quantity of yarn in a set of 480 cops?

(7) A wagon is drawn at the rate of 2½ miles per hour. What time would it be in passing from Manchester to London, the distance being 182 miles?

(8) A deed is to be engrossed, containing 6480 words; 30 folios, each containing 72 words, are to be put on the first skin of parchment, and 15 folios on every subsequent skin. Required the number of skins of parchment for the deed.

(9) The earth revolves round the sun at the rate of 68000 miles per hour. How many miles is that per Julian year?

(10) If 2¼ hanks of yarn can be spun on one spindle in

twelve hours, what quantity will 480 spindles turn off in the same time?

(11) The piston of a steam engine moves at the rate of 220 feet per minute. What is the rate per hour and per day of $11\frac{1}{2}$ hours?

(12) Suppose a person in trade can clear £362..10..6½. a year, how much will he have in $13\frac{1}{2}$ years' trading?

(13) In 8000 turns of a wheel, $16\frac{1}{2}$ feet in circumference, how many miles will it run over?

(14) If 45 patients were to have 20 boluses each, and each bolus to weigh 4 scruples, how many pounds of ingredients would it take to make the whole composition?

(15) There are 38 sheet cards, each $4\frac{1}{2}$ inches broad, to clothe a cylinder. Required the circumference.

(16) Required the weight of a cask of oil, containing 130 gallons, allowing $7\frac{1}{2}$ *lbs.* to a gallon.

(17) A lap frame will deliver 36 *lbs.* of cotton per hour. What is that per day, of 11 hours; and per week, of 66 hours?

(18) A piece of cambric, 54 inches broad, has 90 warp threads in one inch. How many in the whole breadth?

(19) A throstle delivers 316 yards of twist per spindle per hour. How many hanks per day, of $11\frac{1}{2}$ hours?

(20) A mule, of 480 spindles, makes 2 stretches, of 54 inches each in one minute. How much yarn is spun in one day, of $11\frac{1}{2}$ hours?

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## COMPOUND DIVISION.

RULE. Begin at the highest denomination. Divide it as in Simple Division. Reduce the remainder into the next inferior name, adding the given number of that name; divide this in the same manner, and so on till the lowest.

NOTE. If the Divisor is 12, or under, work mentally.

| | £. | s. | d. | | £. | s. | d. | | £. | s. | d. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 4)63 | 18 | 8 | (6) | 9)80 | 6 | 9 | (11) | 8)481 | 13 | $7\frac{1}{2}$ |
| (2) | 5)48 | 12 | 6 | (7) | 10)434 | 15 | 8 | (12) | 9)23 | 0 | $9\frac{2}{4}$ |
| (3) | 6)234 | 14 | 9 | (8) | 11)26 | 0 | 9 | (13) | 7)121 | 14 | 0 |
| (4) | 7)175 | 16 | 7 | (9) | 12)257 | 14 | 9 | (14) | 6)53 | 16 | $4\frac{1}{2}$ |
| (5) | 8)67 | 13 | 4 | (10) | 11)43 | 17 | 6 | (15) | 12)596 | 19 | $11\frac{3}{4}$ |

| | | cwt. | qrs. | lbs. | oz. | dr. |
|---|---|---|---|---|---|---|
| (16) | 3)146 | 3 | 14 | 10 | 14 | |
| | | lbs. | oz. | dwts. | gr. | |
| (17) | 5)17 | 10 | 16 | 12 | | |
| | | lbs. | oz. | dr. | scr. | gr. |
| (18) | 9)23 | 11 | 7 | 2 | 14 | |
| | | yds. | qrs. | n. | | |
| (19) | 7)46 | 2 | 2 | | | |
| | | hks. | le. | th. | in. | |
| (20) | 11)474 | 3 | 23 | 49 | | |
| | | yds. | ft. | in. | | |
| (21) | 6)237 | 2 | 9 | | | |
| | | m. | fur. | p. | | |
| (22) | 8)93 | 4 | 24 | | | |
| | | hhds. | gal. | p. | | |
| (23) | 11)54 | 27 | 3 | | | |

| | | t. | qrs. | oz. |
|---|---|---|---|---|
| (24) | 12)75 | 3 | 14 | |
| | | m. | p. | ft. |
| (25) | 9)49 | 33 | 9 | |
| | | hks. | th. | |
| (26) | 4)93 | 53 | | |
| | | a. | r. | p. |
| (27) | 11)86 | 3 | 27 | |
| | | hhds. | gal. | p. |
| (28) | 8)64 | 3 | 2 | |
| | | lbs. | oz. | dr. |
| (29) | 7)43 | 6 | 11 | |
| | | cwt. | qrs. | lbs. |
| (30) | 8)456 | 3 | 23 | |
| | | yrs. | m. | w. d. |
| (31) | 9)243 | 11 | 3 | 4 |

When the Divisor is the product of any two Factors, not exceeding 12, divide successively by these Factors.

| | | £. | s. | d. |
|---|---|---|---|---|
| (32) | 15)17 | 14 | $9\frac{3}{4}$ | |
| (33) | 16)43 | 0 | 8 | |
| (34) | 18)153 | 7 | $0\frac{1}{2}$ | |
| (35) | 21)6 | 0 | 9 | |
| (36) | 24)104 | 15 | $9\frac{1}{2}$ | |
| (37) | 32)38 | 6 | $4\frac{3}{4}$ | |
| (38) | 35)84 | 19 | 5 | |
| (39) | 48)175 | 8 | 0 | |

| | | £. | s. | d. |
|---|---|---|---|---|
| (40) | 25)246 | 18 | 6 | |
| (41) | 63)57 | 8 | 9 | |
| (42) | 84)146 | 7 | 3 | |
| (43) | 72)279 | 18 | 11 | |
| (44) | 121)153 | 6 | 8 | |
| (45) | 132)259 | 14 | 9 | |
| (46) | 144)736 | 9 | 4 | |

| | | cwt. | qrs. | lbs. |
|---|---|---|---|---|
| (47) | 16)43 | 2 | 8 | |
| | | yds. | ft. | in. |
| (48) | 27)146 | 2 | 11 | |
| | | bar. | g. | p. |
| (49) | 36)46 | 9 | 4 | |
| | | hks. | le. | th. |
| (50) | 45)473 | 6 | 45 | |
| | | a. | p. | |
| (51) | 56)168 | 27 | | |
| | | m. | f. | p. |
| (52) | 64)325 | 3 | 14 | |

| | | yrs. | m. | d. |
|---|---|---|---|---|
| (53) | 75)1473 | 11 | 24 | |
| | | t. | cwt. | lbs. |
| (54) | 88)1694 | 17 | 14 | |
| | | lbs. | oz. | dwts. |
| (55) | 96)257 | 11 | 15 | |
| | | hhds. | gal. | |
| (56) | 108)678 | 53 | | |
| | | yds. | qrs. | n. |
| (57) | 132)594 | 3 | 2 | |
| | | yrs. | w. | h. |
| (58) | 144)987 | 3 | 21 | |

EXERCISES.

1st. When the value, weight, measure, &c. of a given number of articles is given, to find the value, &c. of one.

RULE. Divide the value, &c. by the number of articles.

2nd. When the value, weight, measure, &c. of the whole is given, and also the value, &c. of one, to find the number of articles.

RULE. Divide the value, &c. of the whole by the value, &c. of one; both values, &c. being first reduced to the lowest name mentioned.

3rd. To find the wages, work, &c. in a single year, day, &c. divide by the number of years, days, &c.

4th. To find the time of earning wages, performing work, &c. divide by the amount per year, day, &c.

(1) If 17 yards of cloth cost £19..3..9. what is it per yard?

(2) If 1 *cwt.* of cheese cost 42*s.* what is that per *lb.*?

(3) A farm of 56 acres pays a rent of £280. what is that per acre?

(4) A set of yarn weighs 4 *lbs.* and contains 500 hanks; required the counts.

(5) If 9 bags of cotton weigh 32 *cwt.* 2 *qrs.* 22 *lbs.* required the average weight of one bag.

(6) If a set of yarn weighs 5 *lbs.* 4 *oz.* and contains 630 hanks, what will be the counts of yarn?

(7) Out of 12 *cwt.* 3 *qrs.* 12 *lbs.* of tea, how many canisters can I fill, each canister holding 12 *lbs.*?

(8) A person promises to discharge a debt of £3..10..10. by weekly payments of 34*d.* How long will it take to discharge the debt?

(9) A stone is to be raised 120 feet in 8 minutes. Required the velocity per minute.

(10) If a spindle turns off 3 hanks, 2 leas, 6 threads of yarn per day of 12 hours, what quantity is that per hour?

(11) A gentle gale of wind passes off at the rate of 5 miles per hour. How many feet is that in one second of time?

(12) Dr. Herschell has seen 116000 stars pass through the field view of his telescope in 15 minutes. How many passed per minute?

(13) A piece of cloth, at 5*s.* per yard, cost £20. How many yards were in it?

(14) If 43 yards of cloth cost £22..11..6. what is that per yard?

(15) Divide £3..10. among 5 men and 6 women, and give each man thrice the share of a woman.

(16) What is the weekly rent of a labourer's house, if he pays £6. for one year?

(17) Five persons clear £473..18..6. by making bricks in one season. Required each person's gain.

(18) A gold vase cost £188..2..6. at £4..7..6. per ounce. What was its weight?

(19) A piece of calico, 28 yards long, 42 inches broad, is to be printed with blocks, each 8 inches long, 6 inches broad. Required the number of impressions on one piece.

(20) How many motions, one revolution of the cylinder, ought the crank of the doffer to make, to strip the cotton every $\frac{1}{2}$ inch from a cylinder 38 inches in circumference?

(21) Required the number of gallons in a cask of oil, weighing neat 4 *cwt.* 3 *qrs.* 12 *lbs.* one gallon being $7\frac{1}{2}$ *lbs.*

(22) How many teeth, of 2 inches pitch, are in a wheel of 12 feet circumference?

(23) If a plank be 3 inches thick, and 12 inches broad, how much more weight will it bear with its edge than with the flat side uppermost?

(24) Suppose the piston of a steam engine to travel 220 feet per minute, and the length of the stroke up and down to be 8 feet, what is the number of strokes per minute?

*Questions applicable to the preceding Rules.*

Multiply £6..17..$4\frac{1}{2}$. by $2\frac{1}{2}$.
Multiply £8. 9..3. by $5\frac{1}{4}$.
Multiply 17 *t.* 6 *cwt.* 2 *qrs.* 18 *lbs.* by $7\frac{3}{4}$.
Multiply 43 *hks.* 6 *le.* 53 *th* 47 *in.* by $9\frac{3}{8}$.
Multiply 9 *hhds.* 27 *gal.* 6 *pts.* by $11\frac{1}{3}$.
Divide £35..9..$8\frac{1}{2}$. by $3\frac{1}{5}$.
Divide £104..18..$11\frac{1}{2}$. by $6\frac{7}{8}$.
Divide £26..19..$4\frac{1}{2}$. by $8\frac{3}{8}$.
Divide 276 *cwt.* 3 *qrs.* 24 *lbs.* by $11\frac{1}{4}$.

(1) What cost 8 warps, each weighing 11 *lbs.* 4 *oz.* at 1*s.* $3\frac{1}{2}$*d.* per *lb.*?

(2) What cost $7\frac{1}{2}$ dozen Pullicat handkerchiefs, at $10\frac{1}{2}$*d.* each?

(3) What cost 7854 *lbs.* of cotton, at $7\frac{3}{8}$*d.* per *lb.*?

(4) If 5534 *lbs.* of cotton cost £256..3..5. what is that per *lb.*?

(5) How many *cwt.* of cotton can I have at $11\frac{1}{2}$*d.* per *lb.* for £168..15..3.?

(6) Suppose a person by trading can clear £4894..2..$3\frac{3}{4}$. in $13\frac{1}{2}$ years, what is his yearly increase of fortune?

(7) How many parcels, each $126\frac{1}{2}$ *lbs.* can I have out of an hogshead of sugar weighing $8\frac{3}{4}$ *cwt.*?

(8) There are 9 butts of bricks, the 2 first contain 178 bricks long and 36 broad each; 3 others, 246 long and 32 broad each; 4 others, 378 bricks long and 40 broad each. How many bricks in the whole?

(9) How many moons, of $29\frac{1}{2}$ days, are there in $365\frac{1}{4}$ days?

(10) A draper paid £44..13..4½. for 17 pieces of print, at $10\frac{1}{2}d.$ per yard. How many yards were in a piece?

(11) A gentleman, on landing at Liverpool, found himself possessed of the following sums, viz. 36 pieces, of £3..12. each; 27, of 36*s.* each; 94, of 16*s.* 6*d.* each; 84, of 27*s.* each; 543, of 4*s.* 6*d.* each. Required the amount.

(12) A labourer's wages amount to 18*s.* per week. How much have his family to live upon if he lays by £11. for house rent and clothes?

(13) A gentleman is desirous of saving 180 guineas per annum out of a yearly income of £764. How much may he spend daily?

(14) Required the value of yarn contained in the following list, at 15*d.* per *lb.* for 24 hanks twist, rising $\frac{1}{4}d.$ per *lb.* at every 2 hanks, each bundle weighing 10 *lbs.*

126 bundles, 24 hanks.
84 bundles, 26 hanks.
140 bundles, 28 hanks.
60 bundles, 30 hanks.
72 bundles, 32 hanks.

(15) In 14 *cwt.* of 120 *lbs.* each, how many *cwt.* of 112 *lbs.* each?

(16) In 15 *cwt.* of 112 *lbs.* each, how many *cwt.* of 120 *lbs.* each?

(17) How many planks, $\frac{7}{8}$ of an inch thick, can be cut out of a balk 20 inches broad, allowing $\frac{1}{8}$ of an inch to each plank for the saw guage?

(18) The main cylinder of a carding engine is 162 inches in circumference. How many sheet cards, $4\frac{1}{2}$ inches wide, will be required to cover the same?

(19) A warp contains 2520 ends, and upon waling there are 15 ends in $\frac{1}{4}$ of an inch. Required the breadth of the cloth.

(20) Required the number of tokens, of 20 threads each, upon each of 4 heald shafts, to weave a warp of 1200 ends.

(21) If a steam vessel, let into a basin of water, causes an overflow of 50000 cubic feet of water, what will be the weight of the vessel?

*To find the average of any sum of numbers.*

RULE. Add up the numbers, and divide the sum by the number of Items; the Quotient will be the average number.

(1) Find the average of the following numbers: 35, 48, 56, 21, 63, 84, 105.

(2) Required the average of the following numbers: 45, 81, 72, 99, 107, 153, 135, 144.

(3) Sold woollen cloth, the lengths as under: required the average length per piece; 13 yards, 14 yards, 15 yards, 16 yards, 17 yards, 19 yards, 20 yards, 21 yards, 22 yards, 23 yards, 24 yards.

(4) Bought cotton as under: required the average weight per bag.

| *cwt.* | *qrs.* | *lbs.* |
|---|---|---|
| 3 | 2 | 22 |
| 3 | 1 | 5 |
| 3 | 0 | 17 |
| 3 | 2 | 19 |
| 3 | 1 | 27 |
| 3 | 1 | 17 |
| 3 | 3 | 6 |

(5) What will be the average numbers of the following list of yarn: No. 24 hanks, No. 26's, No. 28's, No. 30's, No. 32's, No. 34's?

(6) Three cops wrap 6 hanks, 4 leas, 10 threads. Required the average length of one cop.

(7) There are six numbers which average 14. Required the amount.

(8) The velocity of a stream of water on the surface is 25 feet per second, and at the bottom 16 feet per second. Required the mean velocity.

(9) If the girts of a tree, in different places, be 6 *ft.* 8 *in.*; 6 *ft.* 4 *in.*; 5 *ft.* 10 *in.*; 5 *ft.* 3 *in.*; 4 *ft.* 7 *in.*; 4 *ft.* 3 *in.*; 3 *ft.* 9 *in.* and 2 *ft.* 10 *in.* what is the mean girt?

(10) A boat, calculated to carry 1 ton for every inch of water she dips above the keel, dips at the stem 19 inches, in the middle 18 inches, at the stern 17 inches. Required the number of tons loading.

(11) Another boat dips unevenly at each side; the stem dips being 18 *in.* and 16 *in.*; the middle 17 *in.* and 15 *in.* and the stern 14 *in.* and 13 *in.* Required the loading she carries.

## PRACTICE

**Is generally understood to be the method of computing by Aliquot parts.**

TABLE OF ALIQUOT PARTS.

| *Of a pound.* | | | *Of a shilling.* | | | *Of a cwt.* | | |
|---|---|---|---|---|---|---|---|---|
| *s.* | *d.* | | *d.* | | | 2 *qrs.* | = | $\frac{1}{2}$ |
| 10 | 0 | = $\frac{1}{2}$ | 6 | = $\frac{1}{2}$ | | 1 | = | $\frac{1}{4}$ |
| 6 | 8 | = $\frac{1}{3}$ | 4 | = $\frac{1}{3}$ | | 56 *lbs.* | = | $\frac{1}{2}$ |
| 5 | 0 | = $\frac{1}{4}$ | 3 | = $\frac{1}{4}$ | | 28 | = | $\frac{1}{4}$ |
| 4 | 0 | = $\frac{1}{5}$ | 2 | = $\frac{1}{6}$ | | 16 | = | $\frac{1}{7}$ |
| 3 | 4 | = $\frac{1}{6}$ | $1\frac{1}{2}$ | = $\frac{1}{8}$ | | 14 | = | $\frac{1}{8}$ |
| 2 | 6 | = $\frac{1}{8}$ | 1 | = $\frac{1}{12}$ | | 8 | = | $\frac{1}{14}$ |
| 2 | 0 | = $\frac{1}{10}$ | $\frac{3}{4}$ | = $\frac{1}{16}$ | | 7 | = | $\frac{1}{16}$ |
| 1 | 8 | = $\frac{1}{12}$ | $\frac{1}{2}$ | = $\frac{1}{24}$ | | *Of a hank of cotton.* | | |
| 1 | 4 | = $\frac{1}{15}$ | $\frac{1}{4}$ | = $\frac{1}{48}$ | | *yds.* | | |
| 1 | 3 | = $\frac{1}{16}$ | *Of a sixpence.* | | | 420 | = | $\frac{1}{2}$ |
| 1 | 0 | = $\frac{1}{20}$ | *d.* | | | 210 | = | $\frac{1}{4}$ |
| 0 | 10 | = $\frac{1}{24}$ | 3 | = $\frac{1}{2}$ | | 140 | = | $\frac{1}{6}$ |
| 0 | 8 | = $\frac{1}{30}$ | 2 | = $\frac{1}{3}$ | | 120 | = | $\frac{1}{7}$ |
| 0 | 6 | = $\frac{1}{40}$ | $1\frac{1}{2}$ | = $\frac{1}{4}$ | | 70 | = | $\frac{1}{12}$ |
| 0 | 4 | = $\frac{1}{60}$ | 1 | = $\frac{1}{6}$ | | 60 | = | $\frac{1}{14}$ |
| 0 | 3 | = $\frac{1}{80}$ | $\frac{3}{4}$ | = $\frac{1}{8}$ | | 56 | = | $\frac{1}{15}$ |
| 0 | 2 | = $\frac{1}{120}$ | $\frac{1}{2}$ | = $\frac{1}{12}$ | | 30 | = | $\frac{1}{28}$ |
| 0 | 1 | = $\frac{1}{240}$ | $\frac{1}{4}$ | = $\frac{1}{24}$ | | | | |

Case 1. When the given price is the Aliquot part of £1. or 1*s.* &c.

Rule. Write down the value at £1. or 1*s.* &c. and take the same parts of it that the given price is of £1. or 1*s.* &c. and it will give the answer in pounds or shillings, &c.

(1) 9374 at 10*s.*
(2) 8435 at 10*s.*
(3) 5926 at 6*s.* 8*d.*
(4) 4327 at 5*s.*
(5) 8935 at 4*s.*
(6) 3896 at 3*s.* 4*d.*
(7) 6487 at 2*s.* 6*d.*
(8) 4739 at 2*s.*
(9) 8973 at 1*s.* 8*d.*
(10) 7064 at 1*s.* 4*d.*
(11) 2759 at 1*s.* 3*d.*
(12) 3753 at 1*s.*

(13) 4738 at 6*d.*
(14) 5743 at 6*d.*
(15) 9534 at 4*d.*
(16) 6857 at 3*d.*
(17) 5946 at 2*d.*
(18) 6389 at $1\frac{1}{2}$*d.*
(19) 7854 at 1*d.*
(20) 6438 at $\frac{3}{4}$*d.*
(21) 8594 at $\frac{1}{2}$*d.*
(22) 9436 at $\frac{1}{4}$*d.*
(23) 2351 at 2*d.*
(24) 54325 at $1\frac{1}{2}$*d.*

(25) 54936 at 3*d.*
(26) 78596 at $1\frac{1}{2}$*d.*
(27) 3459 at 2*d.*
(28) 5736 at 1*d.*
(29) 38947 at $\frac{3}{4}$*d.*
(30) 8965 at $\frac{1}{2}$*d.*
(31) 4784 at $\frac{1}{4}$*d.*
(32) 3721 at 5*s.*
(33) 1725 at 1*s.* 8*d.*
(34) 7591 at 1*s.* 3*d.*
(35) 3275 at 4*d.*
(36) 4573 at $\frac{3}{4}$*d.*

**Case 2. When the price is not the exact part of 1*s.* &c.**

**Rule. Take an exact part less than the price, and if the Remainder be not a part, take a part less than it, and so on; then find the value at all these prices and add them together, the sum is the value at the given price.**

**Note. After one part is taken, a part of it also may be taken.**

| | | |
|---|---|---|
| (1) 3751 at $1\frac{1}{4}d.$ | (11) 7521 at $5\frac{3}{4}d.$ | (21) 6325 at $9\frac{1}{4}d.$ |
| (2) 7210 at $2\frac{1}{4}d.$ | (12) 7914 at $6\frac{1}{4}d.$ | (22) 7294 at $9\frac{1}{2}d.$ |
| (3) 6524 at $1\frac{3}{4}d.$ | (13) 3250 at $6\frac{1}{2}d.$ | (23) 2150 at $9\frac{3}{4}d.$ |
| (4) 7062 at $3\frac{1}{4}d.$ | (14) 2708 at $6\frac{3}{4}d.$ | (24) 5724 at $10\frac{1}{4}d.$ |
| (5) 2065 at $4\frac{1}{4}d.$ | (15) 3254 at $7\frac{1}{4}d.$ | (25) 6327 at $10\frac{1}{4}d.$ |
| (6) 3572 at $4\frac{1}{2}d.$ | (16) 2701 at $7\frac{1}{2}d.$ | (26) 3254 at $10\frac{1}{2}d.$ |
| (7) 2107 at $4\frac{3}{4}d.$ | (17) 3714 at $7\frac{3}{4}d.$ | (27) 7291 at $10\frac{3}{4}d.$ |
| (8) 3210 at $5d.$ | (18) 3514 at $8\frac{1}{4}d.$ | (28) 3754 at $11\frac{1}{2}d.$ |
| (9) 2715 at $5\frac{1}{4}d.$ | (19) 2759 at $8\frac{1}{2}d.$ | (29) 7972 at $11\frac{3}{4}d.$ |
| (10) 3120 at $5\frac{1}{2}d.$ | (20) 9872 at $8\frac{3}{4}d.$ | (30) 4063 at $11\frac{1}{4}d.$ |

**Case 3. When the price is more than one shilling and less than two.**

**Rule. Take the Aliquot part or parts for so much of the given price as is more than one shilling, which add to the given quantity, and divide by 20 for the Answer.**

| | | |
|---|---|---|
| *s. d.* | *s. d.* | *s. d.* |
| (1) 2790 at 1 $1\frac{1}{2}$. | (8) 7250 at 1 $5\frac{1}{4}$. | (14) 1004 at 1 $8\frac{3}{4}$. |
| (2) 7904 at 1 $1\frac{3}{4}$. | (9) 7103 at 1 $6\frac{1}{4}$. | (15) 2751 at 1 $9\frac{1}{4}$. |
| (3) 3912 at 1 $2\frac{1}{4}$. | (10) 7925 at 1 $6\frac{3}{4}$. | (16) 7506 at 1 $9\frac{3}{4}$. |
| (4) 7250 at 1 $2\frac{3}{4}$. | (11) 14210 at 1 $7\frac{1}{4}$. | (17) 1007 at 1 $10\frac{3}{4}$. |
| (5) 5271 at 1 $3\frac{1}{2}$. | (12) 2054 at 1 $7\frac{3}{4}$. | (18) 2705 at 1 $11\frac{3}{4}$. |
| (6) 3254 at 1 $3\frac{3}{4}$. | (13) 2905 at 1 $8\frac{1}{4}$. | (19) 4000 at 1 $11\frac{3}{4}$. |
| (7) 2759 at 1 $4\frac{3}{4}$. | | |

**Case 4. When the price consists of an even number of shillings under 20.**

**Rule. Multiply the given quantity by half the Price, doubling the first figure of the Product for shillings, and the rest of the Product will be pounds.**

| | | |
|---|---|---|
| (1) 3760 at 2*s.* | (4) 3782 at 8*s.* | (7) 6498 at 14*s.* |
| (2) 4278 at 4*s.* | (5) 4534 at 10*s.* | (8) 3359 at 16*s.* |
| (3) 7599 at 6*s.* | (6) 5437 at 12*s.* | (9) 7568 at 18*s.* |

**Case 5. When the price consists of shillings and pence, &c. and they are not the aliquot parts of a pound.**

RULE. Multiply the quantity by the shillings and take parts for the rest, add them together, and divide the sum by 20.

| | s. | d. |
|---|---|---|
| (1) 7514 at | 4 | 7. |
| (2) 2517 at | 5 | 3. |
| (3) 2547 at | 7 | $3\frac{1}{2}$. |
| (4) 3271 at | 5 | $9\frac{1}{2}$. |

| | s. | d. |
|---|---|---|
| (5) 2103 at | 15 | $4\frac{1}{2}$. |
| (6) 7152 at | 17 | $6\frac{3}{4}$. |
| (7) 2150 at | 14 | $7\frac{1}{4}$. |
| (8) 3715 at | 9 | $4\frac{1}{2}$. |

| | s. | d. |
|---|---|---|
| (9) 2572 at | 13 | $7\frac{1}{2}$. |
| (10) 7251 at | 14 | $8\frac{1}{4}$. |
| (11) 3210 at | 15 | $7\frac{3}{4}$. |
| (12) 2710 at | 19 | $2\frac{1}{2}$. |

Case 6. When the price is pounds, shillings, pence and farthings.

RULE. Multiply by the pounds and take parts for the shillings, &c. according to the preceding rules; these sums added together will give the Answer.

| | £. | s. | d. |
|---|---|---|---|
| (1) 2170 at | 2 | 3 | $7\frac{1}{2}$. |
| (2) 3125 at | 4 | 6 | 8. |
| (3) 2154 at | 7 | 1 | 3. |
| (4) 2701 at | 2 | 3 | 4. |
| (5) 2715 at | 1 | 17 | $2\frac{1}{2}$. |
| (6) 2517 at | 3 | 15 | $2\frac{1}{4}$. |

| | £. | s. | d. |
|---|---|---|---|
| (7) 3210 at | 1 | 18 | $6\frac{3}{4}$. |
| (8) 2517 at | 2 | 7 | $4\frac{1}{2}$. |
| (9) 7927 at | 3 | 6 | $11\frac{3}{4}$. |
| (10) 3514 at | 4 | 11 | $8\frac{1}{2}$. |
| (11) 2107 at | 5 | 4 | $7\frac{3}{4}$. |

Case 7. When the quantity contains a fraction.

RULE. Work for the integers as before, and for the fraction take the same part of the price that the upper figure is of the under. If the upper be not a part of the under divide it into parts.

| | £. | s. | d. |
|---|---|---|---|
| (1) $678\frac{1}{2}$ at | 1 | 8 | 4. |
| (2) $608\frac{1}{4}$ at | 3 | 2 | 6. |
| (3) $439\frac{3}{4}$ at | 4 | 5 | 6. |
| (4) $48467\frac{7}{8}$ at | 0 | 7 | $7\frac{1}{2}$. |
| (5) $5943\frac{5}{8}$ at | 0 | 11 | $5\frac{3}{4}$. |
| (6) $4567\frac{3}{8}$ at | 1 | 4 | $9\frac{3}{4}$. |
| (7) $4567\frac{1}{8}$ at | 4 | 7 | 4. |

| | £. | s. | d. |
|---|---|---|---|
| (8) $5297\frac{5}{6}$ at | 1 | 3 | $2\frac{1}{2}$. |
| (9) $3572\frac{3}{5}$ at | 4 | 5 | 9. |
| (10) $2459\frac{7}{12}$ at | 1 | 4 | 3. |
| (11) $4637\frac{5}{12}$ at | 2 | 7 | 3. |
| (12) $3897\frac{5}{12}$ at | 3 | 9 | 6. |
| (13) $4357\frac{2}{3}$ at | 14 | 7 | 4. |

Case 8. When the quantity is compound, and the price of the highest name given.

RULE. Find the value of the highest name as before, and take parts of the given price for the lower names.

| | *cwt.* | *qrs.* | *lbs.* | | £. | *s.* | *d.* | |
|---|---|---|---|---|---|---|---|---|
| (1) | 36 | 1 | 7 | at | 3 | 18 | 6 | *per cwt.* |
| (2) | 28 | 3 | 14 | at | 2 | 12 | 6 | |
| (3) | 13 | 3 | 4 | at | 2 | 18 | 4 | |
| (4) | 10 | 0 | 14 | at | 4 | 6 | 9 | |
| (5) | 7 | 3 | 18 | at | 0 | 17 | 6½ | |
| (6) | 72 | 3 | 19 | at | 3 | 17 | 4 | |
| (7) | 35 | 2 | 5 | at | 3 | 7 | 11 | |
| (8) | 2 | 1 | 4 | at | 3 | 12 | 6 | |
| (9) | 19 | 3 | 7 | at | 4 | 2 | 8 | |
| | *qrs.* | *bu.* | *p.* | | | | | |
| (10) | 37 | 4 | 3 | at | 4 | 16 | 6 | *per quarter.* |
| | *ac.* | *r.* | *p.* | | | | | |
| (11) | 34 | 2 | 20 | at | 2 | 11 | 6 | *per acre.* |
| | *lbs.* | *oz.* | *dwt.* | | | | | |
| (12) | 65 | 10 | 14 | at | 3 | 6 | 8½ | *per lb.* |

Case 9. When feet, inches and parts are to be multiplied by feet, inches and parts.

RULE. Multiply the greater quantity of feet, inches, &c. by the number of feet contained in the less quantity and take such Aliquot part or parts of a foot, &c. as the inches and parts require, these added together, will give the answer.

6 *in.* = ½ *ft.* *in.* *pts.*
multiply 45 8 6 by 8 *ft.* 9 *in.* 8 *pts.*
8

| | | | | |
|---|---|---|---|---|
| | 365 | 8 | 0 | |
| 3 *in.* = ½ | 22 | 10 | 3 | „ |
| 6 *pts.* = ½ | 11 | 5 | 1 | 6 |
| 2 = ⅓ | 1 | 10 | 10 | 3 |
| | 0 | 7 | 7 | 5 |
| Feet | 402 | 5 | 10 | 2 |

| | *ft.* | *in.* | *pt.* | | *ft.* | *in.* | *pt.* |
|---|---|---|---|---|---|---|---|
| (1) | 7 | 9 | 0 | × | 3 | 6 | 0 |
| (2) | 8 | 5 | 0 | × | 4 | 7 | 0 |
| (3) | 9 | 8 | 0 | × | 7 | 6 | 0 |
| (4) | 8 | 1 | 0 | × | 3 | 5 | 0 |
| (5) | 7 | 6 | 0 | × | 5 | 9 | 0 |
| (6) | 4 | 7 | 0 | × | 3 | 10 | 0 |
| (7) | 7 | 5 | 9 | × | 3 | 5 | 3 |
| (8) | 10 | 4 | 5 | × | 7 | 8 | 6 |

| | *ft.* | *in.* | *pt.* | | *ft.* | *in.* | *pt.* |
|---|---|---|---|---|---|---|---|
| (9) | 75 | 7 | 0 | × | 9 | 8 | 0 |
| (10) | 97 | 8 | 0 | × | 8 | 9 | 0 |
| (11) | 57 | 9 | 0 | × | 9 | 5 | 0 |
| (12) | 75 | 9 | 0 | × | 17 | 5 | 0 |
| (13) | 87 | 5 | 0 | × | 35 | 8 | 0 |
| (14) | 311 | 4 | 7 | × | 36 | 7 | 5 |
| (15) | 321 | 7 | 3 | × | 9 | 3 | 6 |

### EXERCISES.

(1) What cost 7846 pounds of cotton at $11\frac{1}{2}d.$ per pound?
(2) What cost 4681 yards of cloth, at $8\frac{3}{4}d.$ per yard?
(3) What cost 1927 score of sheep, at £6..9..6. per score?
(4) What cost 1276000 bricks, at 27*s.* 9*d.* per thousand?
(5) What cost 6874 quarters of wheat, at 15*s.* 6*d.* per quarter?
(6) What cost 56 *cwt.* 18 pounds of indigo, at £34. 12*s.* per *cwt.*?
(7) What cost 17 *cwt.* 3 quarters of steel, at 27*s.* per *cwt.*?
(8) What cost 3 tons, 5 *cwt.* 2 quarters of iron bars, at £71..9..3 per ton?
(9) What cost 4 yards, 2 quarters, 3 nails of cloth, at £1..2..4. per yard?
(10) What cost 17 pounds, 5 ounces, 14 pennyweights of silver plate, at £3..6..9. per pound?
(11) What cost 32 acres, 1 rood, 14 perches of land, at £1..16..0. per acre?
(12) What cost $1046\frac{3}{4}$ tons of iron, at 12*s.* 3*d.* per *cwt.*?

### CONTRACTIONS IN PRACTICE.

Having the price of one given, to find the price of 120.

RULE. For every penny that one costs reckon 10 shillings.

If one cost $4\frac{3}{4}d.$ what will 120 cost?

Having the price of 120, to find the price of one.

RULE. For every £. reckon 2*d.* for every 2*s.* 6*d.* one farthing.

If 120 cost £7..15. what will one cost?
120 at £5..10. 120 at £25..7..6. 120 at £36..15.

Having the price of one, to find the price of 1000.

RULE. For every 6*d.* of the price of one reckon £25. and for every penny $£4\frac{1}{6}$.

At 13*s.* 4*d.* what cost 1000? At 12*s.* 6*d.* what cost 1000?

Having the price of 1000 given, to find the price of one.

RULE. Take as many farthings as pounds in the price of one, deducting the 25th. part.

At £645..18..9. per thousand, what is the price of one?

Having the price of one given, to find the price of a dozen.

RULE. For every penny of the price reckon 1*s.* and for every ¼*d.* reckon 3*d.*

If one yard cost 10½*d.* what will 12 cost?

12 at 13*s.* 6*d.* 12 at 11½*d.* 12 at 23*d.* 12 at 27*d.*

Having the price of a dozen given, to find the price of one.

RULE. Take as many pence as there are shillings.

12 at 15*s.* 6*d.* 12 at 10*s.* 9*d.* 12 at £1..2. 12 at £1..13.

Having the price of one given, to find the price of 24.

RULE. Take the number of halfpence in the price of one, as so many shillings for the price of 24.

24 at 10½*d.* each; 24 at 2*s.* 8*d.* each; 24 at 3*s.* 4*d.* each; 24 at 4*s.* 3½*d.* each.

Having the price of 24 given, to find the price of one.

RULE. For every shilling in the price of 24, take one halfpenny for the price of one.

24 at £1..1. 24 at £3..4. 24 at £4. 24 at £5..3.

---

## ALLOWANCES ON GOODS.

The *Gross Weight* means the weight of both goods and packages.

*Tare* is an allowance granted to the purchaser for the weight of the package containing the goods.

*Draft* is allowed on madder, cotton and some other goods, and is to be deducted before the tare.

*Trett* and *Cloff* are obsolete.

After every allowance is subtracted the remainder is called the *neat weight.*

Case 1. When the tare is at so much for the whole.

RULE. From the gross weight subtract the tare, and the remainder will be the neat weight required.

(1) The gross weight is 648 *cwt.* 3 quarters, 10 pounds. Tare 73 *cwt.* 3 quarters, 14 pounds. Required the neat weight?

(2) Required the neat weight of 16 hogsheads of sugar, weighing in the whole 73 *cwt.* 2 quarters, 19 pounds. Tare 9 *cwt.* 2 quarters, 23 pounds?

Case 2. When the tare is at so much per hogshead, cask, skip, bag, &c. and the gross and tare of each the same.

RULE. From the gross weight of one subtract the tare, multiply the remainder by the number of articles, and the product will be the neat weight.

(3) The gross weight of one skip is 264 pounds, the tare 27 pounds. Required the neat weight of 16 skips?

(4) Required the neat weight of 23 casks of sumach, each weighing 473 *lbs.* gross, the tare 1 quarter, 19 pounds, per cask?

(5) Required the neat weight of 24 bags of waste cotton, each weighing gross 103 pounds, tare 7 pounds per bag.

Case 3. When the tare is at so much per *cwt.* or per 100 pounds.

RULE. Divide the gross weight by the aliquot parts of the rate, which subtract from the gross weight, the remainder is the neat weight.

(6) What is the neat weight of 376 *cwt.* 2 *qrs.* 16 *lbs.* Tare 14 pounds per *cwt.*

| | *cwt.* | *qrs.* | *lbs.* | | *lbs.* | |
|---|---|---|---|---|---|---|
| (7) What is the neat weight of | 473 | 2 | 24 | at | 16 | *per cwt.* |
| (8) What is the neat weight of | 209 | 3 | 18 | at | 7 | |
| (9) What is the neat weight of | 594 | 1 | 14 | at | 8 | |
| (10) What is the neat weight of | 356 | 3 | 21 | at | 24 | |
| (11) What is the neat weight of | 364 | 2 | 24 | at | 21 | |
| (12) What is the neat weight of | 174 | 3 | 15 | at | 19 | |

(13) What is the neat weight of 4 casks, each weighing 14 *cwt.* 3 *qrs.* 19 *lbs.*; tare 20 pounds per *cwt.*?

(14) What is the neat weight of 5 hogsheads of sugar, each weighing 4 *cwt.* 18 *lbs.*; tare 24 pounds per *cwt.*?

(15) Required the neat weight of 10 bags of cotton, each weighing gross as under,

| *No.* | *cwt.* | *qr.* | *lbs.* | |
|---|---|---|---|---|
| 1. | 3 | 0 | 20 | |
| 2. | 3 | 0 | 5 | allowing draft 1 pound per bag; |
| 3. | 2 | 3 | 13 | tare 4 pounds per 100 pounds. |
| 4. | 2 | 3 | 13 | |
| 5. | 2 | 3 | 9 | |
| 6. | 2 | 2 | 20 | |
| 7. | 2 | 3 | 10 | |
| 8. | 2 | 3 | 7 | |
| 9. | 2 | 2 | 15 | |
| 10. | 2 | 3 | 22 | |

(16) Required the neat weight of the following bales of Surat cotton, gross weight as under,

| *No.* | *cwt.* | *qr.* | *lbs.* | |
|---|---|---|---|---|
| 62. | 4 | 2 | 17 | |
| 55. | 4 | 1 | 23 | allowing 1 pound per bale for draft, |
| 72. | 3 | 3 | 26 | 4 pounds per *cwt.* for ropes, and 4 |
| 61. | 4 | 2 | 6 | pounds per 100 pounds tare. |
| 74. | 4 | 1 | 24 | |
| 57. | 4 | 2 | 14 | |
| 73. | 4 | 2 | 19 | |

(17) How many gallons (allowing $7\frac{1}{2}$ pounds to a gallon) are contained in 5 casks of oil, each weighing 3 *cwt.* 1 quarter, 24 pounds gross, tare 16 pounds per *cwt.* ?

(18) How much pure gold is there in a mass of 78 pounds, allowing 24 pennyweights of alloy for each pound?

(19) In bleaching linen yarn the loss upon 684 pounds is $12\frac{1}{2}$ per cent. how much neat weight ought I to receive?

(20) If 4200 pounds of linen yarn lose $17\frac{1}{2}$ per cent. in bleaching, what weight of yarn will remain?

(21) Bought 6 bags of cotton weighing gross as under, draft 1 pound per bag, tare $2\frac{1}{2}$ per 100 pounds, and found in the bags 273 pounds damaged cotton, required the neat amount of sound cotton?

| *No.* | *cwt.* | *qr.* | *lbs.* |
|---|---|---|---|
| 48. | 3 | 1 | 5 |
| 41. | 3 | 0 | 22 |
| 47. | 3 | 2 | 9 |
| 38. | 3 | 0 | 17 |
| 51. | 2 | 2 | 25 |
| 46. | 3 | 1 | 27 |

Allowances are made in many other cases which generally depend on the following

RULE. Multiply the quantity by the rate and divide by the number on which the rate depends.

(22) In malting 484 bushels of barley it increased in quantity at the rate of 3 bushels in 22, how much malt had I?

(23) What is that merchant's capital who began business with £1570. and has since increased it at the rate of £13. on £20.?

(24) How much neat yarn should I have out of 1832 pounds of cotton if the waste in working be 2 pounds in 16 pounds?

## PROPORTION.

RULE. Place the conditions of the Question, considered as the principal cause and effect, in one line, taking care to separate the cause from the effect; set down the second conditions, each under each; and where the term sought is in the second line, mark its place with an asterism.

Multiply each cause into the contrary effect; use the Products where the asterism is for a Divisor, and the other for a Dividend; the Quotient will be the answer.

N. B.—Where a term is understood, mark its place with an unit, or 1; and, where necessary, reduce like terms to the same denomination.

If 16 *lbs.* of weft cost 12*s.* what will 224 *lbs.* cost?

| Cause. *lbs.* | | *s.* effect. |
|---|---|---|
| 16 | ⋈ | 12 |
| 224 | | |

$$\frac{224 \times 12}{16} = 168s.$$

If 28 persons can do a piece of work in 36 days, how many persons will complete the same in 9 days?

| *persons.* | *days.* | *work.* |
|---|---|---|
| 28 | 36 | 1 |
| * | 9 | 1 |

$$\frac{28 \times 36}{9} = 112 \text{ persons.}$$

If £48. be the wages of 36 men, for 9 days, what will be earned by 12 men in 90 days?

| *men.* | *days.* | £. |
|---|---|---|
| 36 | 9 | 48 |
| 12 | 90 | * |

$$\frac{48 \times 12 \times 90}{36 \times 9} = £160.$$

### EXAMPLES.

(1) If 4 yards of cloth cost 3*s.* what will 24 yards cost?

(2) If 24 yards of cloth cost 18*s.* what will 4 yards cost?

(3) If 3*s.* will buy 4 yards of cloth, what will 18*s.* buy?

(4) If a set of yarn weighs 4 *lbs.* and contains 500 hanks, what will be the counts of the yarn?

(5) If a carding engine throws off 4 *lbs.* of cotton in 45 minutes, in what time will it throw off 64 *lbs.*?

(6) What quantity of hanks of yarn will be required to make a warp of 1800 ends broad, 140 yards long?

(7) A shaft makes 44 revolutions per minute, driven by a pulley 2 *ft.* 9 *in.* diameter. Required the diameter of another pulley, to turn the same shaft 56 times per minute.

(8) What will be the weight of 30 yards of cotton, delivered from the carding engine at the rate of one hank in the pound?

(9) If 40 yards of drawing weigh $666\frac{2}{3}$ *grs.* what will be the counts?*

(10) I am spinning 160's with a pinion of 28 teeth. What number of pinion will 200's require?

(11) If a set of yarn contains 644 hanks, and weighs 6 *lbs.* 7 *oz.* what will be the counts of the yarn?

(12) A set of yarn weighs 7 *lbs.* 4 *oz.* and is wrapped No. 80's. How many hanks should there be?

(13) A set of yarn weighs 5 *lbs.* $15\frac{1}{2}$ *oz.* and is wrapped 160 hanks in one pound. How many hanks should there be?†

(14) The doffing cylinder of a carding engine 13 inches diameter, has on its axis a pulley of 4 inches diameter, which gives motion to a pulley of 12 inches diameter; on the axis of the latter pulley is a lap drum. Required its diameter.

(15) A set of yarn is wrapped 190's, and weighs 3 *lbs.* $7\frac{1}{2}$ *oz.* How many hanks should there be?

(16) If a set of yarn contain [illegible] hanks, and is wrapped 110's, required the weight.

(17) What is the weight of a set of yarn, containing 664 hanks, wrapped 180's.?

(18) If the amount of money paid for picking cotton in one week be £13..13. what would be the weight of cotton, admitting I pay 1*s.* 6*d.* for every $4\frac{1}{2}$ *lbs.*?

(19) I have 10 *lbs* of 24 hanks twist to make a warp 120 yards long. Required the number of ends.‡

(20) In a wheel of 16 feet in circumference there are 96 teeth. How many teeth in a wheel of 12 feet circumference, the pitch being the same?

(21) A mule, of 528 spindles, makes 7 stretches, of 54

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* In this question, 840 yards make one hank; and the counts, or number of hanks in a pound, will be found by dividing the Quotient by the number of grains in a pound avoirdupois, for which see the table.

† Bring the weights into half ounces.

‡ The question will stand thus:

| | *yds.* | *lbs.* | *hks.* | *end.* |
|---|---|---|---|---|
| | 120 | 1 | 1 | 1 |
| Yards in 1 hank. | 840 | 10 | 24 | |

inches each, in 3 minutes. What quantity of yarn is spun in 12 hours?*

(22) A shaft, making 120 revolutions per minute, has a pulley of 9 inches diameter. Required the diameter of a pulley to turn the next shaft 64 revolutions per minute.

(23) If 8 *oz.* of cotton will extend 18 inches broad and 40 inches long, what will be the extent of 28 *lbs.* the breadth being the same?†

(24) A stone of wire, containing 24 yards, is to be drawn, and the increase to be 8 inches per foot. Required the length when drawn, allowing no waste of metal.‡

(25) A beam has a warp wound on it containing 2769 ends, 10 cuts 28 yards each. Required the number of hanks twist.

(26) How many bricks, 9 inches long, 4½ broad, and 3 inches deep, can be made from a cubic yard of earth?§

(27) If 100 *lbs.* of yarn lose 16 *lbs.* in bleaching, what will 480 *lbs.* lose?

(28) What length of flags, 45 inches broad, will be required to flag a street 70 yards long and 2½ yards broad?‖

(29) What is the length of a street, the causeway 1¾ yards broad, to be laid with 260 yards of flags, 3½ yards broad?

(30) A cop is wrapped 140 hanks, and the set weighs 4 *lbs.* 14 *oz.* How many doffings of 20 hanks each?¶

(31) What must be the power applied to raise 1296 *lbs.* the leverage being to the weight as 9 is to 2.

(32) A warp containing 1680 ends, 120 yards long, weighs 11 *lbs.* 4 *oz.* Required the counts of the yarn.**

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* Thus: If

| *sp.* | *m.* | | *str.* | *in.* |
|---|---|---|---|---|
| 1 | 3 | ⋈ | 7 | 54 |
| 528 | 720 | | 1 | * |

the answer will be in inches; which, divided by the number of inches in one hank, will give the quantity of hanks.

† Bring the ounces and pounds into half pounds.

‡ 12 inches will be the first cause, and 20 (being 12 + 8) the first effect, the 24 yards the second cause.

§ The length, breadth and depth of the brick will be the first cause, the brick the effect, and the cubic inches in a yard the second cause.

‖ Thus,

| *in.* | *yds. l.* | | *flag.* |
|---|---|---|---|
| 45 | 1 | ⋈ | 1 |
| 90 | 70 | | * |

2½ yards =

¶ Divide the number of hanks by 20, for the number of doffings.

** Thus,

| *lbs.* | *oz.* | | *ends.* | *yds.* | *hk.* |
|---|---|---|---|---|---|
| 11 | 4 | ⋈ | 1680 | 120 | 1 |
| 0 | 16 | | 1 | 840 | * |

(33) If a column of water, 11 yards deep, press with a force equal to 15 *lbs.* per square inch, what will be the force if the depth be 33 yards?

(34) There are 84 threads in one inch of 6-4 Jaconett. Required the quantity of hanks weft in 24 yards.*

(35) What quantity of 40 hanks weft will be required for a piece of calico 24 yards long, 6-4 broad, and 64 picks in one inch?†

(36) A piece of Jaconett, 36 inches wide, 24 yards long, has 76 picks in one inch. How many hanks weft in the piece?

(37) If the neat weight of yarn upon a beam weigh 32 *lbs.* of 36 hanks twist, the number of ends to be 2520, required the length of warp?

(38) If a cistern, containing 270 gallons, has a cock which discharges 6 gallons in a minute, and another has a cock which discharges 8 gallons in a minute, and both cisterns are emptied in the same time, how many gallons does this last cistern contain?

(39) If 8 *oz.* of No. 60's yarn contain 30 hanks, what will be the counts of 2 *oz.* the length to be the same?‡

(40) If the fly shaft of a steam engine makes 60, and the governor 38 revolutions per minute, and the wheel on the fly shaft be 19 inches diameter, required the diameter of the governor wheel.

(41) If a force of 200 *lbs.* be applied on the head of a rectangular wedge, its thickness being 3 inches, and the length of its side 18 inches, what weight will it raise or balance perpendicular to its side?

(42) If a lever be 100 inches long, what weight, lying 8 inches from the end, resting on a pavement, may be moved with the force of 168 *lbs.* lifting at the other end of the lever?§

---

| | | | | | |
|---|---|---|---|---|---|
| | | *in.* | | *thr.* | *quar.* |
| * Thus, | | 1 | ⋈ | 84 | 6 |
| 24 yards | = | 864 | | • | 4 |
| | *lb.* | *hks.* | *yds.* | *p.* | *in.* |
| † Thus, | 1 | 40 | 840 | 1 | 1 |
| | • | 1 | 1½ | 64 | 864 in 24 yards. |
| | | | *oz.* | *hks.* | |
| ‡ Thus, | | | 2 | 30 | |
| | | | 16 | • | |
| | | | *in.* | *lbs.* | |
| § Thus, | | | 8 | 168 | |
| | | | 92 | • | |

(43) The main shaft makes 44 revolutions per minute, having a wheel on it of 24 inches diameter. Required the diameter of a wheel, that the next shaft may make 48 revolutions per minute.

(44) A pulley of 19 inches diameter makes 60 revolutions per minute, and turns another of 10 inches diameter. Required the revolutions of the latter pulley.

(45) A shaft, making 640 revolutions per minute, has a wheel on it of 14 inches diameter, to drive a wheel of 8$\frac{3}{4}$ inches diameter. Required the number of revolutions.

(46) What power is requisite to move a weight of 140 *lbs.* up an inclined plane, 8 feet long and 4 feet high?

(47) A teagle rope is attached to a beam of 8* inches radius, which is driven by a wheel of 4 feet radius. What force will be necessary to raise 25 *cwt.*?

(48) The wheel of a teagle is 5 feet radius, attached to a beam of 7* inches radius. If a power of 64 *lbs.* be applied to the wheel, what weight will it raise?

(49) A shaft makes 180 revolutions per minute, has a wheel containing 15 cogs: the next shaft is required to make 225 revolutions per minute. How many cogs must there be?

(50) A wheel, 192 inches diameter, makes 4 revolutions per minute; what is the diameter of another wheel, to work in it, which is to make 81 revolutions per minute?

(51) There are two shafts for the purpose of turning machinery: one makes 50, and the other 40 revolutions per minute; the diameter of the drum on the first shaft above is 30 inches. Required the diameter of the drum on the other shaft, so that it will drive the machinery at the same speed as the first shaft.

(52) A screw is 12 inches in circumference, and one inch pitch. Required the power to raise 8760 *lbs.*

(53) A crank, 9 inches long, turned by a wheel, is 6 feet from the joint of a lever, 9 feet long, working a pump. Required the length of the stroke in the pump barrel.†

(54) What weight, placed at 70 inches from the fulcrum

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* The radius of the rope is included in this.

† The length of the crank forms the radius of a circle, which double for the diameter.

| | *ft.* | | *in.* |
|---|---|---|---|
| Then, | 6 | ⋈ | 18 |
| | 9 | | |

of a steel-yard, will equipoise $9\frac{1}{2}$ *cwt.* at 2 inches distance on the contrary side?

(55) A body of 20 *lbs.* is impelled at the rate of 100 feet in 1 second. Required the velocity of 8 *lbs.* moved with the same force.

(56) If a carding engine, 18 inches on the wire, making 120 revolutions per minute, will turn off 40 *lbs.* of cotton per day, what weight will one of 36 inches on the wire, making 132 revolutions per minute, turn off in the same time?

(57) If 8 *oz.* of cotton, 18 inches broad, will extend 40 inches long, what will be the extent of 12 *lbs.* 36 inches broad?

(58) Required the number of bricks to build a wall 9 inches broad, 264 feet long, 6 feet high, allowing $11\frac{1}{4}$ square yards to 1000 bricks.*

(59) Required the number of bricks to build a wall $13\frac{1}{2}$ inches broad (i. e. brick and half) 264 feet long, 6 feet high, allowing $11\frac{1}{4}$ square yards to 1000 bricks, in a wall of 9 inches broad.*

(60) If 1000 bricks will build a wall 9 inches broad, 26 feet long, 4 feet high, how many will build a wall 18 inches broad, 130 feet long, and 6 feet high?

(61) If a lever, 40 effective inches long, will, by a certain power, in 13 hours raise a weight 104 feet, in what time will two other levers, each 18 effective inches long, raise an equal weight 73 feet?†

(62) A solid foot of stone was 16 inches broad and 3 inches thick. Required the length.

(63) If an iron bar, 2 feet long, 3 inches broad, and 1 inch thick, weighs 18 *lbs.* what will be the weight of another bar of iron, which is 7 feet long, 6 inches broad, and $3\frac{1}{2}$ thick?

(64) How many men will build a wall 240 yards long, 6 feet high, and 3 feet thick, in 8 days, when 7 men can build another wall 40 yards long, 4 feet high, and 2 feet thick, in 32 days?

(65) A common joist is 7 inches deep and 2 thick, but I want a scantling, just as big again, that shall be 4 inches thick. What will the depth be?‡

---

* Reduce the square yards to feet.

† Thus,

| *lever.* | *in. l.* | *hrs.* | | *ft.* |
|---|---|---|---|---|
| 1 | 40 | 13 | ⋈ | 104 |
| 2 | 18 | • | | 73 |

‡ Thus,

| *in. d.* | *in. br.* | | *joist.* |
|---|---|---|---|
| 7 | 2 | ⋈ | 1 |
| • | 4 | | 2 |

(66) If a $4\frac{1}{2}$ hank roving will make 52 hanks yarn with a 30 change wheel, what will be the pinion to produce 80's from a 6 hank roving?

(67) The bevel wheel, at the bottom of the lying shaft, contains 48 teeth, and drives the carriage out of gear while the rim makes 36 revolutions. What bevel must be in its place, for the carriage to be out of gear in 32 revolutions of the rim?

(68) If a mule, of 360 spindles, turn off 5 hanks of yarn in 8 stretches, what will be the length of the stretch?*

(69) A warp from No. 36 hanks twist contains 1800 ends, 120 yards, 4 cuts. What will be the weight of one cut, when woven, if 2 *lbs.* 4 *oz.* of 40 hanks weft be put in?†

(70) Allowing 2 *lbs.* 8 *oz.* of 40 hanks weft to be put in 28 yards of warp, to stand 30 inches in the reed, how many threads of weft should there be in one inch?‡

(71) If 150 hanks yarn can be spun from a 8 hanks roving with a 27 change pinion, what number of hanks yarn can be spun from a 12 hanks roving with a 36 change pinion?

(72) A power of 18 *lbs.* is applied to the winch of a crane, the length of which is 8 inches; the pinion makes 12 revolutions for 1 of the wheel: the barrel is 6 inches diameter. Required what weight the crane will raise to a height equal to double the length of the winch.

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## VULGAR FRACTIONS.

1. A fraction is a part of a thing, and supposes the unit divided into a number of parts.

2. It is expressed by two numbers, one above the other, with a line between them, as $\frac{1}{3}$, $\frac{3}{5}$, $\frac{4}{12}$.

3. The under number is called the Denominator, and shows the number of parts into which the unit is divided

4. The upper number is called the Numerator, and shows

---

* Thus,

| *sp.* | *str.* | *hks.* | *ft.* |
|---|---|---|---|
| 360 | 8 | 5 | 2520 in one hank. |
| 1 | 1 | 1 | |

† Add the weight of the weft to the weight of one cut.

‡ 2 *lbs.* 8 *oz.* of 40 hanks = 100 hanks.

Then,

| *in.* | *yds.* | *in.* | *hks.* |
|---|---|---|---|
| 30 | 28 | 1 | 100 |
| 1 | 840 | | 1 |

how many of these parts the fraction contains, as $\frac{3}{4}$ = three quarters; $\frac{5}{8}$ = five eighth parts, &c.

5. A proper fraction is that of which the Numerator is less than the Denominator, as $\frac{5}{7}$.

6. An improper fraction is that of which the Numerator is equal to, or greater than the Denominator, as $\frac{8}{8}$, $\frac{5}{3}$.

7. A compound fraction consists of two or more fractions connected with the word of, as $\frac{2}{3}$ of $\frac{3}{8}$.

8. A mixed number consists of an integer, or whole number and a fraction, as $4\frac{3}{7}$, &c.

9. A mixed, or complex fraction, as $\frac{4\frac{1}{2}}{9}$, $\frac{7}{11\frac{3}{4}}$, &c.

An integer, or whole number, may be expressed as a fraction by writing 1 under it for a denominator, as 3, in fractions $\frac{3}{1}$.

NOTE. The value of a fraction is not altered by multiplying or dividing both Numerator and Denominator by the same number.

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## REDUCTION.

### PROBLEM I.

To abbreviate, or reduce fractions to their lowest terms.—Find a number that will divide both the Numerator and Denominator without a Remainder, and the Quotients will be the term of a new fraction, equal in value to the former. If the same operation be repeated till the terms of the reduced fraction are not divisible by any number greater than one, the fraction will be in its lowest terms.

NOTE. If there should be any difficulty in finding out the proper Divisor, proceed by the following Rule, by which it will be correctly found, and sometimes with the least trouble.

To find the greatest Common Measure or Divisor of any given fraction, or of any two given numbers.—Divide the greater term by the less, and the Divisor by the Remainder continually, till nothing remains. The last Divisor is the greatest Common Measure.

Reduce $\frac{176}{484}$, $\frac{48}{160}$, $\frac{7845}{26780}$, $\frac{8664}{8988}$, $\frac{740}{8673}$, $\frac{764}{8240}$, $\frac{644}{1728}$, $\frac{768}{1024}$, $\frac{2360}{46852}$, to their lowest terms.

Let it be proposed to abbreviate $\frac{42}{72}$.

$\frac{42}{72}$, $\frac{21}{36}$, $\frac{7}{12}$, by dividing first by two and then by three.

NOTE 1. Any number ending with an even number, or a cipher, may be divided by 2.

$\frac{16}{24}$, $\frac{8}{12}$, $\frac{4}{6}$, $\frac{2}{3}$, $\frac{32}{56}$, $\frac{120}{236}$ =

NOTE 2. Any number ending with a 5, or a cipher, is divisible by five.

$\frac{35}{40}$, $\frac{75}{100}$.

NOTE 3. Any number is divisible by 3, if the sum of the digits be so; and by 9, if the sum of the digits be so. Thus, 417 is divisible by 3, because 12, the sum of 4, 1, and 7, is so; the same with 45819, by 9.

$\frac{45}{120}$, $\frac{126}{411}$, $\frac{543}{672}$, $\frac{3627}{5445}$.

NOTE 4. Any number is divisible by 4, if the two last digits be so; and by 25, if the two final digits be so. Thus, 316 is divisible by 4, and 8275 is divisible by 25.

NOTE 5. Any number is divisible by 8, if the four final digits be so. Thus, 9672 is divisible by 8.

NOTE 6. If there be any ciphers at the end of each, cut off as many as are common to both.

$\frac{200}{340} = \frac{20}{34}$. $\frac{1200}{18000} = \frac{12}{180}$.

### PROBLEM II.

To reduce compound fractions to simple ones.—Multiply all the Numerators together for the Numerator of the simple fraction, and all the Denominators together for the Denominator thereof.

Reduce $\frac{3}{8}$ of $\frac{4}{15}$, and $\frac{5}{7}$ of $\frac{2}{3}$ of $\frac{1}{6}$, and $\frac{4}{7}$ of $\frac{5}{12}$ of 6, and $\frac{2}{5}$ of $\frac{8}{11}$, and $\frac{6}{11}$ of $\frac{5}{8}$, to simple fractions.

### PROBLEM III.

To reduce an improper fraction to a whole or mixed number.—Divide the Numerator by the Denominator, and if there be a Remainder, set the Denominator below it in the form of a fraction, and annex it to the Quotient.

Reduce $\frac{55}{8}$, $\frac{19}{3}$, $\frac{57}{4}$, $\frac{108}{7}$, $\frac{101}{8}$, $\frac{15}{2}$, $\frac{78}{7}$, $\frac{87}{8}$, to mixed fractions.

### PROBLEM IV.

To reduce mixed numbers to improper fractions.—Multiply the integer, or whole number, by the Denominator of the fraction, and add the Numerator thereto; under this sum write the Denominator.

Reduce $4\frac{3}{5}$, $6\frac{1}{3}$, $14\frac{1}{4}$, $15\frac{3}{7}$, $12\frac{5}{8}$, $7\frac{1}{2}$, $11\frac{1}{7}$, $17\frac{2}{3}$, to improper fractions.

PROBLEM V.

To reduce fractions to others of equal value, having a common Denominator.—Multiply each Numerator into all the Denominators except its own for the new Numerator, and all the Denominators together for the common Denominator.

NOTE. Fractions may often be brought to a Common Denominator by multiplying some of their Denominators by such number as will produce the highest Denominator, but their Numerators must be multiplied by the same number.

(1) Reduce $\frac{7}{8}$ and $\frac{5}{8}$ to a common denominator.
(2) $\frac{1}{2}$, $\frac{1}{3}$, $\frac{3}{4}$. (3) $\frac{5}{6}$, $\frac{7}{8}$, $\frac{8}{9}$, $\frac{9}{10}$. (4) $\frac{7}{11}$, $\frac{8}{9}$, $\frac{6}{13}$.
(5) $\frac{8}{15}$, $\frac{18}{19}$, $\frac{9}{11}$. (6) $\frac{4}{13}$, $\frac{11}{12}$, $\frac{5}{13}$, $\frac{1}{11}$. (7) $\frac{4}{5}$, $\frac{5}{7}$, $\frac{12}{13}$, $\frac{16}{17}$.
(8) $\frac{1}{2}$ of $\frac{3}{4}$, $\frac{5}{6}$ of $\frac{2}{3}$, $\frac{2}{5}$ of $\frac{1}{4}$.

PROBLEM VI.

To reduce a complex fraction to a single one.—If necessary, reduce the Numerator and Denominator to improper fractions; then multiply the Numerator of the upper fraction into the Denominator of the lower for a new Numerator, and the Denominator of the upper into the Numerator of the lower for a new Denominator, which reduce to its lowest terms.

(1) Reduce $\frac{24\frac{3}{4}}{38}$ to a simple fraction.

(2) $\frac{16}{24\frac{1}{5}}$. (3) $\frac{8\frac{1}{4}}{12\frac{2}{3}}$. (4) $\frac{4\frac{1}{3}}{6\frac{1}{8}}$.

PROBLEM VII.

To reduce any given number of fractions to a common Denominator.—The Product of all the Denominators, except its own, will give a Multiplier for the Numerator; the respective Multipliers for each fraction being divided by their greatest common measure, will give the answers in their least common denomination.

(1) Reduce $\frac{3}{5}$ and $\frac{6}{13}$ to a common denominator.

| | | |
|---|---|---|
| Given fractions | $\frac{3}{5}$ | and $\frac{6}{13}$ |
| Multipliers . . | 13 | and 5 |
| Answers . . . | 39 | and 30 |
| | 65 | 65 |

(2) Reduce $\frac{2}{3}$, $\frac{4}{5}$ and $\frac{5}{7}$ to a common denominator.
(3) $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{5}$ and $\frac{4}{7}$. (4) $\frac{5}{8}$, $\frac{7}{10}$ and $\frac{11}{20}$.
(5) $\frac{2}{5}$, $4\frac{1}{6}$ and $\frac{8}{4}$.

PROBLEM VIII.

To reduce fractions from one denomination to another.—If from a lower to a higher, multiply the Denominator by the number of the lower that makes one of the higher; if from a higher to a lower, multiply the Numerator thereby.

(1) Reduce $\frac{4}{9}$ of a farthing to the fraction of a pound.
(2) Reduce $\frac{4}{7}$ of a shilling to the fraction of a guinea.
(3) Reduce $\frac{5}{12}$ of a crown to the fraction of a pound.
(4) Reduce $\frac{4}{7}$ of a farthing to the fraction of a shilling.
(5) Reduce $\frac{2}{5}$ of half a crown to the fraction of a pound.
(6) Reduce $\frac{5}{7}$ of a pound to the fraction of a ton.
(7) Reduce $\frac{3}{8}$ of an ounce to the fraction of a *cwt.*
(8) Reduce $\frac{4}{5}$ of a dram to the fraction of a pound.
(9) Reduce $\frac{9}{11}$ of a yard to the fraction of a mile.
(10) Reduce $\frac{4}{15}$ of a second to the fraction of an hour.

(1) Reduce $\frac{1}{2100}$ to the fraction of a farthing.
(2) Reduce $\frac{4}{1037}$ of a guinea to the fraction of a shilling.
(3) Reduce $\frac{5}{48}$ of a pound to the fraction of a crown.
(4) Reduce $\frac{1}{84}$ of a shilling to the fraction of a farthing.
(5) Reduce $\frac{1}{12}$ of a pound to the fraction of a half crown.
(6) Reduce $\frac{1}{3136}$ of a ton to the fraction of a pound.
(7) Reduce $\frac{1}{2016}$ of a *cwt.* to the fraction of an ounce.
(8) Reduce $\frac{1}{3200}$ of a pound to the fraction of a dram.
(9) Reduce $\frac{9}{1760}$ of a mile to the fraction of a yard.
(10) Reduce $\frac{1}{3600}$ of an hour to the fraction of a second.

NOTE. In questions such as the following reduce the given quantity to the lowest name in it for the Numerator, and reduce the denomination it is required to be reduced into the same name for the Denominator.

(1) Reduce 7*d.* to the fraction of a pound.
(2) Reduce $4\frac{1}{2}$*d.* to the fraction of a shilling.
(3) Reduce $9\frac{3}{4}$*d.* to the fraction of a guinea.
(4) Reduce 19*s.* 8*d.* to the fraction of a pound.
(5) Reduce 7*s.* $8\frac{1}{2}$*d.* to the fraction of a pound.
(6) Reduce 4 pounds 3 drams to the fraction of a *cwt.*
(7) Reduce $7\frac{3}{4}$ drams to the fraction of a pound, avoirdupois.
(8) Reduce 8 pennyweights, $17\frac{1}{3}$ grains, to the fraction of a pound troy.

(9) Reduce 7 gallons, $3\frac{1}{2}$ pints, to the fraction of a hogshead of wine.

(10) Reduce 5 days, 3 hours, 17 minutes, to the fraction of a year.

(11) Reduce 5 yards, $2\frac{1}{2}$ feet, to the fraction of a mile.

(12) Reduce 3 roods, 5 perches, to the fraction of an acre.

(13) Reduce 7 furlongs, 4 poles to the fraction of a mile.

(14) Reduce $8\frac{3}{4}d.$ to the fraction of a crown.

(15) Reduce $6s.$ $10\frac{1}{2}d.$ to the fraction of a half-guinea.

(16) Reduce 13 pounds, 4 ounces, to the fraction of a ton.

(17) Reduce 7 pennyweights, 13 grains, to the fraction of an ounce.

(18) Reduce 3 bushels, 3 pecks, to the fraction of a quarter.

(19) Reduce 5 ounces, 7 grains, to the fraction of a *lb.* troy.

(20) Reduce 2 roods, 17 perches, to the fraction of an acre.

(21) Reduce 24 seconds to the fraction of an hour.

(22) Reduce 15 hours, 15 minutes, to the fraction of a day.

### PROBLEM IX.

To find the value of a fraction.—Reduce the Numerator into the next inferior name, and divide by the Denominator. Reduce the Remainder into the next lower name and divide again, and so on as far as necessary.

What is the value of

(1) $\frac{7}{240}$ of a pound?
(2) $\frac{5}{8}$ of a shilling?
(3) $\frac{13}{350}$ of a guinea?
(4) $\frac{5}{60}$ of a pound?
(5) $\frac{3}{9}\frac{7}{0}$ of a pound?
(6) $\frac{10}{2}\frac{9}{8}\frac{7}{0}\frac{7}{2}$ of a *cwt.* ?
(7) $\frac{3}{1}\frac{1}{0}\frac{1}{4}\frac{2}{2}$ of a pound, avoir.
(8) $\frac{2}{1}\frac{2}{4}\frac{1}{4}\frac{1}{6}\frac{1}{0}$ of a pound, troy?
(9) $\frac{3}{3}\frac{7}{1}\frac{7}{5}$ of a hhds. of spirits?
(10) $\frac{7}{3}\frac{7}{2}\frac{3}{5}\frac{7}{6}\frac{7}{0}$ of a year?
(11) $\frac{4}{1}\frac{5}{3}\frac{5}{2}\frac{5}{0}$ of a mile?
(12) $\frac{2}{5}\frac{5}{0}$ of an acre?
(13) $\frac{7}{8}\frac{1}{0}$ of a mile?
(14) $\frac{7}{1}\frac{7}{6}$ of a crown?
(15) $\frac{2}{8}\frac{2}{4}$ of a half-guinea?
(16) $\frac{1}{8}\frac{6}{6}\frac{5}{0}$ of a ton?
(17) $\frac{1}{4}\frac{1}{8}\frac{1}{0}$ of an ounce, troy?
(18) $\frac{1}{3}\frac{5}{2}$ of a quarter?
(19) $\frac{2}{3}\frac{4}{7}\frac{2}{6}\frac{7}{0}$ pounds, troy?
(20) $\frac{9}{1}\frac{7}{6}\frac{5}{0}$ of an acre?
(21) $\frac{1}{1}\frac{5}{5}\frac{5}{0}$ of an hour?
(22) $\frac{6}{9}\frac{1}{6}$ of a day?

### PROBLEM X.

To find the least common Multiple of any series of numbers.—Place the given numbers in a line and divide any two or more of them by a common Divisor, placing the Quotients and undivided numbers below; repeat the process till the numbers will not divide and the Product of the Divisors, Quotients and undivided numbers will be the least common Multiple.

The least common multiple of 1, 2, 3, 4, 5, 6, 7, 8, 9.

2)1, 2, 3, 4, 5, 6, 7, 8, 9
2)1, 1, 3, 2, 5, 3, 7, 4, 9
2)1, 1, 3, 1, 5, 3, 7, 2, 9
3)1, 1, 3, 1, 5, 3, 7, 1, 9
1, 1, 1, 1, 5, 1, 7, 1, 3

$2\times2\times2\times3\times5\times7\times3=2520$ least common multiple.

(2) Find the least common multiple of 7, 64, 48, 84, 72.
(3) What is the least common multiple of 4, 4, 10, 8, 6, 9, 8, 6?

PROBLEM XI.

To find whether one fraction be greater or less than another in value.—Multiply each Numerator into the other's Denominator, and if the Products are equal the fractions are so; otherwise the Numerator of the greater fraction multiplied by the Denominator of the other will be the greater Product.

(1) Which fraction is of the greater value $\frac{7}{9}$ or $\frac{5}{6}$?
$7\times6=42$
$5\times9=45$ thus $\frac{5}{6}$ is of the greater value.

(2) Is $\frac{3}{4}$ or $\frac{2}{2\frac{1}{3}}$ of greater value?
$3\times28=84$
$4\times21=84$ they are of equal value.

(3) Which fraction is of the greater value $\frac{5}{8}$ or $\frac{4}{7}$?
$5\times5=25$
$4\times8=32$ $\frac{4}{7}$ the greater value.

PROBLEM XII.

1. To reduce a fraction to a given Denominator.—As the Denominator of the given fraction is to its Numerator, so is the Denominator of the required fraction to its Numerator.

(1) Reduce $\frac{6}{11}$ to a fraction of the same value whose denominator shall be 44.
(2) Reduce $\frac{4}{7}$ to a fraction of the same value whose denominator shall be 21.
(3) Reduce $\frac{5}{9}$ to a fraction of the same value whose denominator shall be 81.

2. To reduce a fraction to a given Numerator.—As the Numerator of the given fraction is to its Denominator, so is the Numerator of the required fraction to its Denominator.

(1) Reduce $\frac{2}{3}$ to a fraction of the same value whose numerator shall be 9.

(2) Reduce $\frac{4}{7}$ to a fraction of the same value whose numerator shall be 12.

(3) Reduce $\frac{5}{9}$ to a fraction of the same value whose numerator shall be 45.

## ADDITION.

RULE. Reduce the fractions to a common Denominator; add the Numerators and under their sum write the common Denominator.

(1) $\frac{7}{8} + \frac{9}{15} + \frac{6}{7}$.
(2) $\frac{5}{11} + \frac{6}{11} + \frac{8}{11}$.
(3) $\frac{5}{17} + \frac{4}{9} + \frac{1}{2} + \frac{6}{19}$.
(4) $\frac{2}{3}\frac{1}{7} + \frac{1}{2}\frac{3}{5} + \frac{1}{1}\frac{4}{7}$.
(5) $\frac{3}{4}$ of $\frac{7}{8} + \frac{8}{11}$ of $\frac{1}{2}$.
(6) $\frac{1}{2}\frac{3}{5} + \frac{1}{1}\frac{1}{8} + \frac{1}{1}\frac{0}{1}$.
(7) $\frac{7}{8} + \frac{1}{1}\frac{4}{3} + \frac{1}{2}\frac{5}{7} + \frac{1}{2}$ of $\frac{6}{8}$.

NOTE 1. When mixed numbers are given, find the sum of the fractions as before; to which add the integers.

(8) $4\frac{1}{2} + 7\frac{1}{8} + 8\frac{4}{7}$. (9) $9\frac{1}{4} + 6 + 8 + 11\frac{1}{3}$.
(10) $\frac{7}{8} + 6\frac{5}{11} + 14\frac{1}{3} + 51\frac{3}{4}$.

NOTE 2. When fractions are of different names reduce them into the same name by Problem 8, and add as before, or find their value by Problem 9, and add as in Compound Addition.

(11) $\frac{7}{8}$ shilling + $\frac{4}{11}$ pound.
(12) $\frac{3}{4}$ shilling + $\frac{5}{8}$ pound + $\frac{6}{7}$ guinea.
(13) $\frac{1}{4}$ pound + $\frac{1}{7}$ ounce + $\frac{2}{3}$ pennyweight.
(14) $\frac{3}{8}$ crown + $\frac{5}{12}$ pound + $\frac{8}{15}$ guinea.
(15) $\frac{1}{3}$ pound + $\frac{2}{5}$ *cwt.* + $\frac{5}{8}$ ton.
(16) $\frac{2}{5}$ quarter + $\frac{2}{3}$ bushel + $\frac{3}{5}$ peck.
(17) $\frac{2}{5}$ hour + $\frac{5}{12}$ day + $\frac{4}{7}$ week.
(18) *A* borrowed at one time £84$\frac{7}{11}$. at another time £17$\frac{5}{7}$. at another 18$\frac{5}{8}$*s.* at another time 11$\frac{3}{8}$*d.* how much did he borrow in all?

(19) Bought cotton 4$\frac{2}{7}$ *cwt.* + 18$\frac{7}{8}$ pound + 28$\frac{1}{4}\frac{2}{4}$ pound + 13$\frac{3}{4}$ ounces, how much was bought in all?

(20) Suppose I have $\frac{3}{8}$ of a manufacturing concern and I purchase $\frac{5}{16}$ more, how much of it belongs to me.

## SUBTRACTION.

RULE. Having reduced the fractions as in Addition find the difference of the Numerators; under which write the common Denominator.

NOTE. In mixed numbers first subtract the fractions and if the

Numerator of the Subtrahend exceed that of the Minuend, subtract it from the common Denominator, and to the Remainder add the Numerator of the Minuend for the Numerator of the fraction, then add one to the unit's place of the Subtrahend.

(1) $\frac{4}{5} - \frac{5}{12}$.
(2) $\frac{13}{16} - \frac{5}{16}$.
(3) $\frac{8}{11} - \frac{5}{17}$ of $\frac{1}{3}$.
(4) $\frac{24}{25} - \frac{15}{43}$.
(5) $\frac{11}{54} - \frac{5}{28}$ of $\frac{6}{8}$.
(6) $\frac{9}{11} - \frac{1}{17}$ of 4.
(7) $6\frac{1}{8} - 4\frac{3}{4}$.
(8) $7\frac{5}{12} - 3\frac{1}{2}$.
(9) $8\frac{1}{2} - 4\frac{1}{4}$.
(10) $15 - \frac{3}{7}$.
(11) $18 - 5\frac{3}{8}$.
(12) $13\frac{7}{8} - 4\frac{1}{7}$.
(13) £$\frac{7}{11}$ — $\frac{7}{12}$s.
(14) £$\frac{1}{13} - \frac{1}{7}$ crown.

(15) Paid a debt of $7\frac{4}{11}$ pounds out of a purse containing $9\frac{1}{17}$ guineas, how much remained?

(16) A person possessed $\frac{2}{3}\frac{7}{8}$ of an estate, sold $\frac{3}{4}$ of his share, how much remained?

(17) What part of a spinning concern remained after selling $\frac{4}{7}$ of $\frac{5}{8} + \frac{1}{2}$ of $\frac{3}{7}$.

(18) Required the difference in troy weight between the ounce troy and the ounce avoirdupois, the latter being equal to 18 pennyweights, $5\frac{1}{3}\frac{5}{2}$ grains, troy.

## MULTIPLICATION.

Rule. Multiply all the Numerators together for the Numerator of the Product; and all the Denominators together for its Denominator.

Note. Reduce the integers and mixed numbers to improper fractions.

(1) $\frac{4}{5} \times 1\frac{1}{2}$.
(2) $\frac{4}{13} \times \frac{4}{9}\frac{7}{7}$.
(3) $\frac{1}{3}\frac{2}{7} \times \frac{1}{4}\frac{8}{3}$.
(4) $\frac{7}{11} \times \frac{6}{9}$ of $\frac{3}{7}$.
(5) $\frac{5}{8}$ of $\frac{7}{11} \times \frac{9}{11}$.
(6) $8 \times \frac{5}{7}$.
(7) $8\frac{3}{4} \times \frac{5}{12}$.
(8) $7 \times \frac{5}{13}$.
(9) $16 \times \frac{3}{4}$.
(10) $5\frac{3}{8} \times 11\frac{1}{4}$.
(11) $18\frac{3}{16} \times 11\frac{3}{4}$.
(12) $3\frac{5}{8} \times 4\frac{5}{6}$.
(13) $\frac{3}{8} - \frac{1}{8}$ of $\frac{5}{6} \times 73\frac{1}{3}$.

(14) What is the value of $\frac{5}{8}$ pound of yarn at £$1\frac{7}{18}$. per pound?

(15) What is the value of $\frac{3}{5}$ acre at £$2\frac{5}{11}$. per acre?

(16) What is the value of $17\frac{5}{11}$ yards at $7\frac{5}{12}$s. per yard?

(17) What is the value of $\frac{5}{7}$ ounce of silver at £$3\frac{1}{8}$. per pound?

## DIVISION.

Rule. Invert the Divisor, and proceed as in Multiplication.

NOTE. Reduce the integers and mixed numbers to improper fractions.

(1) $\frac{11}{12})\frac{11}{15}$.
(2) $\frac{4}{27})\frac{16}{351}$.
(3) $\frac{16}{47})\frac{816}{1591}$.
(4) $\frac{8}{9}$ of $\frac{3}{5})\frac{56}{105}$.
(5) $\frac{9}{11})\frac{315}{308}$.
(6) $\frac{5}{7})5\frac{6}{7}$.
(7) $\frac{5}{12})33\frac{1}{48}$.
(8) $\frac{5}{13})2\frac{9}{13}$.
(9) $\frac{3}{4})12$.
(10) $11\frac{1}{3})60\frac{15}{32}$.
(11) $11\frac{3}{4})213\frac{45}{64}$.
(12) $4\frac{5}{8})17\frac{25}{48}$.
(13) $\frac{7}{72})7\frac{7}{48}$.

(14) If $7\frac{6}{7}$ pounds of yarn cost $38\frac{7}{8}s$. what is the price per pound?

(15) A farm of $17\frac{5}{11}$ acres was rented at £$14\frac{7}{15}$. what was the rent per acre?

(16) A man performed a piece of work in $6\frac{1}{18}$ days, what part did he perform in one day?

(17) How many stones each $13\frac{1}{2}$ inches by $7\frac{1}{4}$ will lay a room $40\frac{7}{8}$ feet long and $32\frac{3}{4}$ broad?

NOTE 1. If the Divisor and Dividend have both the same Denominator, the Quotient may be found by dividing one Numerator by the other.

Divide $3\frac{3}{4}$ by $\frac{3}{4}$. Divide $\frac{5}{17}$ by $\frac{15}{17}$.

NOTE 2. If the Divisor and Dividend have each the same Numerator; divide one of the Denominators by the other, which will give the Quotient required.

Divide $\frac{4}{17}$ by $\frac{4}{5}$. Divide $\frac{7}{9}$ by $\frac{7}{25}$.

NOTE 3. If the Numerator and Denominator of the Dividend can be divided without a Remainder, by the Numerator and Denominator of the Divisor, their Quotients will answer the question.

Divide $\frac{90}{28}$ by $\frac{5}{7}$.

NOTE 4. If a number can be found that will Divide both the Numerators, or both the Denominators without a Remainder, use those Quotients and the result will be in its lowest terms.

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## PROPORTION.

STATE the terms, as in Integers, and multiply and divide as directed above.

(1) If $\frac{7}{11}$ of a house cost £360. what will $\frac{17}{24}$ of the same cost?

(2) How many planks, 15 feet long and $1\frac{1}{4}$ wide, will floor a room $60\frac{1}{2}$ feet long and $33\frac{1}{3}$ wide?

(3) The height of a staff from the ground is $5\frac{6}{8}$ feet, and

casts a shadow $6\frac{5}{12}$ feet. Required the height of a steeple which casts a shadow of $220\frac{1}{2}$ feet.

(4) If an iron bar, 2 feet long, 3 inches broad, and 1 inch thick, weighs 18 *lbs.* what will be the weight of another bar of iron, which is 7 feet long, 6 inches broad, and $3\frac{1}{2}$ inches thick?

(5) A haystack, 7 yards long, $3\frac{1}{2}$ yards broad, and 4 yards high, was sold for £23..10.; and if another stack, 12 yards long, $7\frac{1}{2}$ broad, and $3\frac{1}{2}$ high, be valued by the former, what will it come to?

(6) If a rectangular box, 3 feet long, 2 feet wide, and $1\frac{1}{2}$ deep, hold 13 bushels of grain, what must be the depth of a box, 7 feet long, and 5 feet broad, to hold 146 bushels?

(7) If a sheet of metal, 3 feet in length, 18 inches broad, and $\frac{3}{8}$ of an inch thick, weigh 10 *lbs.* required the thickness when a sheet of the same metal, 4 feet by 3 inches, weighs only 2 *lbs.*

(8) A roof, which is $24\frac{3}{4}$ feet, by $14\frac{1}{2}$, is to be covered with lead at 8 *lbs.* to the square foot. How many pounds of lead will be wanted?

(9) Admitting the length of the lever to be $7\frac{1}{2}$ inches the long arm, the short arm $\frac{1}{2}$ inch, the weight hanging $1\frac{3}{4}$ *lbs.* what will be the weight on the front roller?

(10) Admitting the pressure on the front roller to be $26\frac{1}{4}$ *lbs.* the distance from the bridle to the front roller $\frac{3}{4}$ of an inch, and from the bridle to the back saddle, where it presses on the centre of the back roller, is $2\frac{1}{4}$ inches, the weight on the back roller is required.

(11) Admitting the weight on the front roller to be $19\frac{1}{4}$ *lbs.* the short arm $\frac{1}{2}$ inch, the weight hanging 20 *oz.* required the length of the long arm.

(12) If the long arm be $7\frac{7}{10}$ inches, the weight on the front roller $19\frac{1}{4}$ *lbs.* and the weight hanging 20 *oz.* required the length of the short arm.

(13) The front roller of a drawing frame is $1\frac{1}{4}$ inch diameter, the delivery roller $2\frac{1}{2}$ inches diameter, on its axis is a pulley of $3\frac{1}{2}$ inches diameter, required the diameter of the pulley on the front roller.

(14) The front roller is $1\frac{1}{4}$ inch diameter, on its axis is a pulley of $1\frac{3}{4}$ inch diameter, the delivery roller is $2\frac{1}{2}$ inches diameter, required the diameter of a pulley to be placed on the axis of the delivery roller.

(15) The front roller is $1\frac{1}{4}$ inch diameter, on its axis is a

pulley of $1\frac{3}{4}$ inch, that turns a pulley of $3\frac{1}{2}$ inches diameter, required the diameter of the delivery roller.

(16) If the diameter of the front roller be $1\frac{1}{8}$ inch, having on its axis a pinion of 16 teeth, that turns a wheel of 72 teeth on the axis of the mendoza shaft, what will be the diameter of the mendoza pulley, to draw out the carriage equal to what the rollers deliver?*

(17) If a set of rovings weigh $5\frac{1}{4}$ *lbs.* with a pinion of 48, what pinion will a set of rovings require to weigh $6\frac{3}{8}$ *lbs.*?

(18) If a set of rovings weigh $7\frac{3}{8}$ *lbs.* with a pinion of 36, what will a set, weighing $6\frac{5}{8}$ *lbs.* require?

(19) If a set of rovings weigh $9\frac{1}{4}$ *oz.* with a 40 pinion, what weight will a 44 pinion deliver at the same rate?

(20) There is a wheel of 31 teeth drives one of 19 teeth, and the latter drives one of 17 teeth. Required the number of turns each wheel must make before they arrive at the same point they set out from.

(21) A certain dial plate is divided into 73 divisions, over which move three indexes; the first moves over 5 divisions, the second over 8, the third over 10, in the same space of time (in one hour.) Supposing all to start together, how many hours will elapse before they all come to one point for the first time?

(22) Another dial plate has 134 divisions, over which move 2 indexes; the first goes over 11 divisions in 2 minutes, the second over 17 divisions in 3 minutes. Supposing them to be placed exactly opposite each other, how many times will they go round the dial before the nimbler overtakes the slower?

## DECIMAL FRACTIONS.

A DECIMAL fraction is that which has 1, with a cipher or ciphers for its denominator, as $\frac{6}{10}$, $\frac{73}{1000}$.

Hence in Decimals, the unit is divided into 10, or 100, or 1000 equal parts.

The Numerator only is written; and it must have as many places as there are ciphers in the Denominator; and when it has not, so many ciphers must be placed before it in order to

* From the Answer subtract $\frac{1}{4}$ inch for the diameter of the mendoza band.

supply the deficiency; and the point is placed on the left hand to distinguish it from an integer. Thus the Denominator is easily known: for it consists of 1, with as many ciphers as there are places in the Numerator; as ·7 or $\frac{7}{10}$, ·26 or $\frac{26}{100}$, ·057 or $\frac{057}{1000}$.

Hence a cipher *on the left* diminishes the value of the significant figures 10 times; but *on the right hand* it makes no alteration.

Decimals are divided into *terminate* and *interminate*; for which see Problem 1. Reduction.

## ADDITION AND SUBTRACTION.

PLACE like names under like names, which is readily done by placing the decimal points under each other, then proceed as in Integers.

(1) 478·63 + 89·005 + 5437·25 + ·000125 + 91·75 + 541·2375.
(2) 6·75 + 89·5 + ·00009 + ·502 + 7·548.
(3) 51·416 + 915·13 + ·04751 + ·005819 + ·000045 + ·01018.
(4) 74·874 + 81·33486 + ·0974 + 1·0718 + 88·71034.
(5) 61·371568 + ·0091 + ·06371 + ·0008714 + 43·814
(6) 71·48 — 35·71. (7) 87·31 — 6·871496.
(8) 3·187 — 1·00007. (9) ·6748 — ·377.
(10) 1·000009 — ·784163. (11) 4·001 — ·374.
(12) ·00078 — ·000089.

## MULTIPLICATION.

RULE. Proceed as in Integers, and point off as many decimals in the Product as there are in both Factors. If the Product has not so many, supply the defect by prefixing ciphers.

| | |
|---|---|
| (1) 74869·3 × ·673 | (7) 74·58 × ·083 |
| (2) 8914·714 × 6·7 | (8) ·987 × 642 |
| (3) 71·807 × ·0009 | (9) ·078 × ·004 |
| (4) ·0714 × ·013 | (10) ·478 × ·038 |
| (5) 91·07 × ·03 | (11) 748 × ·6 |
| (6) 58·62 × ·3 | (12) 891 × ·72 |

To multiply by a unit with ciphers, remove the decimal point as many places towards the right hand as there are ciphers.

(13) 78·14 × 10 (14) ·98516 × 10000
(15) 6·87146 × 1000000

## DIVISION.

RULE. Proceed as in Integers, and point the Quotient, so that there may be as many decimal places in the Divisor and Quotient together as there are in the Dividend. But if the Divisor have one, two, three, or more decimals than the Dividend, a similar number of ciphers must be added to the Dividend, and the Quotient will be a whole number.

NOTE 1. In case of a Remainder, the Quotient may be carried to any degree of exactness by annexing ciphers in *terminate decimals*, and the repeating, or circulating figures in *interminate ones*.

NOTE 2. To divide by a unit, with ciphers, remove the decimal point in the Dividend as many places towards the left hand as there are ciphers in the Divisor.

(1) ·11)1·4641
(2) ·8204)·504020944
(3) 23·15)1836·88305
(4) 53·146)22118·6052122
(5) ·01548)·04888501956
(6) ·8416591)·0030266061236
(7) ·25)784689·5
(8) ·75)87486·125
(9) ·00785)·8741685
(10) 33·85)37416·556
(11) ·785)18
(12) 1000)7486·35

## REDUCTION.

### PROBLEM 1.

To reduce a vulgar fraction to a decimal.—Divide the Numerator, with ciphers annexed to it, by the Denominator, and point as many places for decimals in the Quotient as you have added ciphers to the Dividend.

NOTE. If the Division terminate without a Remainder, the decimal is said to be *finite*, or *terminate*; if not, it is called *interminate*.

An interminate decimal is either a *repeater*, when the same figure is constantly repeated; or a *circulate*, when several recur in their order. And the repeater, or circulate, is said to be *pure*, when the repeating figures begin at the decimal point; or *mixed*, when there are other figures before them.

(1) Reduce $\frac{1}{6}$ to a decimal.
(2) Reduce $\frac{5}{8}$ to a decimal.
(3) Reduce $\frac{1}{4}$ to a decimal.
(4) Reduce $\frac{3}{4}$ to a decimal.
(5) Reduce $\frac{7}{8}$ to a decimal.
(6) Reduce $\frac{1}{3}$ to a decimal.
(7) Reduce $\frac{1}{5}$ to a decimal.
(8) Reduce $\frac{5}{6}$ to a decimal.
(9) Reduce $\frac{1}{8}$ to a decimal.
(10) Reduce $\frac{9}{16}$ to a decimal.

(11) Reduce $\frac{1}{8}$ to a decimal.
(12) Reduce $\frac{1}{75}$ to a decimal.
(13) Reduce $\frac{1}{125}$ to a decimal.
(14) Reduce $\frac{7}{11}$ to a decimal.
(15) Reduce $\frac{8}{11}$ to a decimal.
(16) Reduce $\frac{4}{9}$ to a decimal.
(17) Reduce $\frac{9}{11}$ to a decimal.
(18) Reduce $\frac{1}{6}$ to a decimal.
(19) Reduce $\frac{5}{11}$ to a decimal.
(20) Reduce $\frac{1}{13}$ to a decimal.
(21) Reduce $\frac{1}{99}$ to a decimal.
(22) Reduce $\frac{1}{5}\frac{1}{4}$ to a decimal.
(23) Reduce $\frac{2}{3}$ to a decimal.
(24) Reduce $\frac{1}{17}$ to a decimal.

### PROBLEM II.

**To reduce a decimal to a vulgar fraction.—The given decimal will be the Numerator; and a unit, with as many ciphers annexed as there are figures in the decimal, will be the Denominator of the required fraction, which reduce to its lowest terms.**

(1) Reduce ·5 to a vulgar fraction.
(2) Reduce ·25 to a vulgar fraction.
(3) Reduce ·75 to a vulgar fraction.
(4) Reduce ·125 to a vulgar fraction.
(5) Reduce ·625 to a vulgar fraction.
(6) Reduce ·34 to a vulgar fraction.
(7) Reduce ·375 to a vulgar fraction.
(8) Reduce ·005 to a vulgar fraction.
(9) Reduce ·078 to a vulgar fraction.

### PROBLEM III.

**To reduce numbers of a lower name to the decimal of a higher.—If the given number be simple, divide by the value of the highest, annexing as many ciphers as necessary; if a compound number, reduce the lowest part to a decimal of the next higher name, prefixing the given part of that name; reduce the number thus obtained to a decimal of the next higher name, and so on, as far as required.**

(1) Reduce 9*d.* to the decimal of a £.
(2) Reduce 10*d.* to the decimal of a £.
(3) Reduce 17*s.* 6*d.* to the decimal of a £.
(4) Reduce 12*s.* 8½*d.* to the decimal of a £.
(5) Reduce 19*s.* 11¾*d.* to the decimal of a £.
(6) Reduce 14*s.* 3½*d.* to the decimal of a £.
(7) Reduce 3*s.* 4*d.* to the decimal of a £.
(8) Reduce 6*s.* 8*d* to the decimal of a £.
(9) Reduce 13*s.* 4*d.* to the decimal of a £.
(10) Reduce 11*d.* to the decimal of a £.
(11) Reduce 4⅓*d.* to the decimal of a £.

(12) Reduce $\frac{3}{4}$*d.* to the decimal of a £.
(13) Reduce 7 *lbs.* to the decimal of a *cwt.*
(14) Reduce 8 *lbs.* to the decimal of a *cwt.*
(15) Reduce 17 *lbs.* to the decimal of a ton.
(16) Reduce 18 *cwt.* 13 *lbs.* to the decimal of a ton.
(17) Reduce 11 *oz.* 17 *dwts.* to the decimal of a *lb.*
(18) Reduce 13 *dwts.* 16 *grs.* to the decimal of a *lb.*
(19) Reduce 5 *dwts.* 12 *grs.* to the decimal of an *oz.*
(20) Reduce 7 *oz.* 14 *drs.* to the decimal of a *cwt.*
(21) Reduce 10 *oz.* 12 *drs.* to the decimal of a *lb.*
(22) Reduce 3 *oz.* 14 *dwts.* 8 *grs.* to the decimal of a *lb.*
(23) Reduce 3 *qrs.* to the decimal of a yard.
(24) Reduce 1 *qr.* 2 *n.* to the decimal of a yard.
(25) Reduce 6 *fur.* 5 *p.* to the decimal of a mile.
(26) Reduce 2 *r.* 11 *per.* to the decimal of an acre.
(27) Reduce 10 *in.* 8 *pts.* to the decimal of a foot.
(28) Reduce 11*d.* to the decimal of a shilling.
(29) Reduce 10*d.* to the decimal of a shilling.
(30) Reduce 7$\frac{1}{2}$*d.* to the decimal of a shilling.
(31) Reduce 12*s.* 4$\frac{3}{4}$*d.* to the decimal of a guinea.
(32) Reduce 5 *yds.* 2 *ft.* 11 *in.* to the decimal of a pole.
(33) Reduce 7 *d.* 6 *hrs.* to the decimal of a year.
(34) Reduce 7 *hrs.* 9 *m.* to the decimal of a day.
(35) Reduce 22 *m.* 3 *sec.* to the decimal of an hour.
(36) Reduce 3 *le.* 27 *thr.* to the decimal of a hank.
(37) Reduce 36 *yds.* to the decimal of a hank.
(38) Reduce 24 *yds.* to the decimal of a lea.
(39) Reduce 30 *yds.* to the decimal of a hank.
(40) Reduce 4 *le.* to the decimal of a hank.

### PROBLEM IV.

To find the value of the decimal in parts of the integer.—Multiply it by the number of times the integer contains the next lower name, and point off as many decimals from the product towards the right hand as there are in the given decimal; the figures on the left hand are integers of the said lower name; reduce the figures pointed off into the next lower name, and point off as before. Proceed thus as far as necessary.

(1) What is the value of ·0375£.?
(2) What is the value of ·0416£.?
(3) What is the value of ·875£.?
(4) What is the value of ·634375£.?
(5) What is the value of ·9989583£.?

(6) What is the value of ·714583£.?
(7) What is the value of ·16£.?
(8) What is the value of ·3£.?
(9) What is the value of ·6£.?
(10) What is the value of ·04583£.?
(11) What is the value of ·01875£.?
(12) What is the value of ·003125£.?
(13) What is the value of ·0625 *cwt.*?
(14) What is the value of ·071428 *cwt.*?
(15) What is the value of ·007859 ton?
(16) What is the value of ·9058 ton?
(17) What is the value of ·9875 *lb.* troy?
(18) What is the value of ·05694 *lb.*?
(19) What is the value of ·275 *oz.* troy?
(20) What is the value of ·004394 *cwt.*?
(21) What is the value of ·671875 *lb.* avoirdupois?
(22) What is the value of ·30972 *lb.* troy?
(23) What is the value of ·75 yard?
(24) What is the value of ·375 yard?
(25) What is the value of ·765625 mile?
(26) What is the value of ·56875 acre?
(27) What is the value of ·8 foot?
(28) What is the value of ·916 shilling?
(29) What is the value of ·83 shilling?
(30) What is the value of ·625 shilling?
(31) What is the value of ·59027 guinea?
(32) What is the value of ·718253 ton?
(33) What is the value of ·1085 perch?
(34) What is the value of ·019863 year?
(35) What is the value of ·2979 day?
(36) What is the value of ·3675 hour?
(37) What is the value of ·3875 hank?
(38) What is the value of ·4825 lea?
(39) What is the value of ·375 thread?
(40) What is the value of ·125 stretch?

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## OF INTERMINATE DECIMALS.

A REPEATER is marked with a point above it, and a circulate with a point over the first and last figure of the circle.

## REDUCTION.

### PROBLEM I.

To reduce an interminate decimal to a vulgar fraction.

1. If it be a pure repeater or circulate, place 9 for the Denominator of the repeater, or 9 for every figure of the circle.

Reduce ·7, ·3, ·27, ·962, ·428571 to a vulgar fraction.

2. If the decimal be mixed, subtract the finite part from the whole, the Remainder is the Numerator, and for the Denominator place 9 for every repeating figure, with a cipher annexed for every finite place.

Reduce ·583, ·2954, ·16, ·045, ·65296 to a vulgar fraction.

### PROBLEM II.

To value an interminate decimal.

1. If it be a repeater, carry at 9 instead of 10 on the right hand, and if there be a cipher on the right of the Multiplier instead of it annex the repeating figure of the Product.

Value £·883, ·5686 crown, ·3725 *cwt.* ·6742 mile.

2. If it be a circulate, multiply as usual, and to the right hand figure of the Product add the carriage from the left of the circle. And if there are 2 or more lines of the Product to be added, the circles must be carried the same length in them all, and when adding, the carriage from the left of the circle must be added to the right hand figure of the sum.

Value ·6745 guinea, ·419644 *cwt.*, £·75307, ·84725 acre.

### PROBLEM III.

To make circles similar.—Make all the circles begin on the right side of the longest finite part, and extend them till the same figures begin to be again below one another, and then the circles are complete.

Make ·36 and ·468, ·4854 and ·762927, ·3 and ·26418 and ·405 similar.

## ADDITION.

1. When there are only repeaters, extend them one place farther than the longest finite, and carry at 9 on the right hand.

(1) Add $\cdot 3813$ and $42$ and $\cdot 5216$ and $\cdot 94724$.
(2) Add $15\frac{1}{3} + 34\frac{1}{4} + {}_{18}^{7} + 16\frac{5}{6} + \frac{1}{24} + 7\frac{1}{9}$.
(3) £3..6..8. + £7..19..11. + £10..12..$6\frac{1}{2}$. + 19*s*. 6*d*. + £$5\frac{2}{3}$.

2. When there are circles make them similar, and to the right of the sum add the carriage from the left of the circle.

(4) $\cdot 7154 + \cdot 3153 + \cdot 8724239$.

(5) $\cdot 7926732 + \cdot 3 + \cdot 516 + \cdot 405$.
(6) $\frac{5}{7} + \frac{9}{7} + {}_{11}^{5} + \frac{19}{27} + \frac{15}{37}$.
(7) $\frac{49}{52} + \frac{278}{390} + \frac{1}{3} + \frac{5}{6} + {}_{12}^{7}$.

## SUBTRACTION.

1. Extend the repeaters one place beyond the longest finite and borrow 9 on the right when necessary.
2. Make circles similar, and subtract as usual; but if there be a carriage from the left of the circle it must be taken from the right hand figure of the remainder.

(1) $\cdot 714583 - \cdot 634375$.

(2) $\cdot 525 - \cdot 3$.

(3) $\cdot 9989583 - \cdot 02916$.

(4) $\cdot 6428571 - \cdot 17857142$.
(5) $1\frac{5}{14} - \frac{2}{3}$.
(6) $18_{12}^{1} - 4_{14}^{5}$.
(7) $7\frac{2}{3} - 3_{18}^{5}$.
(8) $11\frac{19}{27} - 5\frac{25}{37}$.

## MULTIPLICATION.

1. If the Multiplicand be interminate carry at nine on the right of the repeater; or multiply as usual in a circulate, and

to the right of the Product add the carriage from the left of the circle, and before adding extend the repeaters the same length in each Product, and make the circles similar.

NOTE. Instead of annexing ciphers to the Product annex the repeating figures.

(1) $\cdot\dot{1}6 \times 7$.

(2) $27\cdot\dot{0}8\dot{3} \times 9$.

(3) $\cdot 406 \times 52$.

(4) $27\cdot883 \times 8\cdot75$.

(5) $79\cdot\dot{6} \times 50$.

(6) $84\cdot\dot{7} \times 8000$.

(7) $\frac{1}{2}\frac{3}{7} \times 7$.

(8) $7\frac{1}{2}\frac{4}{7} \times \cdot 05$.

(9) $\frac{8}{1\,1} \times 20$.

(10) $4\cdot3\frac{1}{4} \times 600$.

(11) $86\cdot53\frac{8}{3\,7} \times 58\frac{3}{4}$.

(12) $\frac{5}{1\,4} \times \frac{1\,1}{1\,8}$.

2. If the Multiplier be interminate reduce it to a vulgar fraction, then multiply by the Numerator and divide by the Denominator.

(13) $\cdot625 \times \dot{3}$.

(14) $87\cdot2 \times \cdot\dot{0}7$.

(15) $\cdot845 \times \cdot\dot{4}8$.

(16) $87\cdot\dot{3}4 \times 2\cdot\dot{6}7$.

(17) $\cdot623 \times \cdot06$.

(18) $\cdot309 \times \cdot46$.

(19) $\cdot825 \times \cdot\ddot{3}6$.

(20) $64\cdot35 \times \cdot772$.

(21) $16\cdot\dot{1}4\dot{5} \times \cdot\dot{5}7\dot{2}9$.

(22) $\cdot7216 \times \cdot\ddot{5}4$.

(23) $\cdot943 \times \cdot\ddot{2}172$.

(24) $\cdot635 \times 9\cdot\dot{4}8\dot{1}$.

(25) $67\frac{1}{1\,8} \times \frac{8}{9}$.

(26) $8\frac{1}{3}\frac{1}{7} \times \frac{1}{2}\frac{5}{2}$.

(27) $\frac{6}{6}$ of $\frac{7}{9} \times 3\frac{5}{1\,3}$.

(28) $6\frac{2}{2\,7} \times 4\frac{3}{3\,7}$.

(29) $8\frac{1}{1\,2} \times \frac{4}{5}$ of $\frac{5}{8}$.

(30) $\frac{2}{7\,7}\frac{1}{} \times \frac{4\,5}{4\,5}$.

NOTE. To multiply by $\cdot\dot{3}$ take $\frac{1}{3}$ of the Multiplicand, and to multiply by $\cdot\dot{6}$ subtract $\frac{1}{3}$ of the Multiplicand from it.

## DIVISION.

1. If the Dividend be only interminate, divide as in finite decimals, but annex the repeating figures instead of ciphers, in order to carry on the division.

2. If the Divisor be interminate, reduce it to a vulgar fraction, then multiply by the Denominator and divide by the Numerator.

NOTE. To divide by ·3 multiply by 3, and to divide by ·6 add $\frac{1}{4}$ of the Dividend to it.

(1) 4)5·16.

(2) 7)3·370.

(3) 37)4·19662.

(4) 6·25)73·416.

(5) 1·5)15·06.

(6) ·05)169·3.

(7) ·5)75·26.

(8) ·7)·1134.

(9) ·4)23·5

(10) ·3)8·962.

(11) 48·3)363·5407.

(12) ·45)9.

(13) 19·39)·12693.

(14) ·84)17·45.

(15) ·6)·34740.

(16) ·296)·24835.

(17) $7\frac{1}{7})\frac{5}{8}$ of $\frac{1}{12}$.

(18) $\frac{5}{17})\frac{2}{3}$ of $\frac{1}{3\frac{5}{7}}$.

## PROPORTION.

(1) If 3·5 ounce of cotton be spread 7·5 feet long, what portion of a hank will it be?

(2) If the cotton delivered from the drawing frame is 2·5 hanks in the pound, what will be the weight of 90 yards?

(3) If cotton be spread behind the cards 6·75 feet, and is increased as one to 38·375, what will be the length in hanks delivered?

(4) How many deals, 12·5 feet long, 1·75 inches thick, are equivalent to 4500 deals, 14·25 feet long, 2·5 inches thick?

(5) If one spindle of a throstle in 11·75 hours turn off 4·875 hanks, How much will 240 spindles turn off in 69·375 hours?

(6) Four furnaces are employed for running iron ore into pig, the 1st. 2nd. and 3rd. will run a certain quantity in 12 days, the 2nd. 3rd. and 4th. in 14 days, the 3rd. 4th. and 1st. in 15 days, the 4th. 1st. and 2nd. in 18 days, in what time will they all perform it working together?

(7) A beam 20·375 feet long, and supported at both ends bears a weight of 2·4375 tons at the distance of 8·425 from one end; required the weight on each support.

(8) A plank is 14·25 feet long, at what distance from the edge must a line be struck to cut off a square yard exactly?

(9) A square girder is 1·583 feet by ·916 foot, and one with a quarter of the timber in it will answer if it be ·75 foot deep, how broad will it be?

(10) Two bodies in motion the weight of one is 100·75 *lbs.* the other 60·375 *lbs.* the less body is impelled with a force 8·125 times greater than the other, required the proportion of their velocities.

(11) Of two bodies the one contains 8·416 times the matter of the other, and is moved with a force 48·326 times the other, the ratio of their velocities is required.

(12) If the weight of a set of rovings be $10\frac{1}{2}$ *lbs.* and I put 340 stretches on, the length of the stretch 54 inches, the number of spindles 252, what will be the hank roving?

(13) Admitting the draft to be 11·5, the altering pinion 24, what will the draft be if the pinion be changed to 28?

(14) What weight of water will be contained in a pipe whose content is 9·4248 inches, allowing one cubic foot or 1728 inches to weigh 1000 ounces?

(15) Required the number of gallons of water in a pipe, its contents being 21092·38 inches.

(16) In 1 pound avoirdupois, how many pounds troy?

(17) What decimal of a pound avoirdupois is 1 pound troy?

(18) If a cast iron pipe 15 inches diameter, $\frac{3}{4}$ of an inch thick be sufficient for a head of water 600 feet high, what must be the thickness of a pipe 10 inches diameter for a head of 360 feet high?

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## COMMISSION

Is the allowance due to an agent for buying or selling goods, negociating bills, &c.

RULE. Multiply the value of the transaction by the rate, and divide the Product by 100.

If the rate contains a fraction, take parts for it.

Or, take same parts of the value that the rate is of £100.

(1) What is the commission on £1764..16..6. at £$3\frac{1}{4}$. per cent.?

(2) What is the commission on £436..13. at £2¾. per cent.?
(3) What is the commission on £978. at £2½. per cent.?
(4) What is the commission on £1242. at 2*s*. 6*d*. per cent.?
(5) What is the commission on £957. at 3*s*. 4*d*. per cent.?
(6) What is the commission on £937. at 7*s*. 6*d*. per cent.?
(7) What is the commission on £754..14..4. at 4*s*. per cent.?
(8) What is the commission on £598. at 4*s*. 6*d*. per cent.?
(9) What is the commission on £675. at 2*s*. 9*d*. per cent.?
(10) An agent charges £4¼. per cent. commission, and risk of bad debts. His sales in a year amount to £14780. and his losses to £230. What is his neat income?
(11) What is the allowance due to a broker for procuring insurance to the amount of £2840. at 3*s* 9*d*. per cent.?
(12) Rendered an account, sales of 300 bags of cotton; the gross amount came to £2220. duty, freight and other charges £754..14..8. commission £2½. per cent.
(13) Purchased goods for my employer to the amount of £654..14..8. and sent them according to order; packing, porterage and cartage £4..3..8.; commission £2¾. per cent. Required the amount of the invoice.

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## INSURANCE

Is a contract, in which the underwriter engages to repay losses sustained by the insured, in consideration of a certain allowance called premium.

Case 1. To find the premium, work as in Commission.

If the rate be guineas, divide the sum insured by 20, and add the Quotient to the Dividend, then proceed as if the rate were pounds.

(1) What must be paid for insuring property to the amount of £756..10..8. at 3 guineas per cent.?
(2) What is the premium on £1940. at £3⅜. per cent.?
(3) What is the premium on £2736. at 5½ guineas per cent.?
(4) What is the premium on £964..16..8. at 6¾ guineas per cent.?
(5) What is the premium on £1560. at 7½ guineas per cent.?
(6) What is the premium on £1674..18. at 2*s*. 3*d*. per cent.?

(7) What is the premium on £579..12..4. at 3*s*. 9*d*. per cent.?

(8) What is the premium on £720. at $5\frac{7}{8}$ guineas per cent.?

Case 2. To find how much will cover a given sum.

Rule. Multiply the value of the property by 100, and divide by the difference between 100 and the rate.

(9) What sum must be insured, at 10 guineas per cent. to recover £3580. in case of loss?

(10) What sum must be insured, to cover £2736..15. at $5\frac{1}{2}$ guineas per cent.?

(11) What sum must be insured, to cover £964..16..8. at $6\frac{3}{4}$ guineas per cent.?

(12) What sum must be insured, to cover £1560. at $7\frac{1}{8}$ guineas per cent.?

(13) What sum must be insured, to cover £674..14. at 5 guineas per cent.?

(14) What sum must be insured, to cover £730. at $4\frac{3}{8}$ guineas per cent.?

(15) What sum must be insured, to cover £967. at $1\frac{1}{2}$ guinea per cent.?

Case 3. To find how much will cover the given sum in the voyage out and home.

First find, by Case 2, what will cover the given sum in the voyage out; and then find, in the same manner, what must be insured to cover the sum found in the homeward voyage.

(16) What sum must be insured, to cover £32041. on a voyage out and home, at 10 guineas per cent. each voyage?

(17) What sum must be insured, to cover £560. at 5 guineas per cent.?

(18) What sum must be insured, to cover £1280. at 8 guineas per cent.?

(19) What sum must be insured, to cover £800. at $7\frac{1}{2}$ guineas per cent.?

(20) What sum must be insured, to cover £760. at 4 guineas per cent.?

(21) What sum must be insured, to cover £840. at 3 guineas per cent.?

(22) What sum must be insured, to cover £3420. at 7 guineas per cent.?

## BUYING AND SELLING STOCK.

STOCK is the capital of a bank, or trading company; or it is the debt owing by Government, called the Public Funds.

Case 1. To find the value of any quantity of stock, multiply by the rate and divide by 100.

(1) What is the price of £1260. Government stock, at £65½. per cent.?

(2) What is the price of £1460. three per cent. consols, at £62⅝. per cent.?

(3) What is the price of £860. four per cent. consols, at £78¼. per cent.?

(4) What is the price of £750. five per cent. consols, at £93⅓. per cent.?

(5) What is the price of £1640. India stock, at £230. per cent.?

(6) What is the price of £3420. bank stock, at £172. per cent.?

Case 2. To find the quantity purchased by a given sum, multiply the value by 100, and divide by the rate.

(7) What quantity of South Sea stock, at £73¼. per cent. can be purchased for £850.?

(8) What quantity of 4 per cents. at £79½. per cent. can be purchased for £600.?

(9) What quantity of 3 per cents. at £61¾. per cent. can be purchased for £1200.?

(10) What quantity of India stock, at £178½. per cent. can be purchased for £780.

(11) What quantity of bank stock, at £184. per cent. can be purchased for £2400.?

Case 3. To find the rate of interest, multiply the interest or Dividend by 100, and divide by the rate, or current price.

(12) What interest will be obtained by purchasing three per cents. at £58½. per cent.?

(13) What interest will be obtained by purchasing four per cents. at £83¼. per cent.?

(14) What interest will be obtained by purchasing India stock, at £173. per cent. the dividend being 9 per cent.?

(15) What interest will be obtained by purchasing bank stock, at £182. per cent. the dividend being £13. per cent.?

(16) At what price should a purchase be made in the £3. per cents. to secure £5½. per cent. interest?

(17) Bought £3500. stock in the £3. per cents. reduced at £62½. per cent. brokage £⅓. per cent. Required the value of it.

(18) If the four per cents. can be purchased for £75. per cent. what will be the rate of interest per cent.?

The Pars of Stocks are computed as under:

| Pars. | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
|---|---|---|---|---|---|---|---|
| Per cent. | 3 | 3½ | 4 | 4½ | 5 | 5½ | 6 |

*To equate several Stocks to one another.*

RULE. As the par of the stock given is to its current price, so is the par of any other stock to its equivalent price.

(19) When £3. per cents. are at £86½. what should £4. per cents. be at to afford the same rate of interest?

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## CREDIT, AND THE TIME WHEN BILLS BECOME DUE IN CASH.

RULE. Where the time mentioned is weeks, count so many 7 days from that time. Where months, count calendar months; and to bills add 3 days to the day when the time of any bill shall expire.

(1) Sold goods on the 4th. of May, to be paid for in 4 weeks, prompt. On what day of the month will the credit expire?

(2) Sold calicos on the 16th. of June, to be paid for in one month, prompt. Required the time of payment.

(3) Bought yarn on the 17th. of March, to be paid for in 6 weeks. Required the day of the month when the payment becomes due.

(4) Bought cotton on the 15th. of August, to be paid for in a bill at the end of 2 months and 14 days. Required the day of payment.

(5) I have a bill, dated 16th. of October, payable 2 months after date. On what day should the same be paid in cash?

(6) Sold yarn on the 16th. of May, at 2 months' credit and 2 months' bill, prompt. When will the bill be due in cash?

(7) I have a bill, dated 14th. of February, at 3 months' date; 35 days have elapsed. How many days has it to run?

(8) Sold cotton on the 12th. of August, at 3 months and

14 days' credit, and a 3 months' bill. When will the bill become payable?

(9) Find when the following accounts are due in cash.

| | Credit. | | Bill. |
|---|---|---|---|
| | *m.* | *d.* | *m.* |
| June 16, Prints ..... | 2 | 0 and | 2 |
| ..... 25, Yarn ..... | 0 | 14 and | 3 |
| ..... 28, Cotton..... | 2 | 0 and | 3 |
| July 4, Cotton..... | 2 | 14 and | 3 |

## INTEREST

Is the allowance given by the borrower to the lender, for the use of his money.

It is reckoned at a certain rate on every £100. for a year.

The sum borrowed is called the principal; and when the interest is added to it, the sum is called the amount.

RULE. To find the interest for any number of years.—Multiply by the years and the rate, and divide by £100.

Or, if the Product of the years and rate be a convenient aliquot part, or parts of £100. or can be divided into several such parts, take the part or parts of the principal for the interest required.

For months, take parts of a year.

RULE 2. To find the interest for days.—Multiply by the days, and twice the rate, and divide by 73,000.

(1) Required the interest of £754..14..8¾. for a year, at £4. per cent.

(2) Required the interest of £928..18. for 8¾ years, at £4½. per cent.

(3) Required the interest of £1256..14..8¼. for 7 years, at £3½. per cent.

(4) Required the interest of £36..17..7. for 9 months, at £4⅛. per cent.

(5) Required the interest of £2346. for 9 years and 7 months, at £4 17/20. per cent.

(6) Required the interest of £364..17..5. for 5 months, at £3¼. per cent.

(7) Required the interest of £560. for 7 weeks, at £4. per cent.

(8) Required the interest of £1240. for 19 weeks, at £3. per cent.

(9) Required the interest of £3204..14. for 37 days, at £5. per cent.

(10) Required the interest of £910..15. for 68 days, at £4½. per cent.

(11) Required the interest of £256. from May 7, to August 12, at £4½. per cent.

(12) Required the interest of £154. from January 7, to July 23, at £4⅝. per cent.

(13) Required the interest of £630. from September 16, to January 23, at £4¼. per cent.

(14) Required the interest of £150. from January 7, to August 23, at £4¾. per cent.

(15) Required the interest of £630. from September 12, to January 27, at £4¼. per cent.

(16) Required the interest of £720. from March 8, to June 7, at £3. per cent.

(17) Required the interest of £230. from May 27, to September 18, at £3½. per cent.

(18) Required the interest of £590. from January 4, to May 17, at £5. per cent.

*For Months only, at £5. per cent. per annum.*

RULE. Take the pounds as pence; 10*s.* as halfpence; 5*s.* as farthings; this will give the interest required for one month, which multiply by the number of months given.

(1) Required the interest of £160. for 1 month.

(2) Required the interest of £340..10. for 3 months.

(3) Required the interest of £478..15. for 6 months.

(4) Required the interest of £1876..17..6. for 9 months.

(5) Required the interest of £3476..11. for 15 months.

*For Years and Months, at £5. per cent.*

Take the years as shillings, and the months as pence, and divide the principal by such aliquot parts as the years and months form of £1.; the Quotient will be the answer.

(1) Required the interest of £278..16..3. for 6 years and 8 months.

(2) Required the interest of £76..13..4. for 2 years and 6 months.

(3) Required the interest of £54..6..8. for 1 year and 8 months.

(4) Required the interest of £86..4..8. for 7 years and 6 months.

(5) Required the interest of £127..5..4. for 8 years and 4 months.

(6) Required the interest of £20. for 8 months.

(7) Required the interest of £146. for 7 months.

(8) Required the interest of £473..6..8. for 9 months.

(9) Required the interest of £104..5. for 10 months.

(10) Required the interest of £327..6..8. for 4 months.

*For Months, at any rate per cent.*

1200, divided by the Product of the time and rate, wi give a Divisor for the Principal, and the Quotient will be the interest for the time.

(1) Required the interest of £276..10. 8. for 4 months, at £3. per cent.

(2) Required the interest of £468. for 2 months, at £6. per cent.

(3) What is the interest of £594..10. for 3 years and 4 months, at £5. per cent.?

(4) What is the interest of £296..8. for 5 years, at £5. per cent.?

(5) What is the interest of £58..7..6. for 10 months, at £5. per cent.?

(6) What is the interest of £365. for 12½ months, at £8. per cent.?

(7) Required the interest of £264..7..9. for 7 months, at £5. per cent.

(8) Required the interest of £500. for 4 months, at £5. per cent.

(9) Required the interest of £176..4..8. for 15 months, at £3. per cent.

*For Days, at any rate per cent.*

36500, divided by the Product of the days and rate, will give a Divisor for the Principal; the Quotient will be the interest for the time.

(1) Find the interest of £475..16..4. for 73 days, at £5. per cent.

(2) What is the interest of £576..8..9. for 146 days, at £5. per cent.?

*For Days, at £5. per cent.*

RULE. Multiply the principal by one-third of the days, or

the days by one-third of the Principal; the Product, divided by 10, will give the interest, *nearly*, in pence, from which subtract one penny for every six shillings. Or, multiply the Principal by the given number of days, and divide the Product by 7300.

(1) Required the interest of £200. for 144 days.
(2) Required the interest of £1557..12..9. for 171 days.
(3) What is the interest of £1449..11..5. for 81 days?
(4) What is the interest of £833..6..8. for 30 days?
(5) Find the interest of £222..9 for 45 days.
(6) How much is the interest of £513. for 23 days?

When partial payments are made, at different times, multiply the Principal and successive balances by the number of days between the times of payment; and the sum of the respective products, multiplied by double the rate, and divided by 73,000, will give the interest.

(1) A bill of £500. became due March 12, of which £150. was paid April 7; £200. June 28; and the balance September 15. How much is the interest, at £5. per cent.?

(2) Required the interest on a bill, dated 4th. of March, and payable 2 months after date, value £456. of which £120. were paid on the 18th. of June; £116. on the 27th. of September; £136. on the 17th. of November; and the balance on the 27th. of December, at £4½. per cent.

(3) Received a bill for £1000. at 3 months' date from the 10th. of December, and it is dishonoured; on account of which I have received a bill, value £300.; it has 25 days to run from the time of the first bill becoming due; cash, on the 13th. of May £234.; on the 28th. of July £230.; and the balance on the 18th. of October. Required the interest at £4¾. per cent.

Interest on accounts current is often calculated up to the time of the latest date of any part of the account becoming due in cash, whether on the Debtor or Creditor side.

Find the interest and balance on the following account, at £5. per cent. up to the 12th. of December.

*Dr.* Mr. J. H. in account current with J. C. *Cr.*

| | £. | | £. |
|---|---|---|---|
| May 1, To goods ... | 250 | June 8, By cash..... | 124 |
| June 28, To calicos ... | 140 | July 19, By cash..... | 250 |
| Aug. 11, To cottons... | 340 | Oct. 20, By cash..... | 150 |
| Nov. 12, To yarn..... | 221 | Dec. 12, By cash..... | 200 |

*Dr.* Mr. I. N. in account current with W. M. *Cr.*

| | | Credit. | | Bill. | | | |
|---|---|---|---|---|---|---|---|
| | | *m.* | *d.* | *m.* | £. | *s.* | *d.* |
| Oct. 23, | To weft..... | 0 | 14 | and 3 ... | 38 | 7 | 0 |
| Nov. 6, | To twist ..... | 1 | 0 | and 3 ... | 206 | 14 | 0 |
| ..... 27, | To cotton ..... | 2 | 0 | and 2 ... | 187 | 16 | 0 |
| Dec. 10, | To warps ..... | 1 | 0 | and 3 ... | 176 | 10 | 0 |
| ..... 23, | To calicos, 3 months' bill ..... | | | | 248 | 17 | 0 |

*Cr.*

| | | £. | *s.* | *d.* |
|---|---|---|---|---|
| Nov. 29, | By bill, 3 months..... | 50 | 0 | 0 |
| ..... | By bill, 2 months..... | 41 | 3 | 0 |
| ..... | By cash..... | 30 | 18 | 0 |
| Dec. 27, | By bill, 3 months..... | 350 | 8 | 0 |
| Jan. 29, | By bill, 3 months..... | 210 | 16 | 0 |
| Feb. 16, | By bill, 2 months..... | 54 | 0 | 0 |

*Dr.* Mr. C. B. in account current with S. N. *Cr.*

| | | Credit. | | Bill. | | | |
|---|---|---|---|---|---|---|---|
| | | *m.* | *d.* | *m.* | £. | *s.* | *d.* |
| June 27, | To cotton..... | 1 | 0 | and 2 ... | 78 | 15 | 0 |
| July 5, | To weft..... | 1 | 0 | and 3 ... | 57 | 0 | 0 |
| ..... 18, | To yarn ..... | 0 | 14 | and 3 ... | 85 | 12 | 0 |
| Oct. 14, | To cotton, barter..... | | | | 174 | 6 | 0 |
| Nov. 22, | To twist, present bill ..... ..... | | | | 35 | 19 | 0 |

| *Cr.* | | Credit. | | Bill. | | | |
|---|---|---|---|---|---|---|---|
| | | *m.* | *d.* | *m.* | £. | *s.* | *d.* |
| July 3, | By twist ..... | 0 | 14 | and 3 ... | 60 | 0 | 0 |
| ..... 25, | By warps ..... | 1 | 0 | and 3 ... | 84 | 6 | 0 |
| Aug. 15, | By bill, due 10th. of September... | | | | 43 | 8 | 0 |
| Oct. 14, | By twist, barter ..... | | | | 174 | 6 | 0 |
| Dec. 16, | By bill, at 3 months, dated Nov. 27 | | | | 38 | 16 | 0 |

*Dr.* Mr. W. T. in account current with H. S. *Cr.*

| | | Credit. | | Bill. | | | |
|---|---|---|---|---|---|---|---|
| | | *m.* | | *m.* | £. | *s.* | *d.* |
| Aug. 20, | To cotton ..... | 2 | and | 3 ..... | 148 | 0 | 0 |
| Sept. 24, | To calicos ..... | | | 3 down | 84 | 6 | 0 |
| Oct. 2, | To yarn ..... | 1 | and | 3 ..... | 109 | 4 | 0 |
| ..... 24, | To prints ..... | 3 | and | 3 ..... | 84 | 7 | 0 |

*Cr.*

| | | £. | s. | d. |
|---|---|---|---|---|
| Sept. 26, | By bill, due 10th. of November ..... | 49 | 0 | 0 |
| ..... | By bill, date 5th. of Sept. 3 months ... | 45 | 12 | 0 |
| Oct. 24, | By cash ..... | 104 | 18 | 0 |
| Nov. 16, | By bill, 95 days ..... | 64 | 0 | 0 |
| Jan. 27, | By acceptance at 75 days, from 16th. of January ..... | 76 | 15 | 0 |

*When Bonds or Bills are to be discharged by instalments.*

RULE. Find the interest up to the time of the respective payments, which add to the Principal before the payments are deducted.

Having found the interest at £5. per cent. whether for years, months or days, the interest, commission or brokerage for any rate under that may be found by using the Multipliers and Divisors opposite the required rate per cent. or by using the decimal multipliers only.

| *Rates per Cent.* | *Multipliers.* | *Divisors.* | *Decimal Multipliers.* | *Rates per Cent.* | *Multipliers.* | *Divisors.* | *Decimal Multipliers.* | *Rates per Cent.* | *Multipliers.* | *Divisors.* | *Decimal Multipliers.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 7/8 | 39 | 40 | ·975 | 3 1/4 | 13 | 20 | ·65 | 1 5/8 | 13 | 40 | ·325 |
| 4 3/4 | 19 | 20 | ·95 | 3 1/8 | 5 | 8 | ·625 | 1 1/2 | 3 | 10 | ·3 |
| 4 5/8 | 37 | 40 | ·925 | 3 | 3 | 5 | ·6 | 1 3/8 | 11 | 40 | ·275 |
| 4 1/2 | 9 | 10 | ·9 | 2 7/8 | 23 | 40 | ·575 | 1 1/4 | 1 | 4 | ·25 |
| 4 3/8 | 7 | 8 | ·875 | 2 3/4 | 11 | 20 | ·55 | 1 1/8 | 9 | 40 | ·225 |
| 4 1/4 | 17 | 20 | ·85 | 2 5/8 | 21 | 40 | ·525 | 1 | 1 | 5 | ·2 |
| 4 1/8 | 33 | 40 | ·825 | 2 1/2 | 1 | 2 | ·5 | 7/8 | 7 | 40 | ·175 |
| 4 | 4 | 5 | ·8 | 2 3/8 | 19 | 40 | ·475 | 3/4 | 3 | 20 | ·15 |
| 3 7/8 | 31 | 40 | ·775 | 2 1/4 | 9 | 20 | ·45 | 5/8 | 1 | 8 | ·125 |
| 3 3/4 | 3 | 4 | ·75 | 2 1/8 | 17 | 40 | ·425 | 1/2 | 1 | 10 | ·1 |
| 3 5/8 | 29 | 40 | ·725 | 2 | 2 | 5 | ·4 | 3/8 | 3 | 40 | ·075 |
| 3 1/2 | 7 | 10 | ·7 | 1 7/8 | 3 | 8 | ·375 | 1/4 | 1 | 20 | ·05 |
| 3 3/8 | 27 | 40 | ·675 | 1 3/4 | 7 | 20 | ·35 | 1/8 | 1 | 40 | ·025 |

## COMMERCIAL DISCOUNT.

THE discounts common in trade vary from the true discount,

the one being the interest on the bills discounted, and the other the interest on the money advanced.

RULE. Find the interest upon the bills for the time they have to run, and half per cent. upon the amount to be discounted, which two sums deduct from the Principal and the Remainder will be the neat discount.

(1) What is the discount of a bill value £678. due 40 days hence at 5 per cent.?

(2) Required the neat proceeds of a bill value £480..17..9. due 45 days hence, and discounted at 4½ per cent.?

(3) Required the discount on a bill dated 25th. of February at 2 months, for £348. at 3½ per cent.

(4) Required the discount on a bill dated 14th. of March, at 3 months, for £596. at 5 per cent.

(5) I received a bill on the 16th. of May, for £128. at 3 months from the 6th. of April, what will the discount be at 5 per cent. and commission 2*s*. 6*d*. per cent.?

(6) Discounted a bill for £500. dated 8th. of September, at 4 months, and received 1 bill for £240. dated 12th. of August, at 3 months; one for £175. dated 25th. of August, at 3 months; one for £48. dated 6th. of September, at 2 months; and the remainder in cash; commission ¼ per cent. Required the neat proceeds.

(7) I had an acceptance for £1250. at 6 months from the 24th. of May; another for £2486. at 9 months from the 18th. of March; got them discounted on the 20th. of June, and received a bill for £750. at 3 months from the 10th. of June; one for £640. at 4 months from the 30th. of May; one for £970. at 5 months from the 12th. of June; and one for £874. at 3 months from the 18th. of June, and the balance in cash. Required how much cash I ought to receive, allowing 5 per cent. interest and ½ per cent. commission.

## TRUE DISCOUNT,

OR the method of finding how much money paid down would increase itself at interest at the rate and time given to a particular sum, to be paid at a future time.

*For Months at any rate per cent.*

RULE. Divide 1200 by the rate of discount, to that Quo-

tient add the time given for a Divisor. Multiply the sum to be discounted by the time for a Dividend, the latter Quotient will be the discount.

(1) Required the discount of £357..10. due 9 months hence, at 5 per cent.

(2) Bought cottons at 2 and 2 months' credit amounting to £3784. required the discount at 5 per cent.

(3) Sold calicos for £4960. for an acceptance at 6 months, what discount ought I to allow for money down at 4 per cent.?

(4) Bought yarns amounting to £3985. at 3 and 3 months' credit, or a discount of $7\frac{1}{2}$ per cent. for cash, how much shall I have to pay down?

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## BILLS OF PARCELS AND INVOICES.

(1) Mr. John Dawson, Manchester, January 4, 1833.

Bought of Charles Mellor.

| | | s. | d. | |
|---|---|---|---|---|
| 8 yards of prints | at | 4 | 6 | per yard |
| 6 pieces of lace | at | 12 | 4 | each |
| 3 pair of black silk stockings | at | 14 | 0 | per pair |
| 4 yards of $\frac{7}{8}$ check | at | 1 | 2 | per yard |
| 9 pair of worsted stockings | at | 3 | 4 | per pair |
| 11 pieces of shirting | at | 18 | 9 | each |

(2) Mr. James Hewitt, Manchester, June 20, 1833.

Bought of John Clegg.

| | | s. | d. | |
|---|---|---|---|---|
| 15 yards super broad cloth | at | 13 | 6 | per yard |
| 24 ..... super super ditto | at | 18 | 9 | ..... |
| 27 ..... yard wide | at | 8 | 4 | ..... |
| 16 ..... druggett | at | 6 | 3 | ..... |
| 12 ..... serge | at | 2 | 10 | ..... |
| 32 ..... shalloon | at | 1 | 8 | ..... |

(3) Mr. W.

Bought of

| | | | s. | d. | |
|---|---|---|---|---|---|
| 45 | pieces calico . . . . . | at | 7 | 6 | each |
| 37 | ..... grey twills, 45 yards each . | at | 0 | $5\frac{1}{2}$ | per yard |
| 27 | ..... dimity, 63 yards each . . | at | 0 | $4\frac{3}{4}$ | ..... |
| 63 | ..... drab nankeen, 72 yards each | at | 0 | $9\frac{1}{4}$ | ..... |
| 150 | ..... white shirting, 53 yards each | at | 0 | $7\frac{1}{2}$ | ..... |
| 96 | ..... cotton checks, 45 yards each | at | 0 | $8\frac{1}{4}$ | ..... |

(4) Mr. B.

Bought of

| | | | s. | d. | |
|---|---|---|---|---|---|
| 18 | demies muslinet, each 24 yards . | at | 2 | $4\frac{1}{2}$ | per yard |
| 16 | demies jaconett, each 30 yards . | at | 1 | $10\frac{1}{2}$ | per yard |
| 24 | dozen crape shawls . . . . . | at | 54 | 0 | per dozen |
| 12 | pieces cross overs, each 64 yards . | at | 0 | $4\frac{3}{4}$ | per yard |
| 7 | pieces cotton checks, each $48\frac{1}{2}$ yds. | at | 0 | $10\frac{1}{2}$ | ..... |
| 5 | pieces sprig muslins, each 26 yds. | at | 2 | 8 | ..... |

(5) Mr.

Bought of

| | | s. | d. | |
|---|---|---|---|---|
| 8 *oz.* | drab silk thread | at 24 | 0 | per *lb.* |
| 6 *oz.* | scarlet markings | at 27 | 0 | ..... |
| 3 *oz.* | brown sewings . | at 23 | 0 | ..... |
| 14 *oz.* | tailors' sewings | at 28 | 4 | ..... |
| 5 *oz.* | tailors' twist . | at 31 | 6 | ..... |
| 7 *oz.* | mixed colours . | at 29 | 0 | ..... |

(6) Mr.

Bought of

| | | | s. | d. | |
|---|---|---|---|---|---|
| 212 | bundles No. 18 water twist, 10 *lbs.* each | at | 1 | $4\frac{1}{4}$ | per *lb.* |
| 173 | ..... No. 20 ..... | at | 1 | 5 | ..... |
| 278 | ..... No. 22 ..... | at | 1 | $5\frac{3}{4}$ | ..... |
| 476 | ..... No. 24 ..... | at | 1 | $6\frac{1}{2}$ | ..... |
| 357 | ..... No. 26 ..... | at | 1 | $7\frac{1}{2}$ | ..... |
| 435 | ..... No. 28 ..... | at | 1 | 9 | ..... |

(7) Sold woollen cloths as under, make out the account.

| | *No.* | *yds.* | |
|---|---|---|---|
| Steel mixture | 134 | 15¼ | |
| | 135 | 15¾ | |
| | 136 | 15½ | |
| | | 46¾ | at 6*s.* per yard. |
| Blue . . . | 148 | 21 | |
| | 149 | 21¼ | |
| | | 42¼ | at 11*s.* 6*d.* per yard. |
| Black . . . | 164 | 20¼ | |
| | 173 | 19½ | |
| | | 39¾ | at 12. 6*d.* per yard. |

| | £ | | |
|---|---|---|---|
| Deduct measurement £5. per cent. ..... | | | |
| Discount £10. per cent. ..... | | | |
| Case, &c. ..... | 0 | 18 | 0 |

(8) Sold Bowds cottons as under; make out the invoice, deduct 1 *lb.* per bag for draft, 4 *lbs.* per *cwt.* for tare; the price 9⅞*d.* per *lb.* discount £4½. per cent. for bill down.

| *No.* | *cwt.* | *qr.* | *lbs.* |
|---|---|---|---|
| 48. | 3 | 1 | 15 |
| 54. | 3 | 2 | 9 |
| 49. | 3 | 3 | 14 |
| 37. | 3 | 0 | 22 |
| 53. | 3 | 2 | 10 |
| 46. | 3 | 2 | 13 |
| 44. | 3 | 1 | 7 |
| 43. | 3 | 2 | 25 |
| 45. | 3 | 3 | 8 |

Draft.

Tare.

*lbs.* at 9⅞*d.* £

Discount ..... ..... £

£

(9) Make out an invoice of the sale of yarns as follow, at 10*s.* per *lb.* for 200's. rising 4¾*d.* per *lb.* at every 2 hanks.

| *Bdles.* | *No.* | | |
|---|---|---|---|
| 10 | 200 | hanks yarn | 5 *lbs.* each. |
| 12 | 206 | ..... | 5 ..... |
| 16 | 210 | ..... | 5 ..... |
| 24 | 212 | ..... | 5 ..... |
| 18 | 216 | ..... | 5 ..... |
| 28 | 220 | ..... | 5 ..... |

And deduct £2½. per cent. for a three months' bill down.

## EQUATION OF PAYMENTS.

To find the time when two or more debts due at as many different times may be paid at once.

RULE. Multiply each debt by the time which it has to run before it be due; the sum of these Products divided by the sum of the debts will quote the equated time nearly.

(1) I owe £60. in 40 days, £80. in 60 days, and £120. in 108 days, when ought the whole to be paid?

(2) I owe £74. in 50 days, £108. in 250 days, and £100. in a year. Required the equated time for paying the whole.

(3) £240. is to be paid as follows, £60. in 60 days, £80. in 96 days, £40. in 250 days, and the rest in a year and 35 days. Required the equated time for paying the whole together.

## PROFIT AND LOSS.

THE difference between the buying and selling price is called gain when the selling price is the greater, and loss when it is the lesser.

1. When the gain or loss on one article is given.—The gain or loss on a given quantity is found by multiplying by that quantity, and on the contrary, when the gain or loss on a quantity is given, the gain or loss on one article is found by dividing by the quantity. Or, if the whole gain or loss and that on one article is given, the quantity is found by dividing by the gain or loss on one article.

(1) Bought 428 yards of cloth at 14*s*. 8*d*. and sold it at 16*s*. 3*d*. What did I gain?

(2) Bought 57 *cwt*. of sugar at £4..3..6. per *cwt*. and sold it at 9¾*d*. per *lb*. What was gained?

(3) Bought 136 yards of cloth at 3*s*. 8*d*.; required the price per yard to be sold to gain £12. on the whole.

(4) Sold 257 yards of lace at 3*s*. 9*d*. and lost £9. What was the yard bought at?

(5) Bought cloth at 17*s*. 6*d*. How much of it must I sell at 19*s*. to gain £43..13..6.?

(6) By selling indigo at 3*s*. 6*d*. per *lb*. which had been bought at £14..10. per *cwt*. I gained £130. How much did I sell?

(7) By selling cotton at 8½*d*. per *lb*. which cost £4..4. per *cwt*. I lost £85. What quantity did I sell?

2. Given the prime cost and the profit or loss upon it; or which is the same thing, the difference between it and the selling price to compute the profit or loss per cent.

RULE. Prime cost ⟩ profit or loss.
£100. ⟨ *gain or loss.

(1) Bought cloth at 3*s*. 8*d*. and sold it at 4*s*. per yard profit. What was the gain per cent.?

(2) Sold cloth of 15*s*. per yard value, at 1*s*. 6*d*. per yard loss. What was the loss per cent.?

(3) Bought cloth at 9*s*. 6*d*. per yard, and sold it at 12*s*. What was the gain per cent.?

(4) Bought tea at 5*s*. 6*d*. per *lb*. but getting damaged I was obliged to sell it at 4*s*. 9*d*. What was the loss per cent.?

(5) Bought 7 *cwt*. 3 *qrs*. of sugar, at 5¾*d*. per *lb*. and sold it at 9*d*. What did I gain per cent. and how much upon the whole?

(6) How much per cent. is 2½*d*. per shilling?

(7) Bought a house for £315. paid for repairs £20. and sold it for £400. What was the gain per cent.?

3. Given the rate per cent. and prime cost to find the selling price.

RULE. £100 ⟩ 100 with the rate added in case of gain or deducted in case of loss.
Prime cost ⟨ *selling price.

(8) Gained £9 1/11 per cent. by cloth which I bought at 3*s*. 8*d*. What did I sell it at?

(9) Lost £10. per cent. by cloth bought at 15*s*. What did I sell it at?

(10) Bought cloth at 9*s*. 6*d*. at what must I sell it to gain £26$\frac{8}{17}$. per cent.?

(11) Tea purchased at 5*s*. 6*d*. getting damaged I lose £13$\frac{7}{11}$. per cent. by it. What must I sell it at to lose so much?

(12) Sugar cost 5$\frac{3}{4}$*d*. per *lb*. What must it be sold at to gain £56$\frac{1}{2}\frac{3}{3}$. per cent.?

(13) Bought coffee at 4*s*. per *lb*. What must I sell it at per *lb*. to gain £20$\frac{5}{8}$. per cent.?

4. Given the rate per cent. and the selling price to find the prime cost.

RULE. 100 with the rate added or deducted. } ⋈ 100.
Selling price ⋈ *prime cost.

(14) If I gain £9$\frac{1}{11}$. per cent. on cloth sold at 4*s*., what was the prime cost?

(15) Lost £10. per cent. on cloth which was sold at 13*s*. 6*d*. What was the prime cost?

(16) Lost £13$\frac{7}{11}$. per cent. by selling indigo at 4*s*. 9*d*. What was the prime cost?

(17) Gained £56$\frac{1}{2}\frac{3}{3}$. per cent. by selling cotton at 9*d*. What was the prime cost?

(18) Sold yarn at 4*s*. 10*d*. per *lb*. by which I cleared £20$\frac{5}{8}$. per cent. What did I buy it for?

(19) Sold gin at 12*s*. per gallon, on which I gained £26$\frac{8}{17}$. per cent. What was the prime cost?

5. Given two selling prices and the rate per cent. in proportion to one of them to find the rate per cent. corresponding to the other.

RULE. The price whose rate per cent. is given. } ⋈ { 100 with the given rate added or deducted.
The other given price ⋈ { *a fourth number from which subtract £100. in case of gain, but which subtract from £100. in case of loss.

(20) By selling cloth at 5*s*. I gained £12. per cent. What is the gain per cent. by selling at 6*s*.?

(21) By selling goods at 8*s.* I lost £14. per cent. What is lost by selling at 7*s.* 6*d.*?

(22) Sold goods at 15*s.* 6*d.* and cleared £18. per cent. and sold the remainder at 16*s.* 4*d.* What did I clear per cent. by the latter price?

(23) By selling cloth at 5*s.* 3*d.* I gained £16. per cent. the same cloth was afterwards sold at 4*s.* 6*d.* What was lost or gained per cent. by the last price?

6. Given the whole gain or loss and the rate per cent. to find what the whole was bought and sold at.

RULE. Rate per cent. ⋈ £100.
Gain ..... ⋈ *the buying price, the selling price is got by adding the gain or subtracting the loss.

(24) By selling goods at £5. per cent. profit, I gained £44..16. What did I pay for them?

(25) Lost £34..18. on a quantity of yarn at £4. per cent. What was it bought and sold for?

(26) Sold 342 *cwt.* of madder at £3. per cent. profit, and gained £53..14. What was it bought and sold at per *cwt.*?

(27) Bought yarn at 5*s.* 8*d.* and by selling it again at £4½. per cent profit, I gained £29..18. What quantity did I sell?

(28) Sold tea at 7*s.* 8*d.* which was £6. per cent. profit, and gained £33..6..8. What quantity did I sell?

(29) By selling 386 gallons of rum at £3. per cent. loss, I lost altogether £19..18..6. What was the gallon bought and sold at?

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## PARTNERSHIP.

Case 1. To divide the profits and losses of merchants in Company in proportion to the shares of the capital, or stock; or to divide the effects of a bankrupt's, or testator's estate, according to the amount of assets; or to divide a number into parts, having the same proportion as certain other numbers.

RULE. As the whole stock is to each particular stock, partners or proportions, so is the whole gain or loss to the respective shares of it. Or, as the sum of the numbers is to each particular number, so is the number to be divided to the required parts.

(1) Divide the number 120 into three parts, which shall be as 3, 4, 5.

(2) *A* and *B* join in trade; *A*'s capital is £300. and *B*'s £700.; they cleared £160. in trade. Required each person's share.

(3) *P*, *Q*, *R* continued in trade one year, with a stock of £1200.; *P*'s share of the gain was £40.; *Q*'s £64.; *R*'s £56. Required their stocks.

(4) *B*, *C*, and *D* join in trade, with a capital of £1294. and in proportion as 4, 6 and 8 are to one another, the amount of their gain is equal to *B*'s stock. What is each man's stock and gain?

(5) *A* and *B*, with equal capital, clear in trade £154.; *A* is to have £8. per cent. for conducting the business, and *B* to have £5. per cent. Required each person's share.

(6) The clear assets of an insolvent's estate amount to £360.; the creditors are 4 in number; *A* for £120. *B* for £140. *C* for £200. and *D* for £260. Required their respective dividends.

(7) Five persons agree to run a coach between Manchester and York; they provide horses as follow: *A* 13 miles, *B* 15 miles, *C* 12 miles, *D* 11 miles, and *E* 9 miles; the proceeds for one month, after paying expenses, amount to £156. Required each person's share.

(8) A testator bequeaths legacies as follow: to *G* £120.; to *H* £100.; to *I* 100 guineas; and to *K* £95.; to be paid by the sale of his estate, which produces only £360. neat. Required each person's share.

(9) A gingham warp, of 1800 ends, 140 yards long, is to be made to this pattern: 12 ends Turkey red, 8 ends blue, and 16 ends white. What quantity of yarn, of each colour, will be required?

(10) There are four shafts, calculated to make 100 revolutions per minute among them; in such order, that for every 3 revolutions of the first, the second must make 5; for every five of the second, the third must make 7; and for every seven of the third, the fourth must make 10. Required the proportionate revolutions.

(11) A lever, 120 inches long; one end is to make a stroke equal to 10 inches, while the other passes through a space of 30 inches. What distance from each end must the fulcrum be placed?

(12) The fly shaft of a steam engine, making 17 revolutions per minute, is to give motion (by a pair of wheels) to

the tumbling shaft in the mill, which is to make 40 revolutions per minute; the distance between the shafts is 105 inches. Required the diameter of the two wheels.

(13) The radii of 2 wheels are respectively $31\frac{1}{5}\frac{4}{7}$ and $73\frac{5}{5}\frac{9}{7}$, and they make together 57 revolutions. Required the revolutions of each.

(14) Suppose a warp 30 yards long, 42 inches broad, 60 threads in one inch; pattern, 16 white, 8 green, 4 red, 4 blue. Required the quantity of each colour.

(15) If a warp 60 yards long, 36 inches broad, is to be woven, 100 threads in one inch; pattern, 20 white, 10 green, 6 blue, 6 red, what will be the quantity of weft of each colour?

(16) A bar of wood, 24 feet long, has a weight suspended at each end, the one 16 *lbs.* the other 4 *lbs.* At what part of the bar must a fulcrum be placed to exactly balance both?

Case 2. When the times of continuing stock in Company are unequal, their respective stocks must be multiplied by their respective times.

Where many persons are concerned, or in dividing a bankrupt's estate amongst his creditors, &c.—Divide the whole gain, or loss, or assets, by the first term, or sum of the Products, or amount of debts claimed, as the case may be, and the Quotient will be a Common Multiplier; by which multiply each separate Product, or debt, and the result will be the required proportions or dividend of each party

(1) *A*'s stock, of £250. was 3 months in trade; *B*'s, of £960. was 2 months in trade; and *C*'s, of £540. was 6 months in trade; they gained £480. Required their shares.

(2) *D*, *E*, and *F* hire a certain pasture for £24.; *D* puts in 40 cows, for 4 months; *E* 30 cows, for 2 months; and *F* 36 cows, for 5 months. What part of the rent ought each to pay?

(3) *G*, *H*, *I*, and *K* enter into partnership, each advancing £300.; at the end of 2 months, *H* took out £120. and *G* put in £150.; at the end of 5 months, *G* took out £200. and *H* put in the same sum at the end of 6 months, and £50. more at the end of 9 months; at the same time *G* put in £150.; *I* put in £180. at the end of 4 months, took out £220. at the end of 9 months, and put in £60. at the end of 10 months; *K* put in £100. at the end of 7 months, and £50. at the end of 9 months; at the year's end they had gained £333. What is each man's share thereof?

(4) Six merchants trade after this manner: *A* puts in £50. for 6 months, and £60. for 4 months; *B* puts in £90. for 8 months; *C* puts in £160. for 5 months, and £100. for 4 months; *D* puts in £200. for 7 months, and £100. for 5 months; *E* puts in £300. for 10 months, and £100. for 2 months; *F* puts in £400. for 3 months, £200. for 4 months, and £200. for 5 months; they gained £686..8. What is the share of each merchant?

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## BARTER

Is the method of exchanging goods without loss to either party.

RULE. Find the value of the goods to be parted with, and it should also be the value of the goods received. If the quantity or price of one article be required, it may be found by Division. In other cases, work according to the nature of the question.

(1) How much yarn, at 23*s.* 4*d.* per *lb.* should I get for 97½ *cwt.* of cotton, at 9¾*d.* per *lb.*?

(2) Exchanged 156 yards of cloth, at 16*s.* 10*d.* per yard, for 936 yards of linen. What did the linen stand me in per yard?

(3) For 67 *cwt.* of tobacco, at 8 guineas per *cwt.* I received in part 600 *lbs.* of tea, at 7*s.* 4*d.* per *lb.* and the rest in stockings, at 2*s.* 8*d.* per pair. How many pair of stockings did I receive?

(4) *A* barters yarn at 15*s.* with *B* for lace at 18*s.* but the yarn was worth only 13*s.* 4*d.* and the lace 16*s.* Which of them was the gainer?

(5) Bartered 96 gallons of brandy, at 23*s.* 8*d.* per gallon; received in return 60 guineas, and 450 yards of cloth. What is the cloth per yard?

(6) Bartered cotton at 8¾*d.* per *lb.* for twist as under: 1200 *lbs.* of 24's, 800 *lbs.* of 26's, 1000 *lbs.* of 28's, at 14¼*d.* for 24's, rising ¾*d.* every 2 hanks. What quantity of cotton ought I to receive?

(7) Cotton, worth 8½*d.* per *lb.* is bartered at 9½*d.* for weft, worth 1*s.* 8*d.* What should the weft be raised to?

(8) Sent to South America 6350 pieces of printed calico, each 28 yards, at 15½*d.* per yard; 8432 pieces of nankeens,

each 24 yards, at 9½*d.* What quantity of cotton ought I to have in return, at 1*s.* 2½*d.* per *lb.*?

(9) *A* and *B* barter; *A* gave *B* 90 pieces of cloth, at 13*s.* 6*d.* each, for which he received £38..5. in money, and 500 *lbs.* of cotton. What was the cotton per *lb.*?

(10) Bartered 251 pieces of dimity, each 50¼ yards, at 17¾*d.* per yard, and 365 pieces of furniture prints, each 28 yards, at 15¾*d.* per yard. What quantity of cotton ought I to receive in return, at 15¾*d.* per *lb.*?

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## EXCHANGE OF MONEY

TEACHES to find what sum of money, of one country, is equal to any given sum of another, according to a given course of exchange. The par of money of one nation, compared with that of another (being always according to their intrinsic value) is fixed. But the *course of exchange*, being the present value allowed for a piece of money of one country, when reduced to that of another, varies upon different occasions. In some places money is distinguished into bank and current. The former is more valuable than the latter, and their difference is called *agio*. Accounts are kept in the latter, and bills of exchange are generally transacted in the former.

The computations may be performed by Proportion or Practice.

### I. FRANCE.

Accounts are kept in francs and centimes.

100 centimes = 1 franc.

Exchange with Britain. 25 francs, 40 cents, for £1. sterling.

Exchange with Amsterdam. 57½ florins for 120 francs.

Exchange with Hamburgh. 185 francs for 100 marks banco.

(1) In £500. how many francs, exchange at 25 francs, 17½ cents?

(2) In 48796 francs, 45 cents, how much sterling exchange at 25 francs, 45 cents?

(3) In 65947 florins, 18 cents, how many francs, exchange at 57½?

(4) In 11950 francs, how many florins, exchange at 57¼?

(5) In 14000 francs, how many marks, exchange at 186 francs for 100 marks?

(6) In 35487 marks, how many francs, exchange at 187 francs, 60 cents?

### II. AMSTERDAM, ROTTERDAM, AND ANTWERP.

Accounts are kept in florins and cents.

100 cents = 5 stivers; 20 stivers = 1 florin.

Exchange with Britain. 11 florins, 95 cents, for £1. sterling.

Exchange with Hamburgh. 35 florins for 40 marks banco.

Exchange with Paris, $57\frac{1}{8}$ florins for 120 francs.

(7) In £500. how many florins, exchange at 12 florins, $11\frac{1}{4}$ cents?

(8) In 147856 florins, 26 cents, how much sterling, exchange at 12 florins, $7\frac{1}{8}$ cents?

(9) In 6489 florins, how many marks banco, exchange at 35 florins, 44 cents?

(10) In 45735 marks banco, how many florins, exchange at 36 florins, 25 cents?

(11) In 97564 florins, how many francs, exchange at $57\frac{3}{8}$ florins?

(12) In 85947 francs, how many florins, exchange at $57\frac{1}{8}$ florins?

### III. HAMBURGH AND ALTONA.

12 pfennings . . = 1 schilling.
16 schillings . . = 1 mark.
3 marks . . . = 1 rix dollar.

Exchange with London. 13 marks, 8 schillings banco for £1.

Exchange with Amsterdam. 35 florins, 40 cents for 40 marks banco.

Exchange with Paris. $188\frac{1}{2}$ francs for 100 marks banco.

When goods are sold in currency, the agio is fixed at from 20 to 25 per cent. and is reckoned upon the banco; and an allowance, called rabat, of from $4\frac{2}{3}$ to $8\frac{2}{3}$ per cent. is reckoned on the neat amount. Agio at 25 per cent. = $\frac{1}{5}$ of the currency, or $\frac{1}{4}$ of the banco; and at 20 per cent. is $\frac{1}{6}$ of the currency, or $\frac{1}{5}$ of the banco. Rabat, at $4\frac{2}{3}$ per cent. is $\frac{7}{107}$ of the amount, and $8\frac{2}{3}$ per cent. is $\frac{15}{163}$ of the same.

Where the agio fluctuates, take aliquot parts accordingly. The amount of agio upon the sum, added to the banco, will

give the currency; or, deducted from the currency, will give the banco, all remittances being made in banco.

(13) Reduce £580. sterling into marks banco, exchange at 13 marks, 6 schillings.

(14) In 4896 banco marks, 12 schillings, how much sterling, exchange at 13 marks, $10\frac{1}{4}$ schillings?

(15) In 22727 marks, 2 schillings currency, agio 20 per cent. rabat $8\frac{2}{3}$ per cent. how many marks banco?

(16) In 11363 marks, 9 schillings currency, agio $23\frac{1}{4}$ per cent. how many marks banco?

(17) How much sterling in 13284 marks current, agio 20, exchange at 13 marks, 12 schillings?

(18) How many marks current in £482. agio $22\frac{1}{2}$, exchange at 13 marks, 10 schillings?

### IV. PRUSSIA, BERLIN.

30 silver groshen = 1 Prussian dollar.

Exchange with Britain. 6 Prussian dollars, $24\frac{3}{4}$ groshen for £1. sterling.

Exchange with Amsterdam. $143\frac{7}{10}$ Prussian dollars for 250 florins.

Exchange with Hamburgh. 152·2 Prussian dollars for 300 marks banco.

Exchange with Paris. 81·2 Prussian dollars for 300 francs.

(19) How much Prussian money in £480. sterling, exchange at 6 Prussian dollars, $28\frac{1}{2}$ groshen?

(20) In 8000 Prussian dollars, how much sterling, exchange at 6 Prussian dollars, $27\frac{1}{2}$ groshen?

(21) In £807..18..6. sterling, how many Prussian dollars, exchange at 6 Prussian dollars, $21\frac{1}{2}$ groshen?

(22) In 4382 Prussian dollars, 16 groshen, how much sterling, exchange at 6 Prussian dollars, 23 groshen?

### V. RUSSIA, ST. PETERSBURGH.

100 copecs = 1 ruble.

There are two sorts of money: a bank, or paper currency, and a metallic currency. The metallic ruble, in silver, is = $37\frac{1}{2}d.$ sterling; its rate of exchange against the paper ruble is variable; at present about $3\frac{2}{4}$ paper rubles for one silver ruble, making the value of the paper ruble about 10*d.* sterling.

Exchange with Britain. $10\frac{1}{2}d.$ per ruble on bills at 3 months date.

Exchange with Amsterdam. $10\frac{1}{4}$ stivers per ruble, at 65 days.

Exchange with Hamburgh. $9\frac{1}{4}$ schillings banco per ruble, at 65 days.

Exchange with Paris. $106\frac{1}{4}$ cents per ruble, at 70 days.

The days of grace are 10 for bills after date, and 3 for bills at sight. Throughout Russia, old style, or the Julian calendar is used, which is 12 days later than the style in England; thus, the 14th. of May in Russia corresponds with the 26th. of May in England.

To reduce paper rubles to silver rubles.—Divide $37\frac{1}{2}d.$ by the exchange, which will give the number of paper rubles in one silver ruble.

(23) In £818..14..4. sterling, how many paper rubles, exchange at $10\frac{3}{8}d.$?

(24) In 18938 rubles, 99 copecs, how much sterling, exchange at $10\frac{3}{8}d.$?

(25) In £800. how many silver rubles, exchange at $37\frac{1}{2}d.$?

(26) In £1000. how many silver rubles, exchange at $10\frac{1}{4}d.$ per paper ruble and $372\frac{1}{2}$ paper copecs per silver ruble?

### VI. FRANKFORT ON THE MAIN.

90 kreuzers . . . . . = 1 rix dollar.
4 hellers . . . . . = 1 kreuzer.
4 kreuzers . . . . . = 1 batz.
15 batzen . . . . . = 1 florin.
$1\frac{1}{2}$ florin . . . . . = 1 rix dollar.

46 rix dollars Wechselzahlung = 55 rix dollars in 24 Guldenfuss.

Exchange with Britain. 148·2 batzen for £1. sterling.

Exchange with Amsterdam. $139\frac{1}{3}$ rix dollars for 250 florins.

Exchange with Paris. $78\frac{3}{4}$ rix dollars for 300 francs.

(27) In £500. sterling, how much Frankfort money, in 24 Guldenfuss, exchange at $150\frac{3}{4}$ batzen?

(28) In 3350 rix dollars, Wechselzahlung, how much sterling, exchange at $150\frac{3}{4}$?

### VII. AUSTRIA, VIENNA AND TRIESTE.

60 kreuzers = 1 florin.

Exchange with London. 10 florins, 3 kreuzers for £1.

Exchange with Amsterdam. 138¼ rix dollars for 250 florins.

Exchange with Paris. 118 florins for 300 francs.

Exchange with Hamburgh. 145 florins for 200 marks.

(29) In £548..16. how many florins, exchange at 10 florins, 1 kreuzer?

(30) In 5000 florins, how much sterling, exchange at 10 florins, 1½ kreuzer?

### VIII. VENICE AND MILAN.

100 centissime . . = 1 lira Austriacha.
3 lire . . . . = 1 florin.
1 lira . . . . = $8\frac{15}{100}d.$

Exchange with Britain. 29 lire, 52 centissime for £1. or 48¾*d.* for 6 lire.

(31) In £500. how many lire, exchange at 30 lire?

(32) In £129..16..5. how many lire, exchange at 47½*d.* for 6 lire.

(33) In 8000 lire Austriacha, how much sterling, exchange at 30 lire, 30 centissime?

(34) In 6424 lire, 60 centissime, how much sterling, exchange at 48½*d.* for 6 lire?

### IX. NAPLES.

100 grani = 1 ducat, value 3*s.* 3¾*d.* sterling.

The ducat is divided in 5 tari or 10 carlini.

Exchange with Britain. 607 grani for £1.

Exchange with Amsterdam. 50·2 grani for 1 florin.

Exchange with Hamburgh. 44·15 grani for 1 mark banco.

Exchange with Paris. 23·75 grani for 1 franc.

(35) In £560. how many ducats, exchange at 39½*d.* per ducat?

(36) In £480. how many ducats, exchange at 607 grani?

(37) In 3037 ducats, 97 grani, how much sterling, exchange at 607 grani?

(38) In 4000 ducats, how much sterling, exchange at 39¾*d.*?

### X. PALERMO.

20 grani = 1 taro; 30 tari = 1 oncia or onza; the scudo = 12 tari or 2 oncie = 5 scudi.

Exchange with Britain. 60 tari for £1.

(39) In £148..12. how many oncie, exchange at 120¼ per oncia?

(40) In £136..12..6. how many oncie, exchange at 59¾ tari per £.?

(41) In 1000 oncie, how many £. exchange at 119*d.*?

(42) In 272 oncie, 3 tari, 10 grani, how much sterling, exchange at 59½ tari?

XI. LEGHORN.

12 denari . . = 1 soldo.
20 soldi . . = 1 pezza or dollar.

Exchange with Britain. 49*d.* for 1 pezza.

(43) In £400. how many pezze, exchange at 48½*d.*?

(44) In 10000 pezze, how much sterling, exchange at 48¼*d.*?

XII. GENOA.

100 centissimi = 1 lira nuova.

Exchange with London. 25 lira, 16 centissimi for £1.

The lira nuova = the French franc.

The calculations are the same as French exchanges.

XIII. SPAIN.

*Plate Money of Exchange and Account.*

34 maravedis, or 16 quartos . . . . = 1 real of plate.
8 reals . . . . . = 1 dollar of plate.
11 reals, 1 maravedi, or 375 maravedis = 1 ducat of plate.
4 dollars of plate . . . . . = 1 pistole of plate.

*Vellon Money of Coin and Account.*

34 maravedis . . . . = 1 real vellon.
20 real vellons . . . . = 1 hard dollar.
17 reals of plate . . . = 32 reals vellon.
85 dollars of plate . . = 64 hard dollars.
1 quarto of plate . . = 4 maravedis vellon.

Exchange with Britain. 36*d.* for 1 dollar of plate.

(45) In £1000. how many reals plate, exchange at 36½*d.* per dollar of plate?

(46) In 8469 reals of plate, 10 quartos, how much sterling, exchange at 37½*d.*?

(47) In 5458 reals vellon, 27 maravedis, how much sterling, exchange at 36½*d.* per dollar of plate?

(48) In £500. sterling, how many reals vellon and reals of plate, exchange at 36½*d.* per dollar of plate?

15 reals vellon = 1 dollar of plate at Malaga.

XIV. GIBRALTAR.

16 quartos . = 1 real.
12 reals . . = 1 hard dollar.
1 hard dollar = 50¼*d.* sterling.

XV. LISBON AND OPORTO.

1000 reis = 1 milrea.
400 reis = 1 crusado.

Exchange with Britain. 49*d.* for 1 milrea.
Exchange with Amsterdam. 39 grotes for 1 crusado.
Exchange with Hamburgh. 42⅔ schillings for 1 milrea.
Exchange with Paris. 192 reis for 1 franc.

(49) In £1000. how many reis, exchange at 50¼*d.*?
(50) In 13572866 reis, how much sterling?

XVI. BREMEN.

5 schwaren . . = 1 grote.
70 grotes . . . = 1 rix dollar.

Exchange with Britain. 612 rix dollars for £1.

XVII. DENMARK, COPENHAGEN.

96 skillings = 1 rix dollar.

The dollar is divided into 6 marks, of 16 skillings each.

The exchange business of Copenhagen is transacted through the medium of Hamburgh; the par of exchange between those places, exclusive of the agio, being 200 rix banco dollars for 300 marks banco.

Exchange with Britain. 9 rix dollars, 35 skillings for £1.

XVIII. SWEDEN AND NORWAY.

| Stockholm. | Christiani. |
|---|---|
| 48 skillings = 1 rix dollar. | 96 skillings = 1 specie dollar. |

Exchange Stockholm with Britain. 11 rix dollars, 24 skillings for £1.

Exchange Christiani with Britain. 6 specie dollars, 24 skillings for £1.

XIX. TURKEY, CONSTANTINOPLE. EGYPT, ALEXANDRIA.

40 paras = 1 piastre.

The value of the piastre is about 4*d.* at Constantinople, and 3½*d.* at Alexandria.

Exchange Constantinople with Britain. 58½ piastres for £1.

### XX. THE IONIAN ISLANDS.

British currency.

### XXI. MALTA.

20 grani . = 1 taro.
12 tari . . = 1 scudo.
30 tari . . = 1 pezza, or Sicilian dollar.

Exchange with Britain. $48\frac{1}{2}d.$ for 1 pezza.

(51) In £400. sterling how many pezza, exchange at $49\frac{1}{4}d.$
(52) In 1000 pezza how much sterling, exchange at $48\frac{3}{4}d.$

### XXII. ROME.

100 bajocchi = 1 scudo Romano.

The scudo, or crown, is divided into 10 paoli.

Exchange with Britain. $48\frac{1}{3}$ paoli for £1.

### XXIII. DRESDEN AND LEIPZIG.

12 pfennings = 1 groshen.
24 groshen . = 1 rix dollar.

Exchange with Britain. 6 rix dollars, $15\frac{3}{4}$ groshen for £1. sterling.

Exchange with Amsterdam. $140\frac{1}{4}$ rix dollars for 250 florins.

Exchange with Hamburgh. $148\frac{1}{4}$ rix dollars for 300 marks banco.

Exchange with Paris. 79 rix dollars for 300 francs.

(53) In £500. how many rix dollars, exchange at 6 rix dollars, $15\frac{1}{2}$ groshen?

(54) In 1000 rix dollars how much sterling, exchange at 6 rix dollars, $16\frac{1}{4}$ groshen?

### XXIV. NORTH AMERICA, BRITISH COLONIES AND THE WEST INDIES.

Canada and the northern provinces. £100. sterling are worth at par £$111\frac{1}{9}$. currency; or £90. sterling are worth £100. currency.

Jamaica. The currency is fixed at £140. for £100. sterling, and the Spanish dollar 6*s.* 8*d.* currency.

Barbadoes. The dollar is fixed at 6*s.* 3*d.* currency.

Grenada, St. Vincent, Tobago, Tortola, &c. the uncut dollar = 9*s.* currency; the cut dollar = 8*s.* 3*d.* currency.

(55) In £600. Canada currency how much sterling, rate of exchange being as 100 to 90?

(56) In £720. sterling how much Canada currency, exchange as 90 to 100?

(57) In £500. Bermuda currency how much sterling, exchange at 180 per cent.?

(58) In £300. sterling how much Bermada currency, exchange at 180 per cent.?

(59) In £600. Jamaica currency how much sterling, exchange at 140 per cent.?

(60) In £428..11..5. sterling how much Jamaica currency, exchange at 140 per cent.?

### XXV. THE UNITED STATES, NORTH AMERICA.

100 cents = 1 dollar.

The dollar is valued at 4*s*. 6*d*. sterling, and the rate of exchange is regulated by a premium or discount upon the sterling.

To reduce dollars into sterling.—Multiply by 9 and divide by 40.

To reduce sterling to dollars.—Multiply by 40 and divide by 9; the cents will be so many decimals of a dollar.

(61) In 5696 dollars, 72 cents, United States currency, how much sterling, exchange at 4*s*. 6*d*.?

(62) In £1281..15..3. sterling how much United States currency, exchange at 4*s*. 6*d*.?

## PREMIUM, OR DISCOUNT.

In all cases where there is a fixed par of exchange, and the variations in the rates are regulated by a premium, or discount, the same is calculated upon the money of that place upon which the bill is drawn; thus,

100 Money at par — 100 with Discount or Premium added. *to the currency.

100 with Premium or Discount added — 100 Currency *to money at par.

(63) What is the value in Jamaica currency of a bill for £500. sterling, at a premium of 12¾ per cent.?

(64) What is the value in sterling of £547..4..5. Canadian currency, at 1½ per cent. discount?

(65) Required the value in sterling of £789..5. Jamaica currency, discount at 12¾ per cent.?

(66) What is the value in sterling of 4826 dollars, 25 cents, United States currency, at a premium of 10½ per cent.?

(67) Required the value in United States currency of £982..14..5. sterling, discount at 10½ per cent.?

### XXVI. SOUTH AMERICA, SPANISH SETTLEMENTS.

16 quarts = 1 real; 8 reals = 1 dollar.

Exchange with Britain. 18½*d.* for 1 paper dollar.

### XXVII. PORTUGUESE SETTLEMENTS.

1000 reis = 1 milrea.

Exchange with Britain. 31½*d.* for 1 milrea.

(68) In 10000 dollars how much sterling, exchange at 18½*d.*?

(69) In 87560 reis how much sterling, exchange at 35¾*d.*?

(70) In £384..0..9. how many dollars, exchange at 19½*d.*?

(71) In £1849..4..10. how many reis, exchange at 31½*d.*?

### XXVIII. EAST INDIES, CALCUTTA.

12 pice = 1 anna; 16 annas = 1 rupee.

The Sicca rupee is the money of exchange, and its value is 1*s.* 11½*d.* sterling.

Madras and Bombay. The rupee, value 1*s.* 10¼*d.*

100 pagodas . . = 350 rupees.
100 reas . . . = 1 quarter.
4 quarters . . = 1 rupee.

### XXIX. CAPE OF GOOD HOPE.

British currency.

(72) In 11864 Sicca rupees, Bengal currency, how much sterling, exchange at 1*s.* 10½*d.*?

(73) In 1962 pagodas, Madras currency, how much sterling, exchange at 1*s.* 9½*d.* per rupee?

(74) In 6688 rupees, Bombay currency, how much sterling, exchange at 1*s.* 9¾*d.* per rupee?

## DRAWING AND REMITTING.

For remittances abroad prefer that mode which gives the greatest sum in foreign money, or costs the least sum in sterling; and for returns or remittances to this country, prefer that which costs the least sum in foreign money, or yields the most in sterling.

## ARBITRATION OF EXCHANGE.

Having the rates of exchange between two or more places given, to find the rate of exchange between the first and last, in correspondence to the rest.

Rule. Place the given equations under each other, so that the terms of the same kind always stand on different sides. Take the Product of the greater number of terms for a Dividend, and the Product of the lesser number for a Divisor; the Quotient will be the required quantity.

Note. Where requisite, reduce like terms on each side to the same name.

(1) A bill drawn on Amsterdam, at 12 florins, 10 cents per £. sterling; the proceeds of the bill are forwarded to Paris, at 57½ florins per 120 francs. Required the proportional exchange between London and Paris.

(2) I have a bill drawn on Hamburgh, at 13 marks, 10½ schillings per £. sterling; it is sent to Amsterdam, exchange at 35½ florins per 40 banco marks; the proceeds are remitted to Paris in French bills, at 57½ florins per 120 francs. What price does this transaction establish between London and Paris?

(3) If 6 yards Hamburgh are equal to 5 yards in Holland, and 7 in Holland = 4 in France, and 5 in France = 5 in England, how many English yards will = 1176 yards of Hamburgh? how many yards of Hamburgh will = 100 yards in English?

*Table of Foreign Weights and Measures compared with English.*

| | 112 *lbs.* Avoirdupois equal to | 100 Gallons equal to | 100 Quarters equal to | 100 Yards equal to |
|---|---|---|---|---|
| France . | 50·79 Kilogrammes . . | 454·34 Litres . . . . | 290·77 Hectolitres . | 91·43 Metres. |
| Netherlands | 101·59 Half Ponders . . | 454·34 Kans . . . . | 9·69 last of 30 Mudde or Hectolitres | 91·43 Ells or Metres. |
| Hamburgh | 104·85 Pounds . . . | 62·75 Veertels 20 to 1 Ahm | 9·18 lasts of 30 Scheffels | 159·58 Ells. |
| Denmark . | 101·69 Pounds . . . | 58·79 Veertels 30 to 1 Oxhoft | 17·42 lasts of 12 Toendes | 145·67 Ells. |
| Prussia . | 108·62 Pounds . . . | 396·79 Quarts 64 to 1 Eimer | 7·34 lasts of 72 Scheffels | 137·1 Ells. |
| Sweden . | 119·50 Pounds . . . . | 173·66 Kannem 30 to 1 Eimer . . . . | 176·41 Tunna of 36 Kappar . . | 154. Ells. |
| Russia . | 3·102 Poods of 40 *lbs.* . . | 36.97 Wedros 18 to 1 Oxhoft . . . . | 138·64 Chetwerts . | 128·57 Arshines. |
| Turkey . | 39·59 Okes . . . . | 86·54 Almudes . . . | 828·4 Killoros . . . | 135·21 Pikes. |
| Austria . | 90·67 Pounds . . . . | 8·03 Eimers . . . . | 472·86 Metzen . . | 117·35 Ells. |
| Naples . | 0·5702 Cantaro of 100 Rotoli | 10·97 Barile of 60 Caraffe | 568·58 Tomoli . . | 43·27 Canne of 8 Palmi. |
| Leghorn . | 1·496 Quintal of 100 Pounds | 9·96 Barile of 20 Fiasche 13·58 Barile of Oil . | 397·89 Sacks . . | 153·87 Braccia. |
| Genoa . | 1.0685 Cantaro of 100 Rotoli | 6·12 Barile . . . . | 241·51 Mine . . | 36·575 Canne of 10 Palmi. |
| Spain . | 4·416 Arrobas of 25 Pounds | 28·10 Cantaros of 8 Azumbras . . . . | 514·78 Fanegas . . | 107·83 Varas. |
| Portugal . | 3·459 Arrobas of 32 Pounds | 27·14 Almudes of Lisbon 17·83 Ditto of Oporto | 2151·5 Alquieras of Lisbon and Oporto | 83·45 Varas. |

## ALLIGATION

DIRECTS computations relating to the mixing of simples of different qualities, and is distinguished into *medial* and *alternate.*

*Alligation medial.*—Given the quantities and rates of the several simples, to find the rate of the mixture.

RULE. Multiply each quantity by its rate, and divide the sum of the Products by the sum of the quantities.

(1) 8 *lbs.* of sugar at 7*d.* per *lb.* were mixed with 5 *lbs.* at 8*d.* and 7 *lbs.* at 1*s.* Required the price of the mixture per *lb.*?

(2) 8 *lbs.* of tea at 5*s.* 7½*d.* were mixed with 12 *lbs.* at 8*s.* 3*d.* and with 16 *lbs.* at 9*s.* Required the value of a *lb.* of this mixture.

(3) If 7 gallons of brandy at 6*s.* 3*d.* be mixed with 9 gallons at 7*s.* 6*d.*; 12 gallons at 7*s.* 11¾*d.*; and 4 gallons at 10*s.* 3*d.*: what is the mixture worth per gallon?

(4) If 9 gallons of wine at 5*s.* 4*d.* be mixed with 8 gallons at 6*s.* 8*d.*; 8 gallons at 7*s.* 7*d.*; and with 3 of water. The value of this mixture per gallon is required.

(5) A rectifier of spirits mixes 18 gallons at 3*s.* 6*d.* with 12 gallons at 5*s.* 7*d.* and 16 gallons at 4*s.* 4*d.* Required at what rate the compound should be sold to gain 10 per cent.

*Alligation alternate.*—Given the rates of the mixture and simples to find the quantity of each simple.

RULE. Write the rates of the simples under each other, with the mixture rate on their left hand. Connect the rates of the simples so that one less than the mixture rate be always linked with one that is greater. Write the difference betwixt the mixture rate and that of each of the simples opposite to that rate with which it is linked. These differences, or their sum, if more than one, will be the quantities at the rates opposite to which they stand.

(6) How much corn at 2*s.* 6*d.* per bushel, and 3*s.* 4*d.* per bushel, must be mixed together, that the compound may be worth 3*s.* per bushel?

(7) How much tea at 3*s.* and 2*s.* must be mixed together that the compound may be worth 2*s.* 6*d.*?

(8) What quantity of sugar at 4*d.* 6*d.* and 9*d.* must be mixed together that the composition may be worth 8*d.*?

(9) How much tea at 4*s*. 5*s*. 6*s*. and 8*s*. should be mixed together that the compound may be worth 7*s*.?

NOTE 1. If the composition be limited to a certain quantity. Say

| Cause. | | Effect. |
|---|---|---|
| The sum of the quantities | ⋈ | given quantity. |
| Each of the quantities found | | quantity required of each. |

(10) How much brandy at 4*s*. 5*s*. and 6*s*. per gallon must be mixed, to form a composition of 24 gallons, worth 5*s*. 6*d*.?

(11) How much corn at 4*s*. 6*s*. and 9*s*. per bushel must be mixed together to form a composition of 40 bushels, worth 7*s*. per bushel?

NOTE 2. If one of the simples be limited, say

| | | |
|---|---|---|
| The quantity of the simple found by linking / The other quantities found | ⋈ | the limited quantity. / required quantity of each. |

(12) How much tea at 4*s*. 6*s*. and 7*s*. per *lb*. must be mixed with 6 *lbs*. at 5*s*. per *lb*. that the mixture may be worth 5*s*. 6*d*. per *lb*.?

(13) How much rum at 7*s*. 9*s*. and 10*s*. per gallon must be mixed with 6 gallons at 8*s*. per gallon that the compound may be worth 8*s*. 6*d*. per gallon?

(14) How much brandy at 5*s*. 5*s*. 6*d*. and at 6*s*. per gallon must be mixed with 3 gallons at 4*s*. per gallon, that the mixture may be worth 5*s*. 4*d*. per gallon?

## POSITION.

IN this rule take any common number and proceed with it according to the tenor of the question, if the result or number thus obtained be the same as the given number, the position or assumed number is the number sought; if not, proceed by the following rules.

Case 1. RULE 1. When the result is proportional to the position, the result is to the given number, as the position is to the required number.

(1) What number is that to which if we add the half, the third, and the fourth, of itself, the sum will be 125?

(2) A man being asked his age said, If to my age you add $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{8}$ thereof, the number 63 will then be had. Quere his age?

(3) Three steam engines are employed to drain a mine,

one can do it in 6 days, the second in 4 days, and the third in 3 days. Suppose they all work together, what time will the mine be drained?

(4) Lent a sum of money at £6. per cent. per annum, simple interest, and at the end of 10 years received for principal and interest £1000. What was the sum lent?

(5) Three wheels are required to make 72 revolutions amongst them, the second to make 2 revolutions for the first 1, the third to make 3 revolutions for the second 1, required the revolutions of each.

(6) *A*, *B*, and *C*, buy a lot of timber for £360. and agree that *B* shall pay $\frac{1}{3}$ more than *A*, and *C* $\frac{1}{4}$ more than *B*. I demand how much each must pay.

RULE. Case 2. When the results are not proportional to the Position; that is, when some given number is added to or subtracted from the position in the course of the process, try two numbers as above, and find the errors or differences between the results and the given number. Multiply each of these errors by the other's position, then if the errors be of the same kind, that is, both less or both greater than the given number, divide the difference of the Products by the difference of the Errors; but if the one error is greater and the other less than the given number, divide the sum of the Products by the sum of the Errors, the Quotient in each case will be the answer.

RULE 2. Multiply the difference of the two numbers supposed by the less error, divide that Product by the difference of the two errors if they are alike, or by their sum if unlike, and the Quotient will be a correctional number; which being added to the nearest supposition when defective, or subtracted from it when excessive, will give the number required; which operation may be repeated to any degree of exactness.

If the signs be alike, subtract from the lesser and add to the greater number supposed answering to the least error.

If the signs be unlike subtract from the greater and add to the lesser number supposed answering to the least error.

(1) What number is that which being doubled and 16 added to the product will make the sum 56?

(2) Three shafts together are to make 235 revolutions per minute, the first to make a certain number, the second to make 4 times as many and 3 more, the third to make twice

as many as the second and 5 more. Required the number of revolutions of each shaft severally.

(3) Three shafts making in the whole 590 revolutions, in such order that the last makes 24 times as many revolutions as the first, wanting only 7; the second 5 times as many as the first, wanting 3. Required the revolutions of each shaft.

(4) Two partners *A* and *B* have both the same income, *A* saves yearly $\frac{1}{5}$ of his, *B* by spending £50. per annum more than *A*, at the end of 4 years finds himself £100. in debt. Required their income.

(5) A testator left by will £1000. between his son and daughter, *viz.* $\frac{1}{3}$ part of the son's share should exceed $\frac{1}{4}$ part of the daughter's by £10. how must the £1000. be divided.

(6) *A* and *B* performed a piece of work in 60 days, for which they received £7..8. *A*'s wages were 2*s*. 8*d*. per day, and *B*'s 2*s*. 2*d*. How many days did each work?

(7) A nurseryman takes 125 acres of ground, for which he is to give £38..5.; the land consists of two sorts, for the better sort he is to give 7*s*. 6*d*. per acre, and for the worst 3*s*. 9*d*. per acre. How many acres were there of each sort?

(8) A grazier laid out £395. in oxen and sheep, the oxen cost £8..15. per head, the sheep 16*s*. per head. He sold the oxen again for £9..18. per head, and the sheep for 18*s*. 6*d*. per head, and gained £53..10. by the bargain. How many oxen and sheep did he buy and sell?

(9) What number is that which being multiplied by $2\frac{3}{4}$, and again by itself, the product will be 600? This relates to the drafts of cotton.

N. B. Many questions may be resolved by this rule which cannot be done by any other rule in Arithmetic.

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## PROGRESSIONS.

An Arithmetical Progression is a series or rank of numbers uniformly increasing or decreasing by the constant addition or subtraction of some number, called the common difference. Thus, 1, 2, 3, 4, 5, is an increasing arithmetical series, where the common difference is 1; and 10, 8, 6, 4, 2, is a decreasing arithmetical series, where the common difference is 2.

A Geometrical Progression or series is a rank of numbers uniformly increasing or decreasing by a constant multiplier or divisor, called the *common ratio*. Thus, 1, 2, 4, 8, is an in-

creasing geometrical series, where the common ratio is 2; and 27, 9, 3, 1, is a decreasing geometrical series, where the common ratio is 3.

The first and last terms are called *extremes*, and the other terms *means*.

## ARITHMETICAL PROGRESSION.

Of these five, *viz.* The two extremes, common difference, number of terms, and the sum of the series; having any three given, the other two may be found.

Theorem. The sum of the extremes is equal to the sum of any two means equally distant from them.

### PROBLEM I.

Given the extremes and number of terms to find the other two.

Rule. The common difference is equal to the difference of the extremes divided by the number of terms minus one. And the sum of the series is equal to the sum of the extremes multiplied by half the number of terms.

(1) Given the extremes 12 and 42, and the number of terms 11. Required the common difference, and sum of the series.

(2) Borrowed £800. which is to be repaid by yearly instalments of £100. each, the interest being £5. per cent. per annum. How much shall I have paid for interest at the end of 8 years?

(3) 18 wheels revolve in arithmetical progression, the first makes 3 revolutions, and the last 51 in the same time; how many revolutions does each wheel exceed the former, and how many do they altogether make in the same time?

(4) 11 wheels revolve in arithmetical progression, the first makes 3 revolutions, and the last 33. Required the sum of the series.

(5) The length of the first layer of roving yarn upon a bobbin is found to be 180 inches, the length of the last layer 741 inches, the number of layers 18. Required the length of yarn on the bobbin.

### PROBLEM II.

Given the extremes and common difference, required the number of terms and the sum of the series.

RULE. Divide the difference of the extremes by the common difference; the Quotient plus one will be the number of terms. For the sum of the series, see Problem I.

(6) The first wheel makes 7 and the last 103 revolutions in the same time, the difference of revolutions 4. Required the number of wheels and the sum of the revolutions.

(7) The first layer of yarn on a bobbin is 180 inches, the last 741, the difference in length 33 inches. Required the number of layers and the length of yarn on the bobbin.

(8) A number of trees are planted in the form of an isosceles triangle, the first row contains 1 plant, the second 3, and so on in arithmetical progression, the last row contains 61. Required the number of rows and the whole number of plants.

(9) In one of the operations for preparing cotton for yarn, the speed of the bobbin is regulated by means of a cone drum and rack; every tooth of the rack being moved decreases the speed of the bobbin. Suppose the bobbin to decrease in speed 3 revolutions every tooth, and the number of revolutions before the first tooth is moved 168, and the last 84. Required the number of teeth in the rack to effect the proportionate speed.*

### PROBLEM III.

Given the common difference, number of terms and the sum of the series, to find the rest.

RULE. Divide the number of terms minus 1, by 2; multiply the common difference by the Quotient: add and subtract this Product to and from the sum of the series divided by the number of terms; the sum and remainder will be the greatest and least terms respectively.

(10) The number of wheels 9, the common difference of revolutions 2, the sum of the revolutions 135. Required the proportionate speed of the first and last shafts.

(11) The number of layers of yarn upon a bobbin are 18,

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* The decrease in speed is regulated according to the fineness of the roving, the number 3 is put only to show the manner of working the question, and this relates to the common fly frame. The rack for the improved fly frame is made from the divisions of a parabolic curve, the ordinate being equal to the space the strap passes over the cone drum.

the difference in length 33 inches, and the length of yarn 8289 inches. Required the first and last layer.

(12) Suppose the number of teeth in a rack to be 29, and every tooth to cause a decrease of 3 revolutions of the bobbin, and the total revolutions from one end of the rack to the other 3654. Required the first and last revolutions of the bobbin.

### PROBLEM IV.

Given either of the extremes, the common difference and number of terms, to find the rest.

RULE. Multiply the common difference by the number of terms minus 1; this Product added to the less extreme gives the greater, or subtracted from the greater extreme gives the less. Add the said Product to twice the least extreme or subtract it from twice the greater; multiply the sum or remainder by half the number of terms, either of these will give the sum of the series.

(13) Given the first revolution 12, difference 3, number of wheels 11. Required the revolution of the last wheel, and the number of revolutions of the whole.

(14) The revolution of the last wheel 123, difference 5, the number of wheels 24. Required the revolutions of the first, and the sum of the revolutions.

(15) The first revolutions of a bobbin are 168, the decrease 3, the number of teeth in the rack 29. Required the revolutions caused by the last tooth of the rack, and the whole number of revolutions.

By the foregoing Problems questions relating to annuities, pensions, rents, &c. in arrear at simple interest, may be very easily solved. The several yearly, half-yearly, or quarterly payments of interest form an arithmetical progression, of which take the last interest due as the first term and common difference; and the number of years, half-years, or quarters, diminished by one, as the number of terms.

(1) If an annuity of £60. be forborne for 8 years, what will be due at the end of that time for principal and interest, rate of interest £5. per cent.?

(2) If a house be let on lease for 6 years at £45. per annum, payable half-yearly, and the rent being in arrear the whole term, required the amount due, interest at £4. per cent. per annum?

(3) If a pension payable quarterly of £80. per annum remain unpaid 4 years, what will be due at the end of that time, rate of interest £4½. per cent. per annum?

## GEOMETRICAL PROGRESSION.

Theorem. The Product of the extremes is equal to the Product of any two means equally distant from them.

### PROBLEM I.

Given the least extreme ratio and number of terms to find the greater extreme or any distant term.

RULE. Raise the ratio to a power less by unity than the number of the required term: multiply that power by the least term, the Product is the greatest.

(1) Given the least term 3, ratio 2. Required the 8th. term.

(2) The first wheel makes 5 revolutions. the increased speed 3 fold, the number of wheels 6. Required the revolutions of the last.

(3) If a cubic inch of atmospheric air be increased to 4 times its rarity at 7 miles from the surface of the earth, what will be its rarity at the height of 49 miles?

### PROBLEM II.

Given the extremes and ratio to find the sum of the series.

RULE. Multiply the last extreme by the ratio, from this Product subtract the first extreme and divide the Remainder by the ratio minus 1.

(4) The first wheel makes 1 revolution in the same space of time that the last makes 2187, the ratio 3. Required the sum of the revolutions of all the wheels.

## DECREASING PROGRESSION.

OF any decreasing series whose last term is a cipher, to find the sum of those series.

RULE. Divide the square of the first term by the difference between the first and second terms, and the quotient will be the sum of all the series.

PROBLEM.

To find the sum of $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}$, &c.

(1) Suppose a ball to be put in motion by a force which drives it 12 miles the first hour, 10 the second, and so on continually decreasing in proportion of 12 to 10 to infinity; what space would it move through?

(2) If a wheel be put in motion by a force which causes 10 revolutions in the first portion of time, 9 in the second, and so on in the ratio of $\frac{9}{10}$ for ever, how many revolutions will it make?

(3) Suppose a man walk 20 miles the first day, 19 the second, 18 the third, &c. in the same decreasing series, would he ever arrive at a city 500 miles distant from the place he set out from, were it possible he could travel through an infinity of ages and never stop?

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## INVOLUTION.

INVOLUTION is the method of finding the *powers* of numbers.

The number to be involved is itself the *first power*; or it is called the *root* of that power it is required to be raised to. If it be multiplied once into itself, the Product is its *square*, or *second power*. If twice into itself, the Product is its *cube*, or *third power*; and, universally, any power of any number is obtained by multiplying the number into itself a number of times, less by unity than the index, or name of the power to which it is required to be raised.

Table of the second and third powers of the nine digits.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1st. power or root | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2nd. power or square | 1 | 4 | 9 | 16 | 25 | 36 | 49 | 64 | 81 |
| 3rd. power or cube | 1 | 8 | 27 | 64 | 125 | 216 | 343 | 512 | 729. |

EXAMPLES.

(1) Raise 24 to the biquadrate or 4th. power.

(2) Raise 37 to the sursolid or 5th. power.

(3) The lineal side of a square table is 29 inches. How many square inches does it contain?

(4) The lineal side of a stone, of a cubic form, measures 5 feet. How many solid feet does it contain?

(5) How many $\frac{3}{8}$ inch cubes can be got out of a 9 inch cube?

## EVOLUTION.

EVOLUTION is the method of finding the *roots* of numbers.

The *Square root* is that of which the given number is the square.

The *Cube root* is that of which the given number is the cube.

To extract the Square root.—Divide the numbers into periods of two figures, beginning at the place of units.

Find the greatest square contained in the left hand period, and place its root in the quotient, and subtract the square itself from that period, and to the Remainder annex the second period for a Dividend.

Double the figure in the Quotient or root for a Divisor; by which divide the Dividend, omitting the right hand figure, and place the result both in the root and on the right of the Divisor; also by it multiply the Divisor thus completed, and subtract the Product from the Dividend, and to the Remainder annex the next period for a new Dividend.

To the completed Divisor add the figure last put in the root; the sum is a new Divisor, with which proceed as before.

Required the square root of 331776.

```
  . . .
  331776(576 root.        576
  25                      576
  ---                     ---
107) 817                  3456
   7 749                  4032
  ---                     2880
1146)  6876               ----
       6876               331776 proof.
```

NOTE 1. If there be a Remainder after all the periods are used, the operation may be continued to decimals, by annexing periods of ciphers, taking care to divide from the decimal point to the right hand.

NOTE 2. Any figure of the root is an integer or decimal, according to the period from which it arises being an integer or decimal.

NOTE 3. The square root of a fraction is got by taking the roots of its two terms, if it can be done exactly; if not, reduce the fraction to a decimal, and extract the root as before.

(1) Required the square root of 576.
(2) Required the square root of 20736.
(3) Required the square root of 622521.

(4) Required the square root of 788544.
(5) Required the square root of 1234321.
(6) Required the square root of 5013914481.
(7) Required the square root of 95023504.
(8) Required the square root of 1524157875019052l.
(9) Required the square root of 65131436864025.
(10) Required the square root of ·5329.
(11) Required the square root of 5·875.
(12) Required the square root of 487683.
(13) Required the square root of 914874.
(14) Required the square root of 6154346.
(15) Required the square root of 5.
(16) Required the square root of 17·3056.
(17) Required the square root of ·8281.
(18) Required the square root of $\frac{49}{144}$, of $\frac{81}{121}$, and of $\frac{529}{1296}$.
(19) Required the square root of $\frac{3}{4}$.
(20) Required the square root of ·000729.
(21) Required the square root of 784·375.
(22) Required the square root of 68·3.
(23) Required the square root of 486·1.
(24) Required the square root of ·00000784.
(25) Required the square root of 11.
(26) Required the square root of ·000000005329.

PROBLEM I.

To find a mean proportional between two given numbers.—Extract the square root of their Product.

(1) Required a mean proportional between 4 and 36.
(2) Required a mean proportional between 7 and 13.
(3) Required a mean proportional between 16 and 64.

PROBLEM II.

To find the side of a square equal in area to any given superficies.—Extract the square root of the given area.

The side of a square being given, to find the side of a square greater or less in quantity than the given square.—Square the side given, and multiply it by the increase, or divide it by the decrease; the square root of the Product or Quotient is the side sought.

(1) The area of a circle is ·7854. Required the side of a square equal in area thereto.

(2) A gentleman has a fishpond in form of a triangle, containing 480 poles; he wants another of equal area in form of a square. Required the side.

(3) If 220 yards long and 22 yards broad will form one acre of ground, what will be the length of each fence to enclose the same in a square?

(4) There are two wheels working together, the one is 6 feet in diameter, the other is 5 times as large. Required its diameter.

(5) I have a building 26 yards long and 8 yards broad. Required the side of a square building to contain three times as much room.

(6) A farm consists of four fields; the first 2 *a.* 3 *r.* 14 *p.*; the second 3 *a.* 1 *r.*; the third 1 *a.* 0 *r.* 18 *p.*; the fourth 4 *a.* 3 *r.* 24 *p.*; which farm is purposed to be exchanged for a square field, equal in area to all the four. Required the length of its side.

(7) Admit a room to be 60 feet long, 20 broad and 15 high. Required the space for light.

### PROBLEM III.

Given any two sides of a right-angled triangle, to find the other side.—The square of the hypotenuse, or longest side, is equal to the sum of the squares of the other two sides; therefore the hypotenuse is equal to the square root of the sum of the squares of the two sides, and either side is equal to the square root of the difference of the squares of the hypotenuse and other side.

(1) Three sides of a triangle are 3, 4, and 5, taking any two of them as given, required the other.

(2) The length of a line, stretched from the top of a steeple to a station 250 feet from its bottom, was found to measure 330 feet. What was the height of the steeple?

(3) Standing on the side of a river, I found that a line stretched from the top of a precipice rising perpendicularly 449 feet, on the other side measured 585 feet. Required the breadth of the river.

(4) The wall of a fortification is 248 feet high, the breadth of a ditch surrounding it is 224 feet. Required the length of a scaling ladder that will reach from the farthest side of the ditch to the top of the wall.

(5) Two travellers set out from Manchester, the one travels south, 25 miles per day; the other west, 32 miles per day. How far were they distant after travelling 5 days?

(6) Two ships sail from the same port; one of them goes due east 50 leagues, the other due north 84 leagues. How far are they asunder?

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## PROPORTION,

### *In which Square and Square Root are required.*

ALL similar plain figures, as circles, squares, triangles, polygons, ellipsis, &c. are to one another in area as the squares of their like sides.

Similar solids, of the same length and matter, are in weight and strength as the square of their sides, diameters, peripheries, &c. whether timber, iron, bars, wire, ropes, yarn, &c.

The effects of light, heat and attraction are as the squares of their distances from the centre whence they are propagated.

(1) If a rope of 6 inches in circumference consists of 450 threads or strands, required the number of such threads to make a 14 inch cable.

(2) The diameter of a circle is seven, and the content 30·3846. Required the content of another circle, whose diameter is 21.

(3) If a beam 8 inches deep be sufficient to support 1000 *lbs.* what must be the depth of another, of the same length, to support 8 times as much?

(4) If a pipe, $4\frac{1}{2}$ inches in diameter, will discharge a certain quantity of water in one hour's time, in what time will a pipe, $2\frac{1}{2}$ inches in diameter, discharge the same quantity from the same current?

(5) If a 1600 jaconett require 128 hanks in the *lb.* what will 2000 require?

(6) Suppose a 600 reed to require 8 *oz.* yarn, what reed will 4 *oz.* give?

(7) Allowing a mule to be spinning 64's with 30 turns to one inch of yarn, how many turns in the same space to spin 81's?

(8) Admit a leaden pipe, $1\frac{1}{2}$ inch diameter, will fill a cistern in two hours; what will be the diameter of another pipe to fill the same cistern in one hour?

(9) If 8 *oz.* of yarn will make a 600 lawn, what quantity of yarn will make a 1200 of the same fabric?

(10) If an enclosure contain 25 statute acres, of 16·5 feet

to the perch, how many Lancashire acres will there be in it, of 21 feet to the perch?

(11) In a farm consisting of 84 acres statute measure, of 16·5 feet to the perch, how many Cheshire acres, of 24 feet to the perch?

(12) How many acres, statute measure, in a farm containing 184 Lancashire acres?

(13) Required the number of statute acres in an estate containing 230 Cheshire acres.

(14) Required the number of Lancashire acres in a farm containing 248 Cheshire acres.

(15) Suppose that in a room where two men are sitting there is a fire; *A* is 3 feet distant, and *B* 6 feet. It is required to find how much hotter it is at *A*'s seat than at *B*'s.

(16) If a body weigh 16 *oz.* upon the earth's surface, what will its weight be 50 miles above it, taking the earth's diameter at 7964 miles?

(17) If a body weigh 28 *lbs.* on the surface of the earth, what will be its weight at 100 miles above it, the earth's diameter being 7964 miles?

(18) If 20 feet of iron railing weigh half a ton when the bars are $1\frac{1}{4}$ inch square, what will be the weight of 50 feet of bars $\frac{7}{8}$ of an inch square, and what will they come to at $3\frac{1}{2}d.$ per *lb.*?

(19) If a round pillar, 7 inches in diameter, has four feet of stone in it, of what diameter is the column of equal length that measures ten times as much?

(20) If a pipe 12 inches long, 1 inch diameter, placed 4 feet below the surface of water in a reservoir, will discharge 7070 cubic inches of water in one minute, required the diameter of a pipe the same length, placed the same depth in the reservoir, to discharge 40000 cubic inches of water in the same time.

(21) If two fly wheels be of the same weight, one of them 12 feet diameter, revolving in 8 seconds, what proportion must the diameter of the other bear, when it revolves in 3 seconds?

(22) Suppose two fly wheels, of the same diameters, the one revolving in 3 seconds and the other in 8 seconds. What will be the proportionate difference of their weights?

Where the depth, length and breadth of one joist are given, to find any of the three terms in another of equal strength.

RULE. Square the depths and lengths.

(23) A joist 24 *ft.* long, 12 *in.* deep, 6 *in.* thick. Required the depth of another, of equal strength, 30 *ft.* long and 4 *in.* thick.

(24) Required the length of a joist 18·37 *in.* deep, 4 *in.* thick, of equal strength with one 24 *ft.* long, 12 *in.* deep, 6 *in* thick.

(25) If a joist be 24 *ft.* long, 12 *in.* deep, 6 *in.* thick, required the thickness of another 30 *ft.* long, 18·37 *in.* deep.

To find the length of a pendulum.—Square the number of vibrations per second, and proceed as in Proportion.

(1) If a royal pendulum, 39·2 inches long, vibrate seconds, or 60 times per minute, how often will that pendulum vibrate in a minute that is 9 inches long?

(2) Required the length of a pendulum that will vibrate half seconds, or 120 times in one minute.

(3) What difference will there be in the number of vibrations made by a pendulum of 9 inches long, and another of 18 inches long, in an hour's time?

### TO EXTRACT THE CUBE ROOT.

Rule 1. Divide the given numbers from the place of units into periods of three figures.

Rule 2. Find the greatest cube in the left hand period, put its root in the Quotient, and subtract the cube itself from that period, and to the Remainder annex the second period for a Dividend.

Multiply the square of the Quotient figures by 300 for a Divisor.

Consider how often the Divisor is contained in the Dividend, and place the resulting figures in the Quotient.

Draw a line under the Dividend, and multiply the Divisor by the figure last put in the Quotient; to which Product add 30 times the square of the last figure, multiplied by the other figure or figures in the root, and also the cube of the last figure put in the root.

Subtract that sum from the Dividend, and to the Remainder bring down another period for a new Dividend, with which proceed as before directed.

**Required the cube root of 22069810125.**

$$
\begin{array}{rl}
 & 22069810125(2805 \\
2 \times 2 \times 2 = & 8 \\
\hline
2 \times 2 \times 300 = 1200) & 14069 \\
1200 \times 8 = & 9600 \\
8 \times 8 \times 2 \times 30 = & 3640 \\
8 \times 8 \times 8 = & 512 \\
\hline
 & 13952 \\
\hline
28 \times 28 \times 300 = 235200) & 117810 \\
\hline
 & 23520000)117810125 \\
23520000 \times 5 = & 117600000 \\
5 \times 5 \times 280 \times 30 = & 210000 \\
5 \times 5 \times 5 = & 125 \\
\hline
 & 117810125
\end{array}
$$

(1) Required the cube root of 15625.
(2) Required the cube root of 21024576.
(3) Required the cube root of 52734375.
(4) Required the cube root of 490982336369.
(5) Required the cube root of 1371737997260631.
(6) Required the cube root of 6745935400 1042485129.
(7) Required the cube root of ·041063625.
(8) Required the cube root of 7835·8748.
(9) Required the cube root of 3.
(10) Required the cube root of 0000091125.
(11) Required the cube root of 784·67341688.
(12) Required the cube root of $\frac{2}{3}\frac{1}{4}\frac{9}{3}$, of $\frac{1}{7}\frac{8}{2}\frac{6}{9}$, and of $\frac{1}{2}\frac{7}{1}\frac{8}{0}\frac{8}{7}$.

### PROBLEM I.

**To find two geometrical means between two given numbers.**

RULE. Divide the greater extreme by the less, and the cube root of the Quotient, multiplied by the less extreme, gives the less mean; multiply the said cube root by the less mean, and the Product will be the greater mean proportional.

(1) Required the two geometrical means between 8 and 27.
(2) What are the two mean proportionals between 6 and 162?

(3) What are the two mean proportionals between 7 and 15379?

PROBLEM II.

To find the side of a cube, equal in solidity to any given solid, as a globe, cylinder, prism, cone, &c.

RULE. The cube root of the solid content given is the side of a cube of equal solidity.

(1) If the solid content of a globe be 2048383, what is the side of a cube of equal solidity?

(2) A chest is 4 *ft.* 7 *in.* long, 2 *ft.* 3 *in.* broad, and 1 *ft.* 9 *in.* deep. Required the side of a cube of equal solidity.

PROBLEM III.

The side of a cube being given, to find the side of a cube that shall be greater or less in quantity to the given cube.

RULE. Cube the side given, and multiply it by the increase, or divide it by the decrease; the cube root of the Product or Quotient is the side sought.

(1) The side of a cubical vessel is 12; what will be the side of another vessel that will contain 3 times as much?

(2) The side of a cubical vessel is 24; required the side of another vessel that will contain only $\frac{3}{4}$ of the quantity of the first?

(3) Suppose the length of a ship's keel to be 125 feet, the breadth of the midship beam 25 feet, and the depth of the hold 15 feet; I demand the dimensions of another ship, of the same form, that shall carry three times as much.

(4) Or, suppose the ship is to be half the burden of that whose dimensions are given above.

(5) What dimensions must I give to a joiner to make a cubical box, that will hold 2000 oranges, at $2\frac{1}{2}$ inches diameter each, supposing the oranges globular, keeping that form, and laid in rows exactly on the top of each other?

## PROPORTION,

*In which the Cube and Cube Root are required.*

(1) If a ball, 20 inches in diameter, weighs 555·$\frac{6}{10}$ *lbs.* what is the diameter of one of the same metal that weighs 15 *lbs.*?

(2) If a 12 inch cable require an anchor 18 *cwt.* what weight must an anchor be for a 15 inch cable?

(3) If a 15 inch cable require an anchor 35·15625 *cwt.* how thick must a cable be for an anchor 18 *cwt.*?

(4) If a vessel, whose side is 6, will contain 37·63 gallons, what will be the contents of another whose side is 20?

The proportion of the following metals:

Brass is to iron as 9 to 8.
Lead is to iron as 3 to 2.
Lead is to stone as 4 to 1.
Iron is to stone as 8 to 3.

(5) If a brass ball weighs 64 *lbs.* what is the weight of a leaden one of the same bulk?

(6) If an iron ball, 2 inches diameter, weighs 3 *lbs.* what will a brass ball weigh that is 4 inches radius?

(7) If a ship of 300 tons have a keel of 78 feet long, beam 25 feet, stern 20 feet, stern post 24 feet, required the length of the keel, beam, stern, and stern post, of one double that burden.

The power of iron to resist twisting is, cast iron will bear 14 to wrought iron 9.

(8) The journal of a wrought iron shaft is 7 inches in diameter. Required the diameter of a cast iron shaft journal of the same power.

(9) Admitting the journal of a cast iron shaft to be 9 inches, what should be the journal of a wrought iron shaft to resist torsion?

Where the depth and length only of a joist are given, to find either of them in another of equal strength.

Square the lengths and cube the depths.

(10) If the length of a joist be 26 feet, and 9 inches deep, what must be the depth of another 22 feet long?

(11) What length of a joist, 8 feet deep, will be equal in strength to another 26 feet long, 9 inches deep?

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## MENSURATION OF SUPERFICIES.

### PROBLEM I.

To find the area of a Parallelogram, whether it be a square, an oblong, rectangle, a rhombus or a rhomboid.

RULE. The Product of the length and breadth or altitude will be the area.

(1) A house stands on a square plot of ground measuring in front 36 feet 9 inches. Required the contents of the ground.

(2) A factory stands upon a rectangular plot of ground, the length in front 84 yards 2 feet 3 inches, the breadth 15 yards 1 foot 6 inches. How much ground does it stand upon, and what does the chief rent come to at $4\frac{3}{4}d.$ per square yard?

(3) A plank is 16 feet 6 inches long, 2 feet 3 inches broad. What length of a room will 28 such planks floor, the breadth being 16 feet 9 inches?

### PROBLEM II.

To find the area of a Triangle.

RULE 1. Half the Product of the base and altitude will be the area.

(1) What is the area of the gable end of a factory, the base or distance between the eaves being 45 feet 8 inches, and the perpendicular from the middle of the base to the ridge, 16 feet 6 inches?

(2) A triangular field measures at the end 54 perches, and from the centre of the end to the angular point 36 perches. How many acres does it contain?

When the three sides only are given.

RULE 2. From half the sum of the sides subtract each side severally: multiply the half sum and the three Remainders continually together, and the square root of their Product will be the area.

(3) How many acres are there in a triangular plot of land whose three sides are 380, 420 and 760 yards?

(4) What is the area of a triangle whose three sides are 13, 14 and 15 feet respectively?

### PROBLEM III.

To find the area of a Trapezium or a Trapezoid.

RULE. Divide the trapezium into two triangles by a diagonal; then half the Product of the diagonal and the two perpendiculars falling upon it will be the area. For a tra-

pezoid, half the product of the two parallel sides and the perpendicular distance will be the area.

(1) A garden is laid out in the form of a trapezium whose diagonal is 84 feet, and the perpendiculars 28 and 21 feet. Required the contents.

(2) Required the area of a trapezium whose diagonal is 108 feet 6 inches, and the perpendiculars 56 feet 3 inches and 60 feet 9 inches.

(3) Required the area of a trapezoid whose two parallel sides are 25 feet 6 inches, and 18 feet 9 inches, and the perpendicular distance between them 10 feet 5 inches.

### PROBLEM IV.

To find the area of any irregular figure.

RULE. Divide it by drawing diagonals into trapeziums and triangles. Find the area of each and their sum will be the whole area.

### PROBLEM V.

To find the area of a regular Polygon.

RULE 1. Multiply the perimeter or sum of the sides by the perpendicular drawn from the centre to one of the sides, and half the Product will be the area.

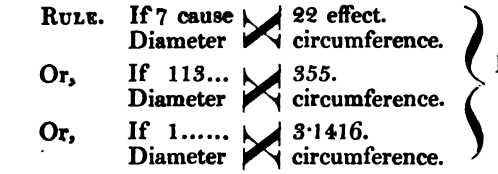
RULE 2. Multiply the square of the side by the corresponding tabular area or multiplier opposite name in the following table, and the Product will be the area.

| *No. of sides.* | *Names.* | *Areas or Multipliers.* |
|---|---|---|
| 3 | Trigon | 0·4330127 |
| 4 | Tetragon | 1·0000000 |
| 5 | Pentagon | 1·7204774 |
| 6 | Hexagon | 2·5980762 |
| 7 | Heptagon | 3·6339124 |
| 8 | Octagon | 4·8284271 |
| 9 | Nonagon | 6·1818242 |
| 10 | Decagon | 7·6942088 |
| 11 | Undecagon | 9·3656399 |
| 12 | Duodecagon | 11·1961524 |

Required the area of an Hexagon whose side is 27 feet.
Required the area of a Decagon whose side is 16 feet.

### PROBLEM VI.

To find the diameter or circumference of a circle, the one from the other.




(1) Required the circumference of a wheel whose diameter is 12 feet.

(2) If the diameter of a cylinder be 3 feet, 6 inches, what will be the circumference?

(3) What is the diameter of a wheel whose circumference is 12 feet 4 inches?

(4) If the circumference of a great circle of the earth at the equator were exactly 25020 miles, what would be the diameter?

(5) Required the circumference of a drawing frame roller, whose diameter is $1\frac{1}{4}$ inch.

(6) If a doffing cylinder be 12 inches diameter, what is the circumference?

(7) How many laths $2\frac{1}{2}$ inches broad will be required to cover the rings of a carding engine of 36 inches diameter?

(8) A pully of 24 inches diameter makes 12 revolutions while the strap revolves once. Required the length of the strap.

(9) The diameter of a carding engine is $54\frac{1}{2}$ inches. How many sheet cards, each $4\frac{1}{2}$ inches broad, will be required to clothe the circumference?

(10) Required the quantity of filletting $1\frac{1}{2}$ inch broad, $\frac{1}{2}$ inch thick, to cover a cylinder $12\frac{3}{4}$ diameter, $19\frac{1}{2}$ long.

(11) Required the length of inch rope to lap a drum 20 inches in diameter, 36 inches long.

(12) What difference in the lengths will there be in a rope one inch diameter, and a strap one inch broad and $\frac{3}{8}$ thick, to lap a drum 18 inches in diameter and 24 inches long?

(13) A drum of 24 inches diameter turns a pulley of 12 inches, 42 revolutions per minute, what thickness of laths must be applied to the drum to turn the same pulley 56 revolutions?

(14) The extreme point of the minute hand of a clock moved 5 inches in the space of $3\frac{1}{4}$ minutes. Required the length of the index.

(15) A lever of 5 feet long is fixed at right angles in a

screw whose threads are ½ an inch asunder so that the lever turns just once round in raising or depressing the screw ½ an inch; admitting the lever to be moved with a force equal to 100 *lbs.* with what force will the screw press?

(16) A wheel 8 feet in diameter makes 24 revolutions per minute, how many feet does the circumference travel in one second of time?

(17) Required the difference between a square balk 48 inches in circumference, and a round tree 4 inches in circumference, the length of each being 20 feet.

### PROBLEM VII.

To find the area of a Circle.

RULE. The area is equal to a fourth part of the Product of the circumference into the diameter; or, the Product of half the circumference and half the diameter. Therefore, when the diameter is 1 the area $= \frac{1 \times 3{\cdot}1416}{4} = {\cdot}7854$. whence we have

RULE 2. Multiply the square of the diameter by ·7854 and the Product will be the area.

RULE 3. Multiply the square of the circumference by ·07958 for the area.

(1) Required the area of the end of a cylinder whose diameter is 12.

(2) What is the area of a circular plate whose circumference is 8¼ feet?

(3) What quantity of wood will be required to inclose the end of a carding engine cylinder, the diameter inside the lags being 38 inches?

### PROBLEM VIII.

To find the side of a square inscribed in a circle.

RULE. Multiply the radius by 1·4142, or multiply the diameter by ·7071.

(1) What is the side of a square inscribed in a circle whose diameter is 18 inches?

(2) If the diameter of a circle be 42 inches, what will be the side of an inscribed square?

(3) The radius of a circle is 34 inches. Required the side of an inscribed square.

(4) Required the difference in area between a circle whose diameter is 24, and a square inscribed in the same circle.

(5) What is the difference in area between a square whose equal side is 24, and a circle inscribed in the same square whose diameter is 24.

### PROBLEM IX.

**To find the length of a Circular Arc.**

RULE 1. From 8 times the chord of half the arc subtract the chord of the whole arc, and $\frac{1}{3}$ of the difference will be the length of the arc, nearly.

RULE 2. Multiply the number of degrees in the arc by the radius, and by ·01745 for the length of the arc.

(1) The chord of the whole arc is 48·74, the chord of half the arc 30·25. Required the length of the arc.

(2) Required the length of an arc of 60 degrees, the radius of the circle being 7 feet.

### PROBLEM X.

To find the diameter of a circle from the base and height of a segment of that circle being given.

RULE. The versed sine or height of the segment ..... } half the chord or base.

Same half chord... } a fourth proportional which being added to the segments' height will give the diameter.

### PROBLEM XI.

To find the area of a Sector of a Circle.

RULE 1. Multiply the length of the arc by the radius, and half the Product will be the area.

RULE 2.

| cause. | effect. |
|---|---|
| 360°. | degrees in the arc. |
| Area of circle | area of Sector. |

(3) The chord of the whole arc is 24, and the chord of half the arc is 13, what is the area of the sector?

(4) The arc of a sector is 30°. and the diameter 3 feet, required the area of the sector.

(5) What is the area of a sector whose arc is 18·6° and the radius of the circle 10?

(6) The radius of a circle is $9\frac{1}{2}$ feet, and the arc of the sector 17°. 15′. what is the area of the sector?

### PROBLEM XII.

To find the area of a Circular Segment.

RULE. To half the chord add the versed sine, square the sum and divide it by 2 which reserve. Then ·1073 times the square of the whole length of the chord subtracted from the reserved sum will give the area.

(1) The chord of the whole arc is 24 and the height or versed sine of half the arc is 5. What is the area of the segment?

### PROBLEM XIII.

To find the area of a Circular Ring.

RULE. Multiply the sum of the inner and outer diameters by their difference, and that Product by ·7854 for the area sought.

(1) Required the area of a ring the outer diameter 6, the inner 4.

(2) The diameters of two concentric circles are 16 and 10, what is the area of the ring formed by these circles?

### PROBLEM XIV.

To find the circumference of an Ellipse.

RULE. The square root of half the sum of the squares of the 2 diameters multiplied by 3·1416 will be the circumference, nearly.

(1) The transverse diameter is 24, and the conjugate 20. Required the circumference of the ellipse.

(2) The two axes are 24 and 18, what is the circumference?

### PROBLEM XV.

To find the area of an Ellipse.

RULE. Multiply the transverse diameter by the conjugate and by ·7854.

(1) Required the area of an ellipse whose transverse diameter is 24, and the conjugate 18.

(2) If the axis of an ellipse be 35 and 25, what is the area?

## ON COTTON SPINNING.

### PERMUTATION

Is the changing or varying the order of things.

To find the number of changes that may be made in the position of any given number of things.

RULE. Multiply the numbers 1, 2, 3, 4, &c. continually together up to the given number of terms, and the last Product will be the answer.

(1) For how many days can 7 persons be placed in different positions round a table at dinner?

(2) How many changes may be rung on 12 bells?

Where cotton in preparation or yarn is doubled, the Product of the drafts, divided by the Product of the doublings, will give the length of the yarn.

(3) Suppose one yard in length of cotton is increased in draft at the carding engine 36 times its length; in the first head of drawing 5, in the second 6, in the third 6, in the fourth 6. One end up at the carding engine, 4 ends at the first head of drawing, 6 at the second, 6 at the third, and 4 at the fourth. Required the length of drawing at the fourth head.

(4) Supposing the draft in the carding engine to be 34, in the first head of drawing 4·2, in the second 5, in the third 5·4, in the fourth 6, in the roving frame 7, in the stretcher 8·5, in the mule 11·66; the number of ends up at each head of drawing 6, in the roving frame 2, in the stretcher 2, in the mule 2, what will be the length of yarn delivered from the mule?

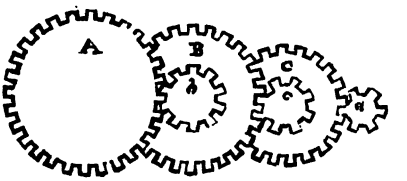
*On Wheels and Pinions.*

RULE. The Product of the teeth of the wheels divided by the Product of the teeth of the pinions, will give the number of revolutions of the last pinion for the first wheel one; and this Quotient, multiplied by the number of revolutions of the first wheel or shaft, in a given time, will give the number of revolutions of the last wheel, pinion, or shaft, in the same time.

Or, if a power be applied to the first wheel, use it instead

of the number of revolutions, and the Quotient will be the power applicable to the last wheel.

(1) Suppose the wheel *A* contains 40, *B* 30, *C* 20 teeth; and the pinion *b* 10, *c* 8, *d* 5 teeth; required the number of revolutions made by the last pinion *c* while the wheel *A* makes one.




(2) Suppose the fly shaft of a steam engine to make 26 revolutions per minute has on a wheel of 60 teeth, driving one 24 teeth, staked on a shaft, on the other end of which is a wheel of 48 teeth, driving the next wheel of 32 teeth, staked on another shaft, having a wheel of 36, which drives a wheel of 24 teeth. Required the revolutions per minute of the last wheel.

(3) Suppose the front roller to have a pinion of 20 teeth, the stud wheel 120, change pinion 22, the back roller wheel 44. Required the number of revolutions of the front roller for the back roller one.

(4) There is a wheel of 48 teeth acts on a pinion of 8, on whose axis is a wheel of 40, driving a pinion of 6, carrying a wheel of 36, which turns a pinion of 6, carrying an index. Required the number of revolutions the index makes for one revolution of the first wheel?

(5) A line shaft in the mill makes 96 revolutions per minute, has on its axis a pulley of 28 inches diameter, turning a pulley of 24 inches diameter, which has on its axis a pulley of 16 inches, that turns a pulley of 12 inches, placed on the axis of the crank, which gives motion to the picker of a loom. Required the number of picks per minute.

(6) A stretching frame, having a rim of 30 inches diameter, makes 44 revolutions per minute, turns a pulley of 18 inches diameter, which has on its axis a pulley of 15 inches diameter, which turns a pulley of 14 inches diameter on the axis of a tin drum of 12 inches diameter, that turns a warve

2 inches diameter placed on the axis of the spindle. The revolutions per minute are required.

(7) A force of 240 *lbs.* is applied to a wheel of 84 teeth, which turns one of 28, the next of 96 turns one of 48. Required the power applicable to the last wheel.

(8) What power must be applied to 4 wheels and pinions, the teeth being respectively 108, 24, 84 and 14, to raise 3969 *lbs.*?

Having the pinions and number of teeth in each pinion given, to find the number of teeth in the wheels to produce a given number of revolutions in the last shaft.

RULE. Find the continual Product of the teeth in each pinion, and the number of revolutions the last shaft is to make for the first one; divide this Product by all the numbers which will divide it without a Remainder; place the Divisors in one line, and divide them at pleasure into as many parcels as there are wheels required; the Product of the numbers in each parcel will give the number of teeth required in each respective wheel.

(9) The last shaft is required to make 720 revolutions for the first one; the pinions connecting contain 24, 16 and 12 teeth respectively. Required the number of teeth in each of three wheels.

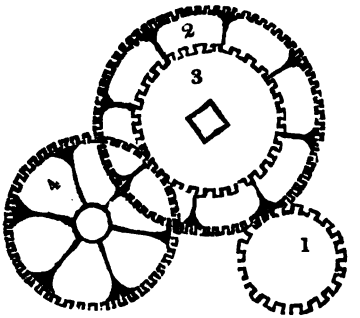
(10) If the last shaft be required to make 84 revolutions for the first one, the pinions containing 36, 24, 16 and 18 teeth, required the number of teeth in each wheel.

(11) What will be the number of teeth in each wheel, the last shaft to make 96 revolutions for the first one, the pinions having 28, 24 and 20 teeth?

*On the Drafts of Rollers, &c.*

RULE. Multiply the number of teeth in the driving wheels and diameter of the back roller for a Divisor; then multiply the number of teeth in the driven wheels and diameter of the front roller for a Dividend; the Quotient will be the draft.

(1) The diameter of the front roller is $1\frac{1}{2}$ inch, the pinion on it 20, the stud wheel 37, on its axis a 22, on the back roller 44, diameter of the back roller one inch. Required the draft.




No. 1, Pinion on the front roller; No. 2, Stud wheel; No. 3, Change pinion; No. 4, Back roller wheel.

(2) The front roller is $1\frac{3}{8}$ inch diameter, the pinion on it 15, stud wheel 30, altering pinion 20, back roller pinion 35, diameter $1\frac{1}{8}$ inch. Required the draft.

(3) The front roller is $1\frac{1}{4}$, pinion 24, stud wheel 74, altering pinion 28, back roller pinion 40, diameter $1\frac{1}{16}$. Required the draft.

(4) What is the draft of one head of drawing, the front roller $1\frac{1}{4}$ inch diameter, the back 1 inch, pinion on the front roller 28 drives a 33, attached is a 32, drives a 60 on the back roller?

(5) The front roller is $1\frac{1}{8}$ inch diameter, pinion on it 26, stud wheel 160, change pinion 48, back roller pinion 50, diameter 1 inch. Required the draft.

(6) The diameter of the front roller is $1\frac{1}{4}$ inch, pinion 24, stud wheel 74, altering pinion 28, back roller pinion 40, diameter $1\frac{1}{16}$. Required the draft.

(7) Admitting the diameter of the front roller of a jack frame to be $1\frac{1}{4}$ inch, has on its axis a pinion of 22 teeth, that turns a wheel of 70, which has on its axis a pinion of 32 teeth, that turns a wheel of 42 teeth placed on the axis of the back roller of 1 inch diameter. Required the draft.

RULE. Find the draft before alteration, and then the draft after; the second draft, multiplied by the hank roving of the first draft, and divided by the first draft, will give the hank roving produced by the alteration.

(8) Suppose a stretching frame to be making a 8 hank roving, the pinion on the front roller being a 24, the stud

wheel 120, the altering pinion 44, the pinion on the back roller 40; change the 24 for a 32, and the 40 for a 56, the front roller diameter $1\frac{1}{8}$, the back $\frac{7}{8}$. Required the hank roving after the alteration.

To find the quantity of cotton delivered from any part of the preparation in a given time.

RULE. The revolutions of the roller or shaft, multiplied by the circumference of the roller delivering the same and the time given, will be the length delivered in inches.

(1) What length of cotton would be delivered per minute from a carding engine, the delivery roller $2\frac{1}{2}$ inches diameter, and making 24 revolutions per minute?

(2) If the delivery roller of a drawing frame, 3 inches in diameter, make 180 revolutions per minute, what length of drawing would be delivered?

(3) If a back roller drawing frame, 1 inch diameter, make 24 revolutions per minute, what length of drawing is taken in?

To find the number of engines necessary to keep up with a given number of heads of drawing.

RULE. The Product of the length taken in by the back rollers, the number of heads of drawing used, and the number of ends put up in each head, divided by the length delivered in the same time by one carding engine, will give the number of engines required.

(1) A drawing frame of 4 heads, the back roller one inch diameter, making 24 revolutions per minute, has three ends up at each head. What number of carding engines will be necessary to keep up with the drawing frame, allowing each engine to deliver 240 inches of cotton per minute?

*On Drafts required in Spinning.*

RULE. Divide the counts required by the single roving; this Quotient, multiplied by the length to be delivered from the rollers, and divided by the whole length of the stretch, will give the draft.

(1) Required the draft to spin 240's from a 25 hank double roving, length of stretch 52 inches, the roller to deliver 36 inches.

(2) Required the draft to spin 170's with a 17 hanks double roving, and deliver 39 inches from the roller, length of stretch 54 inches.

(3) What draft will be required to spin 210's from a double roving of 22 hanks, the roller to deliver 38¼ inches, length of the stretch 54 inches?

(4) Allowing the hanks roving to be 12, the counts 156, the stretch 52, the rollers to deliver 40 inches, the draft is required.

(5) If the hanks roving be 19 single, the counts spinning 250, the rollers to deliver 39 inches, the stretch 54 inches, required the draft.

(6) If 140's be spun with 16 hanks double roving, the stretch being 54 inches, the roller to deliver 40 inches, required the draft.

### *On the Hanks Roving.*

RULE. The Product of the counts of yarn, and the length delivered from the rollers, divided by the Product of the draft and the whole length of the stretch, will give the hanks roving single.

(1) I am spinning 140's with 14 draft and 56 inch stretch, 40 inches delivered from the roller. Required the double roving.

(2) The draft is 13, the counts 130, stretch 56, delivered from the rollers 40. Double roving required.

(3) Required the hanks roving to spin 156's, the draft 10 inches stretch, delivered from the rollers 40 inches, stretch 54.

(4) If 250's be the counts, 9½ the draft, the length of the stretch 54, delivery from the rollers 39 inches, what hanks roving will be required?

To find the number of revolutions the back roller of one set of preparation should make to keep up with the other.

RULE. The Product of the number of ends delivered, the revolutions of the roller delivering the same, and the diameter of the same roller, divided by the Product of the number of ends intended to be put up, and the diameter of the back roller of the next preparation, will give the revolutions of the back roller to keep pace with the former preparation.

(1) Admitting there are 4 heads of a drawing frame, the front rollers 1¼ inch diameter, making 160 revolutions per minute, and the ends delivered are to be removed to a jack frame, the diameter of the back roller 1 inch, 48 ends going up. Required the number of revolutions of the back roller to keep up with the four heads of drawing.

(2) The three last heads of a drawing frame front roller are $1\frac{1}{4}$ inch diameter, and make 156 revolutions per minute; the cotton is removed to a jack frame back roller 1 inch diameter, 30 ends going up. What number of revolutions must the back roller make to keep up with the cotton?

*On the Counts of Yarn.*

RULE. The Product of the hanks roving, the draft, and the length of the stretch, divided by the length delivered from the rollers, will give the counts of the yarn.

(1) The draft is 10, the roving 12 hanks, the stretch 52 inches, the length delivered from the roller 40 inches. Required the counts of the yarn.

(2) The hanks roving 19, the draft $9\frac{1}{2}$, the stretch 54, the length delivered 39. Required the counts

(3) The hanks roving 24, the draft 11·5, the stretch 54, the length delivered 58. Required the counts.

*On the Mendoza Pulley.*

Case 1. RULE. Divide the teeth in the mendoza wheel by the teeth in the pinion on the front roller, from which Quotient subtract the diameter of the mendoza band, the Remainder will be the diameter of the mendoza pulley without gaining.

(1) The pinion on the front roller contains 18, the mendoza wheel 78, the band $\frac{3}{8}$ thick. Required the diameter of the pulley.

Case 2. RULE. The Product of the diameter of the front roller, the number of teeth in the mendoza pulley, and the whole length of the stretch divided by the Product of the stretch, less the gaining, and the number of teeth in the pinion on the axis of the front roller, from which subtract the diameter of the mendoza band; the Remainder will be the diameter of the pulley to effect the gaining required.

(2) Suppose the front roller of a mule to be 1 inch diameter, the pinion 16 teeth, the mendoza wheel 72. Required the diameter of a pulley to gain 4 inches, the whole length of the stretch being 54 inches, the thickness of the band $\frac{1}{4}$ of an inch.

(3) If the front roller be $1\frac{1}{4}$ inch diameter, the pinion 18, the mendoza wheel 80, the gaining 5 inches, the stretch 54, the band $\frac{1}{4}$ of an inch, what will be the diameter of the pulley?

### *On Stretching and Gaining.*

RULE. The Product of the hank roving, the draft, and the length of the stretch, divided by the counts, will give the length delivered from the rollers; and this Quotient subtracted from the whole length of the stretch will give the stretching and gaining.

(1) The length of the stretch 52, the draft 10, the roving 12 hanks. Required the stretching and gaining to spin 156's.

(2) Allowing the hanks roving to be 19, the draft 9½, the stretch 54, the counts 250. Required the stretching and gaining.

(3) The hank roving is 24, the draft 11·5, the length of the stretch 54 inches, the counts spinning 380. Required the stretching and gaining.

### *Wheels necessary for the Draft*

The diameters of the front and back rollers and the draft given to find the number of teeth in each of the wheels, required to produce the draft.

RULE. Reduce the diameters to eighths of an inch. Then the diameter of the back roller multiplied by 8 will give the wheel for the back roller. The diameter of the front roller multiplied by 4 will give the teeth in the change pinion.

One half of the draft multiplied by the supposed pinion on the front roller will give the teeth in the stud wheel.

NOTE. The number of teeth in the stud wheel and back roller wheel divided by 2, will be large enough for drawing frames, throstles and jack frames.

(1) The front roller is one inch diameter, the back roller ⅞, supposed pinion 18. What number of teeth in the wheels shall I want for a 13·3 draft?

(2) The front roller is 1¼ inch, the back roller 1 inch, supposed pinion 24. What number of teeth in the wheels shall I want for 6·5 draft?

### *The Twist necessary per inch of Roving or Yarn.*

RULE 1. The number of revolutions the spindle makes for the front roller one, divided by the circumference of the front roller, will give the number of turns per inch of yarn delivered.

(1) If the spindle makes 15 turns for the front roller one,

its diameter $1\frac{1}{4}$ inch. Required the turns to each inch of roving.

RULE 2. The square root of the counts multiplied by 3·75 for twist, and 3·25 for weft, will give the number of turns per spindle, per inch of yarn.

(2) I am spinning 225's twist, how many turns per inch should the spindle make?

(3) In spinning 225's weft, required the number of turns of the spindle per inch of yarn.

(4) Required the number of turns per inch per spindle to spin 256's twist and weft.

(5) What ought the turns per spindle per inch to be to spin 289's twist and weft?

RULE 3. Square root of the counts given } ⋈ number of turns given.
Square root of the counts required } ⋈ *number of turns required.

(6) Suppose a mule spinning 64's with 30 turns to one inch of yarn, how many turns in the same space will 81's require?

(7) If the counts spinning be 144's with 45 turns, how many turns will 256's require?

(8) If the counts be 196 with 52 turns, required the turns to spin 324.

*Twist and Bevil wheels.*

RULE. 1.
The square root of the counts given } ⋈ the twist wheel given.
The square root of the counts required } ⋈ *the twist wheel required.

RULE 2.
The square root of the counts given } Bevil given ... ⋈ 1 draft.
The square root of the counts required } *Bevil required ⋈ 1 draft.

(1) If 196 hanks yarn have a bevil of 58, and a twist wheel of 54, what size of bevil and twist wheels must 256 have?

*On Double Speed.*

The Product of the small wheels will be the Numerator,

and the Product of the large wheels will be the Denominator, which reduce to the greatest common measure, the result will be the difference of speed.

(1) Admitting a mule to have on the axis of its rim a wheel of 40 teeth, that turns a wheel of 54 teeth, which has on its axis a wheel of 54 teeth, that turns a wheel of 40 teeth, giving motion to the quick speed. Required the difference of speed.

### *The drafts in Carding Engines.*

RULE. The Product of the number of teeth in all the leaders, and the diameter of the delivery roller divided by the Product of all the followers, and the diameter of the feeding roller, will give the draft of the engine.

NOTE. The wheel on the main cylinder is a follower to the feeding roller wheel, and a leader to the doffing cylinder wheel; and the latter wheel is a follower to the main cylinder wheel, and a leader to the delivery roller wheel.

(1) What is the draft of a carding engine, the wheel on the feeding roller 140, pinion 14, wheel 140, main cylinder pinion 20, wheel 96, pinion 24, doffer wheel 96, delivery roller wheel 27, circumference of delivery roller 12·5, diameter of feeding roller $1\frac{1}{8}$ inch?

(2) The feeding roller is $1\frac{1}{4}$ inch diameter, wheel 140, pinion 14, wheel 140, main cylinder pinion 18, wheel 96, pinion 22, doffer wheel 96, delivery roller wheel 24, circumference of roller $11\frac{3}{8}$. Required the draft.

(3) The feeding roller is 1 inch diameter, the wheel 140, pinion 14, wheel 140, axle pinion 22, wheel 120, pinion 26, doffer wheel 120, delivery wheel 30, diameter of the roller $3\frac{1}{2}$ inches. Required the draft.

### *To find the weight of cotton to be put on the lap frame, spread a given length to produce a required No. of hanks yarn.*

RULE. The Product of all the drafts and length to be spread, divided by the Product of all the doublings, will be the length of yarn in inches, produced from the last process, which reduce to hanks, then find by proportion the weight required.

The draft of a spreading machine is 2, carding engine 108, first drawing 6, second 6, third 6, bobbin frame 5·33, jack frame 7·2, mule 9; 4 ends up at the first head of drawing, 6 ends up at the second head, 6 ends up at the third head, 2

ends up at the bobbin frame, 2 ends up at the jack frame, single roving in the mule. What weight of cotton must I put on the lap frame, 52 inches long, to produce 36 hanks yarn without allowance for waste?

*Filleting required for the doffing Cylinder.*

RULE. To the diameter of the cylinder add the thickness of the filleting, which sum take as the diameter; then the circumference of the cylinder multiplied by its length, and divided by the breadth of the filleting, will give the length required.

(1) Required the quantity of filleting to cover a cylinder $12\frac{1}{2}$ inches diameter, 20 inches long, the fillet with the wire $\frac{1}{8}$ inch thick and $1\frac{1}{2}$ broad.

(2) A doffing cylinder $16\frac{1}{2}$ inches diameter, 40 inches long, is to be covered with filleting $\frac{1}{2}$ inch thick and $1\frac{1}{2}$ broad, the length is required.

*Ratio of two Pulleys.*

The Product of the drivers will be the Numerator, and the Product of the driven will be the Denominator, the Quotient will be the ratio of the lesser pulley. The circumference of the doffing cylinder multiplied by the space over which it passes before the doffer strikes, will give the ratio of the greater pulley.

A carding engine has on the axis of the main cylinder a pinion of 16 teeth, that turns a wheel of 136 teeth, on its axis a pinion of 44, that turns a wheel 138 teeth, placed on the axis of the doffing cylinder the diameter of which is $12\frac{1}{2}$ inches. Required the ratio of two pulleys, one on the axis of the main cylinder, the other on the axis of the doffer crank, that may cause the doffer to strike once while the doffing cylinder moves over $\frac{3}{4}$ of an inch.

*To produce the same counts of yarn from an extra doubling in the preparation.*

RULE. Find the draft of the rollers through which the cotton has to pass, commencing at the first head of drawing to the place of the intended increase of doubling, which multiply by the counts then spinning, and divide by the decrease in the counts caused by the additional doubling; divide the Quotient by the increased draft in the fly frame, the latter Quotient will be a power, the root of which must be extracted

according to the number of heads of drawing through which the cotton has to pass; that is, if 2 heads of drawing, extract the square root; if three heads, the cube root; if 4 heads the biquadrate root.

There are 3 heads of drawing, the draft in each head is 7·5, the draft in the fly frame 10·5, the counts spinning 80's. I intend to put 2 ends up at the fly frame with a draft of 12·5. Required the proportionate drafts in the three heads of drawing to produce 80's as before.

*To find the draft of a tube frame which is to supply the place of a can frame and jack frame or stretcher.*

RULE. Find what portion of a hank a given length of the last drawing will produce, (see No. 9. in Proportion) which, multiply by the doubling in the tube frame; this Product multiplied by the counts to be spun will give the amount of draft to be apportioned to the tube frame and mule, to produce which, work by double position, (see Question 9) the result will be the draft for the mule, which multiplied by $2\frac{3}{4}$ will give the draft of the tube frame.

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## ON BLOCKS AND PULLEYS.

### PROBLEM I.

To find the power to raise the weight.

RULE. Divide the weight to be raised by twice the number of moveable pulleys, and the Quotient is the power to raise the weight.

Two blocks having 3 pulleys or shieves each, the one fixed and the other moveable, required the power to raise 216.

### PROBLEM II.

To find the weight to be raised.

RULE. Multiply the power by twice the number of moveable pulleys, and the Product is the weight to be raised.

What weight will a power of 64 *lbs.* lift when applied to a 4 and 5 shieved block and tackle, the 4 shieved block being moveable?

## DUODECIMALS,

### *Or Multiplication of Feet and Inches.*

NOTE. A foot is divided into 12 inches, an inch into 12 parts or primes, a prime into 12 seconds.

RULE. Write the Multiplier under the Multiplicand; feet under feet, inches under inches, &c.

*First.* Multiply the Multiplicand, beginning at the lowest denomination, by the feet in the Multiplier, and place each Product under that denomination of the Multiplicand from which it arises, always carrying at 12.

*Next.* Multiply by inches and set each Product a place farther to the right hand.

*Lastly.* Multiply by the parts and set each Product another place towards the right hand.

NOTE. Feet multiplied by feet give feet.
Feet multiplied by inches give inches.
Feet multiplied by primes give primes.
Inches multiplied by inches give primes.
Inches multiplied by primes give seconds.
Primes multiplied by primes give thirds.

| | *ft.* | *in.* | *p.* | | *ft.* | *in.* |
|---|---|---|---|---|---|---|
| (1) | 48 | 6 | 0 | by | 3 | 4 |
| (2) | 98 | 3 | 0 | by | 5 | 6 |
| (3) | 548 | 5 | 0 | by | 7 | 11 |
| (4) | 141 | 6 | 0 | × | 6 | 10 |
| (5) | 891 | 5 | 0 | × | 9 | 8 |
| (6) | 146 | 3 | 0 | × | 8 | 9 |
| (7) | 678 | 4 | 8 | × | 7 | 11 |
| (8) | 37 | 6 | 9 | × | 11 | 10 |
| (9) | 85 | 11 | 10 | × | 10 | 11 |
| (10) | 67 | 8 | 11 | × | 9 | 11 |
| (11) | 87 | 6 | 8 | × | 11 | 10 |

| | *ft.* | *in.* | *p.* | | *ft.* | *in.* | *p.* |
|---|---|---|---|---|---|---|---|
| (12) | 83 | 4 | 5 | × | 9 | 10 | 0 |
| (13) | 87 | 11 | 11 | × | 11 | 11 | 0 |
| (14) | 78 | 11 | 4 | × | 7 | 8 | 3 |
| (15) | 63 | 4 | 8 | × | 8 | 9 | 6 |
| (16) | 91 | 4 | 9 | × | 9 | 7 | 9 |
| (17) | 33 | 0 | 8 | × | 7 | 6 | 8 |
| (18) | 55 | 8 | 7 | × | 72 | 0 | 8 |
| (19) | 77 | 11 | 8 | × | 37 | 11 | 8 |
| (20) | 88 | 10 | 4 | × | 48 | 10 | 0 |
| (21) | 73 | 5 | 8 | × | 33 | 6 | 4 |
| (22) | 96 | 8 | 9 | × | 55 | 11 | 9 |

(23) What is the price of a marble slab at 6*s.* per foot, measuring 5 feet 7 inches, by 1 foot 10 inches?

(24) There are 8 windows to be glazed, each measuring 3 feet by 1 foot 6 inches, what will the glazing cost at $7\frac{3}{4}d.$ per foot?

(25) A house contains 3 tier of windows, three in a tier, the height of the first is 7 feet 10 inches, the second 6 feet 8 inches, and the third 5 feet 4 inches, the breadth of each is 3 feet 11 inches, what will the glazing cost at 14*d.* per foot?

(26) The circuit of a room is 97 feet 8 inches, and the height 9 feet 10 inches, what will the painting of it cost at 2*s*. 8¾*d*. per yard?

(27) What is the difference between a floor 28 feet long by 20 broad, and two others each 14 feet by 10 feet, and what do they come to at 45*s*. per square of 100 feet?

(28) How many gallons of water will a cistern contain, the inside dimensions being 45 feet 6 inches, 22 feet 8 inches, and 12 feet 9 inches?

(29) A water cistern 4 feet 6 inches long, 3 feet 4 inches broad, and 2 feet 9 inches deep, is to be lined with sheet lead 7½ *lbs*. to the square foot at £1..10..3. per *cwt*. Required the expense.

(30) A partition 7 feet 8 inches by 10 feet 3 inches, deducting a door 6 feet 3 inches by 2 feet 10 inches, is to be plastered, what will it cost at 5*d*. per square yard?

To reduce walls of any thickness to standard.

RULE. Multiply the area by the number of half bricks contained in the breadth of the wall, and divide the Product by 3.

(31) If the area of a wall be 4085 feet, and the thickness 2½ bricks, what is the content in rods?

(32) A wall is 62½ feet long, 14 feet 8 inches high, and 2½ bricks thick. How many rods does it contain?

(33) If the side walls of a house be 28 feet 10 inches in length, the height of the roof from the ground 55 feet 8 inches, and the gable end or triangular part to rise 42 courses of bricks (4 courses = 1 foot) 20 feet high are 2½ bricks thick, 20 more 2 bricks thick, 15 feet 8 inches 1½ brick thick, and the gable 1 brick thick. Required the expense of the whole at £5..16. per rod.

## BOARD MEASURE.

RULE. Multiply the length by the breadth, and the Product will be the answer.

(1) If a plank be 17½ inches broad and 29 feet long, what is the content?

(2) What is the content of a board whose length is 5 feet 7 inches, and breadth 1 foot 10 inches?

(3) What is the value of a plank whose length is 12 feet

6 inches, and breadth 11 inches throughout, at $1\frac{1}{2}d.$ per square foot?

(4) Find the value of 5 oaken planks at 3*d.* per foot, each being $17\frac{1}{2}$ feet long, their breadths as follow; two of $13\frac{1}{2}$ inches in the middle, one of $14\frac{1}{2}$ inches in the middle, and the two remaining ones each 18 inches at the broader end and $11\frac{1}{4}$ at the narrower end?

(5) What is the content of 11 logs of boards as follows:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| No. 1. | 7 feet | 0 inches | by | 10 feet | 4 inches. |
| 2. | 8 ... | 0 ..... | | 9 ... | 8 ..... |
| 3. | 5 ... | 6 ..... | | 12 ... | 3 ..... |
| 4. | 6 ... | 0 ..... ..... | | 9 ... | 6 ..... |
| 5. | 9 ... | 0 . ..... | | 5 ... | 10 ..... |
| 6. | 9 ... | 6 ..... | | 11 ... | 3 ..... |
| 7. | 10 ... | 0 ..... | | 14 ... | 9 ..... |
| 8. | 10 ... | 6 ..... | | 11 ... | 8 ..... |
| 9. | 8 ... | 6 ..... | | 15 ... | 7 ..... |
| 10. | 9 ... | 0 ..... | | 12 ... | 9 ..... |
| 11. | 12 ... | 6 ..... ... | | 8 ... | 8 ..... |

PROBLEM II.

To find the solidity of square or four sided timber.

RULE. The Product of the mean breadth, the mean thickness and the length will give the solidity, according to the customary measure.

(6) The length of a piece of timber is $20\frac{1}{2}$ feet, the breadth at the greater end is $1\frac{3}{4}$ foot, and the thickness $1\frac{1}{4}$ foot; also at the less end the breadth is $1\frac{1}{4}$ foot, and the thickness 1 foot; what is the solidity?

(7) The length of a piece of timber is 24·5 feet, and its ends are equal squares, whose sides are each 1·04 feet, what is the solidity.

(8) What is the solidity of a piece of timber 27·36 feet long, the breadths 1·78 foot and 1·04 foot, thickness 1·23 foot and ·91 foot.

PROBLEM III.

To find the solidity of timber broader at one end than the other.

RULE. To the areas of the two ends add the square root of their Product, which multiplied by $\frac{1}{3}$ of the length will give the solidity.

(9) If a piece of timber be 32 inches broad and 20 inches

deep at the greater end, and 10 inches broad and 6 deep at the less end, and 18 feet long, how many feet of timber does it contain?

(10) Suppose a piece of timber be 24 inches by 18 at the greater end, and 12 by 8 at the less end, and 15 feet long, required the solid content.

(11) The length of a piece of timber is 20·38 feet, and the ends are unequal squares, the sides of the greater being $19\frac{1}{8}$, and that of the less $9\frac{7}{8}$ inches, what is the solidity?

PROBLEM IV.

To find the solidity of round or unsquared timber.

RULE 1. Multiply the square of the quarter girt (or the square of one fourth of the circumference) by the length, and the Product will be the content *according to common practice.*

(12) A piece of timber is $9\frac{3}{4}$ feet long, and the quarter girt is 39 inches, what is the solidity?

(13) The length of a tree is 25 feet, and the girt throughout $2\frac{1}{2}$ feet, what is the solidity?

(14) The length of a tree is $14\frac{1}{2}$ feet, and its girt in the middle 3·15 feet, required the solidity.

(15) An oak tree is 45 feet 7 inches long, and its quarter girt 3 feet 8 inches, what is the solid content, allowing $\frac{1}{12}$ for bark.

(16) The girts of a tree in 4 places are as follow, 5 feet 9 inches, 4 feet 5 inches, 4 feet 9 inches, and 3 feet 9 inches, the length 15 feet, what is the solidity?

RULE 2. Multiply the square of one fifth of the mean girt by twice the length, and the Product will be the solidity nearly, and it will be more accurate than the former.

(17) A piece of timber is $9\frac{3}{4}$ feet long, and $\frac{1}{5}$ of the girt is 2·6 feet, what is the solidity?

(18) If the length of a tree be 24 feet, and the girt throughout 8 feet, what is the content?

(19) If a tree girt 14 feet at the thicker end, and 2 feet at the smaller end, the length 24 feet, required the solidity.

(20) A tree girts in 5 different places as follow, 9·43 feet, 7·92 feet, 6·15 feet, 4·74 feet, and 3·16 feet, and the whole length $17\frac{1}{4}$ feet, what is the solidity?

## ON THE STRENGTH OF BEAMS TO BEAR WEIGHT.

*Table of Multiplicands for the Transverse strength of timber.*

| | | | |
|---|---|---|---|
| English Oak ..... | 1426 | Red Pine ..... | 1341 |
| Canadian ditto..... | 1766 | Fir ..... | 1100 |
| Ash ..... | 2026 | Larch ..... | 1127 |
| Beech ..... | 1556 | Teak..... | 2462 |
| Elm ..... | 1013 | Larch ..... | 653 |
| Pitch Pine ..... | 1632 | | |

### PROBLEM I.

**To find the strength of a beam fixed at one end and loaded at the other.**

RULE. The product of the tabular number, the breadth, and the square of the depth in inches, divided by the length in inches, will give the weight in *lbs.*

(1) What weight will be required to break a beam of English oak, the breadth being 3 inches, the depth 6, and the length 20 feet?

(2) Required the weight to break a beam of fir 8 inches square, 4 feet from the wall.

(3) What weight will break a beam of pitch pine, the breadth 4 inches, the depth 5 inches, and the length 16 feet?

### PROBLEM II.

To find the strength of beams when supported at both ends and loaded in the middle.

RULE. The Product of the tabular number, the square of the depth, and four times the breadth in inches, divided by the length in inches, will give the weight in *lbs.*

(4) What weight will break a beam of ash 6 inches broad, 9 inches deep, and 30 feet between the supports?

(5) A beam of elm 8 inches deep, 5 inches broad, and 10 feet long, supports a weight of 4 tons, what additional weight will break the beam?

(6) What weight will break a beam of oak, 8 inches deep, 6 inches broad, and 24 feet between the supports?

### PROBLEM III.

To find what weight each support of a beam bears when the pressure is not in the middle.

RULE. The Product of the weight and the shorter distance from the support, divided by the whole length of the beam, will give the weight borne by the farther support. The product of the weight and the longer end, divided by the length, will give the weight borne by the nearer support.

(7) A beam 24 feet long, supported at both ends, bears a weight of 5 tons, 10 feet from one end, required the weight on each support.

(8) A beam supported at both ends, 16 feet long, carries a weight of 6 tons, 3 feet from one end, and another weight of 4 tons, 2 feet from the other end, required the weight on each support.

(9) A beam supported at both ends, 20 feet long, bears a weight of 5 tons, 4 feet from one end, and 6 tons, 3 feet from the other, required the weight on each support.

## CAST IRON BEAMS.

### PROBLEM I.

To find the breadth of a cast iron beam to bear a given weight in the middle.

RULE. The Product of the given weight in *lbs.* and the length of the beam in feet between the supports, divided by 850 times the square of the depth in inches, will give the breadth.

(1) Required the breadth of a beam 16 feet long, 14 inches deep, to be loaded with 12 tons.

(2) What breadth should a beam be to support 18 tons, the length 24 feet, the depth 16 inches.

(3) A beam 14 feet long, 9 inches deep, should bear a weight of 12 tons, required the breadth.

(4) If a beam should bear 27 tons, and the length 30 feet, the depth 24 inches, what should the breadth be?

### PROBLEM II.

To find the depth of a cast iron beam to bear a given weight in the middle.

RULE. The square root of the Product of the length of bearing and given weight in *lbs.* divided by 850 times the breadth in inches will give the depth required.

(5) Required the depth of a beam 20 feet long and 3 inches broad, to support a weight of 13 tons.

(6) Required the depth of a beam to bear 12 tons, 16 feet long, and 5 inches broad.

(7) What depth should a beam be to bear 18 tons, the length 24 feet, and the breadth 4·5 inches?

(8) If a beam bear 27 tons, the length 30 feet, the breadth 5·5 inches, what should the depth be.

PROBLEM III.

To find the breadth when the weight is not in the middle between the supports.

RULE. Four times the Product of the short length and long length divided by the whole length between the supports, will give the effective leverage in feet. This Quotient multiplied by the weight and assumed depth, and divided by 850, will give a cube, the root of which will be the depth required, and which root divided by the assumed number will give the breadth.

(9) What are the sectional dimensions of a beam 12 feet long, supporting a weight of 15 tons 3 feet from one end, when the breadth is $\frac{1}{4}$ of the depth?

(10) Required the sectional dimensions of a beam 20 feet, supporting 13 tons 4 feet from the end, when the breadth is $\frac{1}{3}$ of the depth.

(11) A beam 24 feet long bears 18 tons 6 feet from one end, the breadth being $\frac{1}{3}$ of the depth, what are the sectional dimensions?

PROBLEM IV.

To find the breadth when the load is uniformly distributed.

RULE. Worked as in Problem I. only change the Divisor from 850 to 1700.

(12) Required the breadth of a beam 16 feet long, 12 inches deep, to bear 10 tons.

(13) What breadth should a beam be to bear 20 tons, the length 18 feet, depth 12 inches?

(14) A beam 28 feet long, 16 inches deep should bear 22 tons, what ought the breadth to be?

PROBLEM V.

When no particular breadth or depth is given, assume a number at will for the proposed depth.

RULE. The product of the assumed number, the length in feet, and the weight in *lbs.* divided by 850 will give a cube, the root of which will be the depth; this divided by the assumed number will give the breadth.

(15) What are the cross sectional dimensions of a beam 20 feet long, to support a weight of 12 tons, the depth being twice the breadth?

(16) Required the cross sectional dimensions of a beam 16 feet long to bear 14 tons, the depth being 3 times the breadth.

(17) A beam 28 feet long is to bear 22 tons, the depth being 4 times the breadth, what are the cross sectional dimensions?

### PROBLEM VI.

When the beam is fixed at one end and loaded at the other.

RULE. Take the horizontal length in feet of the projected beam when fixed at one end for the length, and work by Rule in Problem I. using 212 instead of 850 for the Divisor. When the load is uniform use 425 for a Divisor.

NOTE. The rules of this problem apply to the teeth of wheels, the length being the length of the teeth, and the depth the thickness of the teeth.

(18) If the power acting at the pitch line of the wheel be 7500 *lbs.* the thickness of the teeth $1\frac{3}{4}$, the length 3 inches. Query the breadth.

$$\frac{7500 \times \cdot 25}{212 \times 1\cdot 75^2} = 2\cdot 88 \text{ inches to allow for wearing double the quotient.}$$

(19) If the thickness of the teeth be $1\frac{1}{2}$ inch, the length $2\frac{1}{2}$, the power acting at the pitch line 5000 *lbs.* what should the breadth be?

### PROBLEM VII.

To find the dimensions of the teeth of wheels.

RULE. Divide the stress at the pitch line in pounds by 1500, and the square root of the Quotient is the thickness of the teeth in inches.

The stress upon teeth should not exceed 400 *lbs.* for each inch in breadth. The length ought not to exceed the thickness.

(20) The power acting at the pitch line of a wheel is 6000 pounds, required the thickness and breadth of the teeth.

(21) What is the thickness and breadth of the teeth of a wheel required to exert a power of 8000 *lbs.* at the pitch circle?

(22) Required the breadth and thickness of the teeth of a wheel, power at the pitch line being 4500.

### PROBLEM VIII.

To find the diameter of a solid cylinder when the weight is in the middle.

RULE. The Product of the weight in *lbs.* and the length in feet divided by 500, and the cube root of the Quotient will be the diameter in inches.

(23) The weight of a water wheel is 15 tons, the length of the shaft 13 feet, required the diameter of the journal.

(24) What is the diameter of the journal of a shaft 18 feet long, to bear a water wheel of 16 tons?

### PROBLEM IX.

When the weight is between the middle and the end.

RULE. The Product of the short end, the long end, and 4 times the weight in *lbs.* divided by 500 times the length in feet, will give a cube, the root of which is the diameter in inches.

(25) Required the diameter of the journal of a shaft 12 feet long, to bear a wheel of 7 tons, 3 feet from one end.

(26) A shaft 9 feet long is to carry a wheel of 6 tons, 4 feet from one end, required the diameter of the journal.

### PROBLEM X.

When the weight is uniformly distributed.

RULE. Multiply the length in feet by the weight in pounds, and one tenth of the cube root of the Product, will be the diameter in inches.

(27) A weight of 15 tons is to be equally distributed over a shaft 13 feet long, required the diameter of the journal.

(28) What is the diameter of the journal of a shaft 18 feet long, to bear 16 tons uniformly distributed?

### PROBLEM XI.

When fixed at one end and loaded at the other.

RULE. One fifth part of the cube root of the Product of the length project in feet and weight in pounds, will be the diameter in inches.

## JOURNALS OF SHAFTS.

RULE. Multiply the length and weight together; extract the cube root, to which add one-third of itself, this will give the journal of the shaft.

What is the diameter of the journal of a water-wheel shaft, 12 feet long, the weight of the wheel 14 tons?

To resist twisting use the following multipliers:

| | |
|---|---|
| For shafts connected with the first motion or power | 400. |
| Inside shafts, or second power | 200. |
| Small shafts | 100. |

RULE. The tabular number, multiplied by the horse power, and divided by the revolutions per minute, will give the cube of the diameter.

(1) Required the diameter of the journal of a shaft for the fly wheel of a 45 horse power engine, making 90 revolutions per minute.

(2) A shaft connected with the second power makes 120 revolutions per minute, the steam power 50 horses. Required the diameter of the journal.

(3) A third power shaft makes 180 revolutions, the steam power 36 horses. Required the diameter of the journal.

The power applicable to a shaft.

RULE. The cube of the diameter of the journal, multiplied by the number of revolutions, and divided by the tabular number, will give the horse power.

(4) The diameter of a first shaft is 6 inches, the revolutions 90. Required the power applicable.

(5) The diameter of a second shaft is 3 inches, the revolutions 80. Required the power.

(6) The diameter of a third power shaft is 2 inches, the revolutions 120. Required the horses' power applicable.

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## STRENGTH OF WHEELS.

To find the breadth and thickness of arms, according to their length and number in the wheel.

The Product of the weight or power acting at the end of

the arm and the cube of the length, divided by 2656 times the number of arms and the deflection will give a Quotient, which divided by the assumed breadth will give the cube of the proportionate depth.

(1) The force acting upon a spur wheel is 1600 *lbs.* the arm or radius of the wheel 6 feet long, the number of arms 8, deflection $\frac{1}{10}$ of an inch, assumed breadth $2\frac{1}{2}$ inches. Required the depth.

(2) The force upon a spur wheel is 2000 *lbs.* the arms 8 feet long, their number 8, deflection $\frac{1}{10}$ of an inch, assumed breadth 3 inches. Required the depth.

To find the power applicable to a wheel.

RULE. The Product of the breadth of the teeth and square of the thickness, divided by the length, will give the proportional strength in horses' power, at the rate of 2·27 feet per second.

| Cause. | | Effect. |
|---|---|---|
| Then, if 2·27 | | horses' power. |
| Given velocity | | power applicable. |

(1) The teeth of a wheel are 6 inches broad, $1\frac{1}{2}$ inch thick, and 1·8 inch long, velocity of 3 feet per second. Required the power.

(2) The velocity of a wheel is 4 feet per second, the teeth 1·25 thick, $1\frac{1}{2}$ inch long, 4 inches broad. What power is applicable?

## ON THE PITCH OF TEETH IN WHEELS.

The pitch given to find the number of teeth.

RULE. The circumference of the wheel, divided by the pitch of the teeth, will give the number of teeth in the wheel.

(1) How many teeth in a wheel of 40 inches diameter at the pitch line, the pitch of the tooth 2 inches?

The number of teeth and the pitch given, to find the diameter

RULE. The Product of the number of teeth and the pitch, divided by the circumference of unity, or 3·1416, will give the diameter.

(2) A wheel is to have 21 teeth, with a pitch of 2 inches. Required the diameter.

The diameter and number of teeth given, to find the pitch.

The circumference, divided by the number of teeth, will give the pitch.

(3) A wheel 70 inches diameter has 146 teeth. What is the pitch of the tooth?

To find the pitch and length of teeth.

The thickness, multiplied by 2·1 will give the pitch.

The same thickness, multiplied by 1·2 will give the length.

(4) The thickness of a tooth is $1\frac{1}{2}$ inch. Required the pitch and length.

(5) A tooth is $1\frac{3}{4}$ inch thick. Required the pitch and length.

(6) If the thickness of a tooth be $1\frac{1}{4}$ inch, what will the pitch and length be?

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## GRAVITATION, OR THE FALLING OF BODIES.

### PROBLEM I.

To find the velocity a falling body will acquire in any given time.

RULE. Multiply the time in seconds by $32\frac{1}{6}$, the Product is the velocity acquired in feet per second.

(1) Required the velocity in 8 seconds.

(2) Required the velocity in 32 seconds.

### PROBLEM II.

To find the velocity a body will acquire by falling from any given height.

RULE. The square root of the Product of the space in feet and $64\frac{1}{3}$ will be the velocity acquired per second. In ascertaining the velocity of water, subtract $\frac{1}{10}$ of the root for the true velocity.

(3) A ball has passed through 256 feet. Required the velocity.

(4) If the height of a weir be 16 feet, what will be the velocity of the water?

(5) If the fall of water is 30 feet, with what velocity will the water act upon the wheel?

PROBLEM III.

To find the space through which a body will fall in a given time.

RULE. The square of the time in seconds multiplied by $16\frac{1}{12}$ will give the space in feet.

(6) Through what space has a ball passed in 8 seconds?

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## HYDROSTATICS.

PROBLEM I.

To find what pressure of water the bottom of a cistern supports.

RULE. The Product of the length, breadth and depth in feet, and the number of pounds in one cubic foot of water, will give the pressure in pounds.

(1) A cistern 6 feet long, 4 feet broad and 7 feet deep, is filled with water. Required the pressure.

(2) What will be the pressure on the bottom of a cistern 9 feet long, 8 feet broad and 11 feet deep?

PROBLEM II.

To find the pressure at the side of a cistern.

RULE. The area of the side, multiplied by half of the depth and the pounds in a cubic foot of water, will give the pressure in pounds.

(3) The gate of a sluice is 14 feet deep, 12 feet broad. Required the pressure against it.

(4) Required the pressure against the gate of a sluice 16 feet deep, 4 feet broad.

PROBLEM III.

To find the area of a stream.

RULE. Multiply the depth by the breadth.

(5) If the depth of a stream be 6 feet, and the breadth 18 feet, required the area.

PROBLEM IV.

Case 1. To find the pressure on a flood-gate, &c.

RULE. The Product of the breadth and square of the

depth, both in feet, multiplied by 31·25, will give the pressure in *lbs.*

(6) Required the pressure upon a flood-gate 25 feet broad, the depth below the surface of the water 12 feet.

(7) A flood-gate is 18 feet broad, 16 feet below the surface of the water. Required the pressure.

(8) What is the pressure on a flood-gate 28 feet broad, 18 feet below the surface of the water.

Case 2. If the gate be wider at the top than the bottom.

RULE. One-third of the difference of the top and bottom breadths, added to the bottom breadth, multiplied by the square of the depth and 31·25 will give the pressure in *lbs.*

(9) A flood-gate is 28 feet at the top and 22 at the bottom, the depth of water 12 feet. Required the pressure.

(10) The top breadth of a flood-gate is 30 feet, the bottom 24, the depth of water 16 feet. Required the pressure.

(11) What is the pressure against a flood-gate, the top breadth 20 feet, the bottom breadth 14 feet, the depth of water 15 feet?

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## HYDRAULICS.

### PROBLEM I.

To find the number of cubic feet of water flowing per second from a sluice, without any pipe or goit connected with it.

RULE. The square root of the depth in feet, multiplied by 5·4 gives the velocity; this Product, multiplied by the area of the orifice in feet, will give the number of cubic feet flowing per second.

(1) Required the quantity of water expended in one second from a sluice 16 feet below the surface of the water, its length 6 feet, open 8 inches.

(2) If a sluice be 10 feet below the surface of the water, its length 4 feet, open 7 inches, what will be the quantity of water expended in one second?

NOTE. Where the area of the opening is great, compared with the head, work by Problem III.

PROBLEM II.

**To find the velocity of a stream of water.**

RULE. The square root of the velocity per second at the middle of the stream, on the surface, diminished by unity or 1, will give the square root of the velocity of the stream at the bottom. The two velocities added together, and divided by 2, will give the mean velocity.

(3) If the velocity of the water at the surface, in the middle of a river, be 25 inches per second, required the velocity at the bottom and the mean velocity.

(4) If the velocity of a stream be 36 inches per second on the surface in the middle, what will be the velocity at the bottom and the mean velocity?

PROBLEM III.

**To find the quantity of water discharged through slits or notches cut in the side of a vessel, or reservoir open at the top, or over weirs.**

RULE. Two-thirds of the Product of the square root of the depth and 5·4, multiplied by the area of the stream running through the slit or notch, or over the weir, will give the quantity of cubic feet flowing per second.

(5) If the breadth of the notch be 6 inches, the depth of water 5 inches, required the quantity run out in 46 seconds.

(6) A weir is 20 yards broad, the water flowing over 9 inches deep. Required the quantity run over in one minute.

PROBLEM IV.

**To find the quantity running through pipes, goits or canals.**

RULE. Divide the Product of 57, and the height of the head of water in inches above the orifice by the length of the pipe, added to 57; extract the square root of the Quotient, which root, multiplied by $23\frac{1}{3}$ and the area of the orifice delivering the water in inches, will give the cubical inches discharged in one second.

(7) A pipe $2\frac{1}{2}$ inches diameter, one foot long, is placed 54 inches below the surface of water in a reservoir. Required the number of cubical inches of water flowing per second.

(8) A paddle is placed 5 feet below the surface of water in a reservoir, the length 9 inches, open 6 inches; the water runs through a goit 6 yards long. Required the quantity of water flowing per second.

## WATER-WHEELS.

Undershot.—The quantity of water flowing per minute, reduced to *lbs.* and multiplied by the velocity, will give the power to produce the mechanical effect.

| | Power. | | Effect. |
|---|---|---|---|
| RULE 1. | 3 | | 1. |
| Power to produce | | | *mechanical effect upon the wheel. |

| | | | |
|---|---|---|---|
| RULE 2. Velocity in 5 theory | | | 2 velocity in effect. |
| Velocity of the water to be ascertained | | | *effective velocity of the wheel. |

Overshot.—The descent of water, including the distance from the sluice to where the water falls upon the wheel and the diameter of the wheel, multiplied by the weight of water expended in one second, will give the power to produce.

| | | | |
|---|---|---|---|
| RULE. Power in theory 3 | | | 2 power in effect. |
| Power to produce | | | *power of the wheel. |

### PROBLEM I.

To find what power a stream of water is equal to.

RULE. Find the number of cubic feet flowing per minute, which reduce to *lbs.* avoirdupois and multiply by the fall; this Product, divided by 44000 for the *lbs.* weight for one horse power, will give the theoretical horses power, which reduce to effective power by last Problem.

(1) A stream of water is 12 inches deep, 22 inches broad, velocity 70 feet in $11\frac{3}{4}$ seconds, fall 60 feet What is the power of the stream?

(2) Required the power of a stream of water 9 inches deep, 36 inches broad, velocity 6 feet per second, fall 24 feet.

(3) What is the power of a stream of water 6 inches deep, 42 inches broad, velocity 84 feet in 14 seconds, fall 18 feet?

### PROBLEM II.

To find the dimensions of a wheel applicable to a given stream.

RULE. Let the diameter of the wheel be two feet less than the given fall. The number of cubic feet of water flowing per minute, divided by the velocity of the wheel, will give

the sectional area of the buckets; which Quotient double for the whole area, as the buckets ought to be only half full.

The effective area, divided by the breadth of the wheel, will give the depth of shrouding.

The velocity of the wheel per minute, divided by the circumference, will give the number of revolutions of the wheel per minute.

(4) If a stream be 12 inches deep, 22 broad, the fall 60 feet, and the velocity 70 feet in $11\frac{3}{4}$ seconds, what dimensions of a wheel 4 feet broad to move 6 feet in one second are applicable?

### PROBLEM III.

To find what power a wheel of given dimensions is equal to.

RULE. The area of the buckets, multiplied by the velocity of the wheel per minute, will give the number of cubic feet of water when the buckets are full, of which take one-half; and this Quotient, multiplied by 16, the space in one second, and the number of *lbs.* in one cubic foot of water, will give the theoretical power, which reduce to effective power, and divide by 44000 for the number of horse power the wheel will be equal to.

(5) What is the power of a water-wheel 16 feet diameter, 12 feet wide, shrouding 15 inches deep, velocity 4 feet per minute?

(6) Required the power of a water-wheel of 20 feet diameter, 8 feet wide, shrouding 16 inches deep, velocity 5 feet per second.

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## SPECIFIC GRAVITY.

THE specific gravity of a body is its relative weight as compared with some other body of the same magnitude, considered as a standard.

*A Table of the Specific Gravity of Bodies.*

| | | | |
|---|---|---|---|
| Fine gold | 19640 | Brick | 2000 |
| Standard gold | 18888 | Light earth | 1984 |
| Quicksilver | 14000 | Solid gunpowder | 1745 |
| Lead | 11325 | Gunpowder shaken | 922 |
| Fine silver | 11091 | Sand | 1520 |
| Standard silver | 10535 | Pitch | 1150 |
| Copper | 9000 | Dry box-wood | 1030 |
| Gun metal | 8784 | Sea water | 1030 |
| Cast brass | 8000 | Common water | 1000 |
| Steel | 7850 | Dry oak | 925 |
| Iron | 7645 | Dry ash | 800 |
| Cast iron | 7425 | Dry maple | 755 |
| Tin | 7320 | Dry elm | 600 |
| Marble | 2700 | Dry fir | 550 |
| Common stone | 2520 | Cork | 240 |
| Loam | 2160 | Air | 1¼ |

PROBLEM I.

To find the magnitude of a body from its weight being given.

| Cause. | | Effect. |
|---|---|---|
| RULE. Tabular specific gravity | | weight in avoirdupois ounces. |
| One cubic foot | | its content. |

(1) Required the content of a piece of common stone, weighing 1 *cwt.* or 112 *lbs.*

(2) How many cubic inches of gunpowder are there in one pound weight?

(3) How many cubic feet in a ton weight of dry oak?

PROBLEM II.

To find the weight of a body from its magnitude being given.

| | | |
|---|---|---|
| RULE. As one cubic foot | | content of the body. |
| Tabular specific gravity | | weight of body. |

(4) Required the weight of a block of marble, whose length is 63 feet, and its breadth and thickness each 12 feet.

(5) What is the weight of a pint of gunpowder?

(6) Required the weight of a cast iron beam, 12 feet long, 8 inches deep and 4 broad.

(7) What is the weight of a block of dry oak, which measures 10 feet long, 3 broad and $2\frac{1}{2}$ deep?

PROBLEM III.

To find the specific gravity of a body.

Case 1. When the body is heavier than water.

RULE. Weigh it both in and out of water, and take the difference, which will be the weight lost in water; then say,

As the weight lost in water is to whole weight.
So specific gravity of water is to specific gravity of body.

(8) A piece of stone weighed in air 10 *lbs.* but in water only $6\frac{3}{4}$. Required its specific gravity.

Case 2. When the body is lighter than water.

RULE. Annex it to another body heavier than water, so that the two may sink together. Weigh each body separately, both in and out of water; find how much each loses in water, by subtracting its weight in water from its weight in air, and take the difference of the Remainders.

Then, as difference is to weight of light body in air.
So specific gravity of water is to specific gravity of body.

(9) A piece of elm weighing 15 *lbs.* in air, and a piece of copper weighing 18 *lbs.* in air; the copper in water weighs 16 *lbs.*; both together, in water, only 6 *lbs.* What is the specific gravity of elm?

PROBLEM IV.

To find the quantities of two ingredients in a given compound.

RULE. Take the difference of the specific gravities of the compound and each ingredient, and multiply the difference of every two by the third.

Then, as greater Product is to whole weight of compound.
So Each Product is to each ingredient.

(10) A composition of 112 *lbs.* being made of tin and copper, whose specific gravity is found to be 8784; required the quantity of each ingredient, the specific gravity of tin being 7320, and of copper 9000.

## CENTRE OF GRAVITY.

THE centre of gravity of a body is that point which, if sustained, the body remains at rest; the particles of which it is composed being equipoised.

### PROBLEM I.

For bars, levers, &c.

RULE. Find the centre between two bodies, then the centre between that centre and a third body, and so on; the last centre found being the common centre of all the bodies.

(1) A bar of wood 24 feet long has a weight suspended at each end, one 16 *lbs.* the other 4 *lbs.* Required the centre of gravity.

(2) Given the length of an inflexible lever; suppose void of weight, 36 inches long; from one end a weight of 40 *lbs.* is hung; and at the distance of 6, 12, 20 and 30 inches from the same end there is hung 16, 9, 10 and 8 *lbs.*; and at the other end is hung a weight of 20 *lbs.* Required from what part of the lever a fulcrum must be placed, so that it may be equally balanced.

(3) If a beam be 10 feet long, each foot weighing 8 *lbs.* and a weight of 90 *lbs.* be suspended from one end, at what point of the beam will the centre of gravity be?

(4) If a beam be 12 feet long, with a weight of 100 *lbs.* fixed at one end, and the beam be in equilibrio, being suspended 2 feet from the end next the weight, required the weight of the beam.

### PROBLEM II.

For a triangle.

RULE Two-thirds of the length of a line, drawn from any angle to the middle of the opposite side, will be the centre of gravity.

(5) A line drawn from the centre of the base of a triangle is 18. Required the centre of gravity from the vertical angle.

(6) A line drawn from the centre of the hypotenuse of an acute angle to the opposite angle is 24. Required the centre of gravity from the acute angle.

### PROBLEM III.

For a cone or pyramid.

RULE. Take three-fourths of the distance of the axis from the vertex.

(7) The height of a cone is 48. Required the centre of gravity.

(8) A cone is 36 inches high. In what part is the centre of gravity?

(9) The height of a pyramid is 40. In what part is the centre of gravity?

PROBLEM IV.

For the arc of a circle.

RULE. The Product of the radius of the circle and the chord of the arc, divided by the length of the arc, will give the distance of the centre of gravity from the centre of the circle.

(10) The radius of the circle is 200, the chord of the arc 153·07, and the length of the arc 157·07. Required the distance of the centre of gravity from the centre of the circle.

(11) The radius of a circle is 48, the chord of the arc 37·5, and the length of the arc 38·75. Where is the centre of gravity from the centre of the circle?

PROBLEM V.

For the sector of a circle.

RULE. Two-thirds of the Product of the chord of the arc and the radius of the circle divided by the length of the arc.

(12) The radius of a circle is 20, the chord of the arc 15·3, the length of the arc 15·7. Required the distance of the centre of gravity from the centre of the circle.

(13) The radius of a circle is 64, the chord of the arc 49, the length of the arc 51·3. Required the distance of the centre of gravity.

PROBLEM VI.

For a parabolic space.

RULE. Take three-fifths of the axis from the vertex.

(14) If a parabolic space be 20 inches long, required the centre of gravity.

(15) If a parabolic space be 35 inches, what is the centre of gravity?

PROBLEM VII.

For a paraboloid.

RULE. Take two-thirds of the axis from the vertex.

(16) If the axis of a paraboloid be 24, required the centre of gravity.

(17) What will be the centre of gravity of a paraboloid, if the axis be 36?

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## CENTRE OF PERCUSSION.

THE centres of percussion and oscillation are in the same point, therefore their properties are the same.

### PROBLEM I.

RULE. To the weight of the body add three times the weight of the ball; then divide this sum by the weight of the body added to twice the weight of the ball; the Quotient, multiplied by two-thirds of the length of the rod, will give the centre of percussion from the point of suspension.

NOTE. The length of the rod is taken from the extreme end to the centre of the ball.

(1) A rod 16 feet long, each foot in length weighing 80 *oz.* to which is suspended a ball weighing 600 *oz.* Required the centre of percussion from the point of suspension.

### PROBLEM II.

In a right line, or very thin cylinder.

RULE. Take two-thirds of the length from the point of suspension.

(2) Required the length of a rod, of uniform density, without a weight, to vibrate seconds when suspended at one end.

(3) A rod is 48 inches long. Required the centre of percussion from the axis of motion.

### PROBLEM III.

In an isosceles triangle and wheels generally.

RULE. Take three-fourths of the height from the angle of suspension.

(4) Required the centre of percussion in an isosceles triangle, oscillating flat-wise, 16 feet from the base to the angle of suspension.

## CENTRE OF GYRATION.

### PROBLEM I.

RULE 1. Multiply each particle by the square of its velocity, or the square of its distance from the centre of motion, and divide the sum of the Products by three times the sum of the whole weight; the square root of the Quotient will be the distance of the centre of gyration from the centre of motion.

(1) A bar, of uniform density, 12 feet long, and each foot weighing 7 *lbs.* and revolving upon a centre 3 feet from one end, at what distance will the centre of gyration be from the centre of motion?

(2) Suppose the same bar to have a weight of 50 *lbs* at each end; then at what distance will the centre of gyration be from that of motion?

RULE 2. The centre of oscillation and the centre of gravity from the point of suspension being given, the centre of gyration will be a mean proportional between those numbers.

(3) If the centre of oscillation be 9, and the centre of gravity 4 from the point of suspension, where will the centre of gyration be?

### PROBLEM II.

For a straight line or cylinder, the axis of motion being in one end.

RULE. The length in inches, multiplied by ·5775, will give the distance of the centre of gyration from that of motion.

(4) A rod 54 inches long is moved from one end. Required the centre of gyration from that of motion.

(5) What is the centre of gyration from that of motion in a rod 45·375 inches long?

### PROBLEM III.

For a cylinder, or plane of a circle revolving about the axis.

RULE. The radius, multiplied by ·7071.

(6) The diameter of a wheel, of uniform thickness, is 28 inches. What is the centre of gyration from the axis?

(7) Required the centre of gyration in a wheel of 84 inches diameter.

PROBLEM IV.

For the plane of a circle about its diameter.

RULE. Take one-half of the radius.

PROBLEM V.

For the surface of a sphere about its diameter.

RULE. Multiply the radius by ·8165.

PROBLEM VI.

For a solid sphere about its diameter.

RULE. Multiply the radius by ·6324.

(8) Required the distance of gyration in a globe revolving about its diameter, which is 4 feet.

PROBLEM VII.

For the circumference of a circle, upon a perpendicular axis passing through its centre, equal the radius.

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## ROTATORY MOTION.

PROBLEM I.

To find the distance of the centre of gyration from the axis of motion.

RULE. The Product of the distance of the force applied from the axis, the force applied, the time it is applied and 32,* divided by the Product of the weight of the wheel and velocity per second, will give the centre of gyration.

(1) A force equal to 2 *cwt.* is applied to a fly wheel for 10 seconds, 7 feet from the centre of motion; the wheel moves at the rate of 8 feet per second, the weight of the wheel 50 *cwt.* Required the distance of the centre of gyration from that of motion.

PROBLEM II.

To find the force acting upon a wheel.

RULE. The Product of the weight of the wheel, the dis-

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* See Gravitation; the fraction is left out.

tance of the centre of gyration from the axis of motion, and the velocity per second, divided by the Product of the time the force acts, the distance the force is applied from the axis of motion and 32, will give the force acting upon the wheel.

(2) A wheel 14 feet diameter, weighing 2 tons, moves at the rate of 10 feet per second; the centre of gyration is 6 feet from that of rotation. What force must be applied, 3 feet from the centre, for 8 seconds to produce that velocity?

PROBLEM III.

To find the distance the force acts from the axis of motion.

RULE. The Product of the weight of the wheel, the distance of the centre of gyration from that of motion, and the velocity per second, divided by the Product of the force acting upon the wheel, the time the force acts and 32, will give the distance the force must be applied from the axis of motion.

(3) The weight of a fly wheel is 40 *cwt.* the centre of gyration 6 feet, the velocity 10 feet per second; a force of 3 *cwt.* is applied for 8 seconds. What distance from the centre of the axis must the force be applied to effect that velocity?

PROBLEM IV.

To find the weight of a fly wheel.

RULE. The Product of the force acting upon the wheel, the distance the force is applied, the time of applying the same and 32, divided by the Product of the distance of the centre of gyration and the velocity per second, will give the weight of the wheel.

(4) A wheel 14 feet diameter is urged by a force of 224 *lbs.* at its rim, acting for 8 seconds, moving at the rate of 10 feet per second; the centre of gyration being 5 feet 6 inches from the centre of motion. Required the weight of the wheel.

PROBLEM V.

To find the time the force acts.

RULE. The Product of the weight of the wheel, the distance of the centre of gyration, and the velocity per second, divided by the Product of the force acting upon the wheel, the distance of the force from the axis of motion and 32, will give the time the force acts upon the wheel.

(5) The weight of a wheel is 2 tons, the centre of gyration

6 feet from that of motion, the velocity of the wheel 10 feet per second. Required the time a force of $3\frac{1}{4}$ *cwt.* must be applied, 6 feet from the centre, to effect that velocity.

PROBLEM VI.

To find the velocity of a wheel.

RULE. The Product of the force applied, the distance of the force from the axis of motion, the time the force acts and 32, divided by the Product of the weight of the wheel and the distance of the centre of gyration, will give the velocity per second.

(6) A force of 84 *lbs.* is applied for 7 seconds at the distance of 4 feet from the axis of a wheel weighing 36 *cwt.* the distance of the centre of gyration 5 feet. Required the velocity.

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## CENTRAL FORCES.

PROBLEM I.

To find the centrifugal force.

RULE. The Product of the square of the velocity per second and the weight of the revolving body, divided by the Product of the radius of revolution and 32, will give the centrifugal force.

(1) Required the centrifugal force of the rim of a fly wheel; the diameter 16 feet, the weight being 4 tons, and moving at the rate of 24 feet per second.

(2) The diameter of a wheel is 12 feet, the weight $3\frac{1}{2}$ tons, making 48 turns per minute. Required the centrifugal force.

PROBLEM II.

To find the radius of the circle of revolution.

RULE. The Product of the square of the velocity per second and the weight of the body, divided by the Product of the centrifugal force and 32, will give the radius of revolution.

(3) What is the radius of a wheel weighing 4 tons, moving at the rate of 24 feet in 1 second of time, the centrifugal force being 9 tons?

(4) The centrifugal force of a fly wheel is 16·58 tons, the weight $3\frac{1}{2}$ tons, velocity 30·16 feet per second. Required the radius of revolution.

PROBLEM III.

To find the weight of the revolving body.

RULE. The Product of the centrifugal force, the radius of the circle and 32, divided by the square of the velocity per second of the revolving body, will give the weight.

(5) The diameter of a fly wheel is 16 feet, moving 24 feet in one second, the centrifugal force 9 tons. Required the weight of the wheel.

(6) What is the weight of a fly wheel, diameter 12 feet, moving 30·16 feet per second, the centrifugal force 16·6 tons?

PROBLEM IV.

To find the velocity of the revolving body.

RULE. The Product of the radius of the circle, the centrifugal force and 32, divided by the weight of the body, will give the square of the velocity per second.

(7) The diameter of a fly wheel is 16 feet, the centrifugal force 9 tons, the weight of the wheel 4 tons. Required the velocity per second.

(8) What will be the velocity of a fly wheel of 12 feet diameter, centrifugal force 16·6, weight $3\frac{1}{2}$ tons?

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## ON PUMPS.

PROBLEM I.

To ascertain the weight of water contained in a pipe of a given length.

RULE. Square the diameter in inches; the Product will be the number of *lbs.* of water contained in every three feet of pipe.

Then, if 3 feet  *lbs.*

Length of pipe **lbs.* of water in the whole pipe.

NOTE. The weight of the water, divided by 10, will give the number of gallons.

(1) Required the weight of water in a pipe $4\frac{1}{2}$ inches diameter, 6 feet long.

(2) What is the weight of water in a pipe of 3 inches bore and 8 feet long?

(3) What weight of water will be contained in a pipe 5 inches diameter, 252 feet perpendicular height?

(4) What number of gallons of water will be contained in a pipe 4½ inches diameter, 180 feet long?

(5) What quantity of water will be contained in a pipe 5 inches diameter, 210 feet long?

PROBLEM II.

To find the power to raise water to a given height.

RULE. The Product of the height to be raised, and the quantity to flow per minute, reduced to *lbs.* and added to ⅓ of itself to resist friction, divided by 44000, will give the horse power.

(6) Required the power to raise 175 gallons of water per minute, through a pipe of 5 inches diameter, 252 feet high.

(7) What power will be necessary to raise 630 gallons of water per minute 320 feet high?

PROBLEM III.

To find the diameter of a pump to deliver a given quantity of water.

RULE. Find the number of cubical feet required to flow per minute, which divide by the number and length of strokes the pump rod makes per minute; the Quotient, reduced to inches, will give the area of the pump, from which find the diameter.

(1) A cistern, placed at an elevation of 60 feet, is 20 feet square, 10 feet deep. What will be the diameter of a pump to make 40 strokes, of 2 feet each per minute, to fill the cistern in 30 minutes?

(2) What will be the diameter of a pump, making 32 strokes, of 3 feet each per minute, to fill a cistern in 45 minutes; the cistern to be 25 feet square, 15 feet deep?

PROBLEM IV.

To find the quantity of water delivered in any given time.

RULE. The diameter of the pump, the length and number of strokes given; square the pump's diameter in inches, and multiply by the length of the stroke in feet, which divide by 30; the Quotient will be the number of gallons delivered.

(3) The diameter of a pump is 12 inches, the length of stroke 4 feet. Required the number of gallons delivered each stroke.

(4) If the diameter of a pump be 9 inches, the length of the stroke 3 feet, 24 per minute, required the number of gallons per minute?

(5) How many gallons per minute will a pump deliver, the diameter 8 inches, the length of the stroke $4\frac{1}{2}$ feet, 27 per minute?

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## ON STEAM ENGINES.

THE pressure of steam, arising from water at the boiling point, is considered to be 15 *lbs.* on the square inch.

One cubic inch of water will expand into one cubic foot of steam when its elasticity is equal to 30 inches of mercury.

### PROBLEM I.

To find the quantity of water necessary to be converted into steam, that a given quantity of water may be raised to any given temperature.

RULE. Take the difference between the temperature to be raised and the cold water temperature, which multiply by the given quantity of water for a Dividend; to the given temperature add 900°, and from that sum take the required temperature; this Remainder will be the Divisor, and the Quotient will be the required quantity of water to be converted into steam.

(1) What quantity of water, converted into steam at 212°, will raise 100 gallons of water at 60° up to 208°?

### *Horse Power.*

The weight a horse will be able to raise one foot high in one minute by

Bolton and Watt is 32000
Desaugliers..... is 27000 } *lbs.* avoirdupois.
Smeaton ..... is 22916

Where the effect produced is by a rotatory motion, the power is very considerably increased, and is calculated by the power of a horse to draw a weight of 200 *lbs.* over a pulley, at the rate of $2\frac{1}{2}$ miles per hour, or 220 feet per minute, with a continuance; and $200 \times 220 = 44000$ *lbs.* one foot per minute.

*Length of the Stroke.*

The engine stroke is one revolution of the crank shaft and double the length of the cylinder. A stroke is called 4 feet when the cylinder is 4 feet long besides an allowance for the piston.

The effective force of the piston is generally calculated at 10 *lbs.* per square inch of its surface.

PROBLEM II.

To calculate the power of an engine.

RULE. The Product of the area of the cylinder, the effective power and the number of feet the piston travels per minute, divided by a horse power, will give the power the engine is equal to.

(2) Required the power of an engine, the cylinder being 42 inches diameter, the power 10 *lbs.* per square inch, the movement 210 feet per minute.

(3) The diameter of a cylinder is 36 inches, the power 10 *lbs.* per square inch, movement 200 feet. Required the power of the engine.

(4) The movement is 220 feet, the power 10 *lbs.* per square inch, diameter of cylinder 54 inches. Required the power.

PROBLEM III.

To find the area of a cylinder requisite for any number of horse power.

RULE. The Product of 44000 and the number of horse power, divided by the effective pressure and rate per minute, will give the area of the cylinder.

(5) Required the area of a cylinder for a 60 horse power engine, the pressure 10 *lbs.* per square inch and the movement 228 feet.

(6) Required the diameter of a cylinder for a 50 horse engine, the effective pressure 12 *lbs.* the movement 220 feet.

(7) Required the diameter of a cylinder for a 20 horse engine, the pressure 10 *lbs.* the movement 240 feet.

PROBLEM IV.

To find the velocity of the piston when the engine works at its maximum.

RULE. The square root of the length of the single stroke, multiplied by 120, will give the velocity per minute; which

divided by the double stroke, will give the number of strokes the engine ought to make per minute.

(8) Admit the length of the single stroke to be 3 feet, required the velocity.

(9) If the length of the single stroke be 4 feet, what is the velocity?

(10) If the single stroke be 6 feet, what is the velocity?

PROBLEM V.

To find the power to move a weight at any velocity.

RULE. The Product of the weight in *lbs.* and the velocity in feet, divided by 44000, will give the number of horses' power required.

(11) What will be the power requisite to move a force equal to 15 tons, 210 feet per minute?

(12) Required the power necessary to move a force equal to 12 tons, 240 feet per minute.

PROBLEM VI.

To find the area of the pump necessary for condensing water, taking $7\frac{1}{2}$ gallons per minute as a standard for each horse power.

RULE. The Product of the number of horse power, $7\frac{1}{2}$ gallons and the cubic inches in a gallon, divided by the number of strokes per minute and the length of the pump stroke, will give the area of the pump.

(13) Required the diameter of a pump for a 24 horse engine, making 28 strokes per minute, the pump stroke 15 inches.

PROBLEM VII.

To find the weight of a fly wheel requisite for an engine.

RULE. The number of horses' power of the engine, multiplied by 2000 and divided by the square of the velocity of the circumference of the wheel per second, will give the weight of the wheel in *cwts.*

(14) The fly wheel of an engine of 30 horses' power makes 24 revolutions per minute, its diameter 21 feet. Required the proper weight of the wheel.

(15) An engine of 50 horses' power has a fly wheel making 22 revolutions per minute, its diameter 24 feet. Required the proper weight of the wheel.

PROBLEM VIII.

To find the revolutions the governor or double pendulum ought to make.

The balls will revolve in the same plane if their revolutions be equal; the distance of that plane from the point of suspension will equal the length of a pendulum whose vibrations will be double the revolutions of the balls.

RULE. The square root of 39·1393, multiplied by the number of seconds in one minute and divided by the square root of the distance from the point of suspension to the plane of revolution, will give the number of vibrations; which divided by 2, will give the number of revolutions the balls ought to make per minute.

(16) What number of revolutions per minute ought the governor balls to make, if the distance from the point of suspension to the plane of revolution be 36 inches?

PROBLEM IX.

To find the superficial surface of water necessary in the boiler to supply an engine with steam.

RULE. Square the diameter of the cylinder in inches, and multiply the Product by ·13; this will give the surface required.

(17) If the diameter of a cylinder be 36 inches, what will be the number of square feet required on the surface of water in the boiler?

PROBLEM X.

To find the diameter of the air pump.

RULE. The diameter of the main cylinder, multiplied by ·7071, will give the diameter of the air pump.

(18) If a cylinder be 24 inches diameter, what will be the diameter of the air pump?

(19) Required the diameter of the air pump to an engine, the cylinder being 36 inches diameter.

PROBLEM XI.

To find the proportions of an engine.

RULE. Take the length of the stroke as 1; the length of

the crank $\frac{1}{2}$; of the beam, from centre to centre of the gland 4; of the connecting rod 3; the radius and parallel bars one-half of the distance between the fulcrum of the beam and the gland; the straps 2 inches less from centre to centre than half the length of the stroke; the diameter of the valves fully one-fifth of the diameter of the cylinder; the stroke of the air pump half the length of the engine stroke, and its area equal one-half the area of the cylinder; or let the cubical contents of the air pump equal one fourth of the cubical contents of the cylinder, and the capacity of the condenser somewhat exceed that of the air pump.

(20) If the stroke be 6 feet, required the other proportions of the engine.

### PROBLEM XII.

To find the proportions of a boiler.

RULE. Take the width as 1; the depth 1·1; the length 2·5; and allow 25 cubic feet for each horse power.

(21) If a boiler be 6 feet wide, required its depth and length and the power applicable.

(22) What power is applicable to a boiler 8 feet wide?

### PROBLEM XIII.

To find the weight on the safety valve.

RULE. Find the area of the valve in square inches, which multiply by $3\frac{1}{2}$ *lbs.* for the necessary pressure.

(23) If the safety valve of a boiler be $2\frac{1}{2}$ inches diameter, what weight will be sufficient to retain the steam?

(24) Required the necessary pressure upon a steam valve of 4 inches diameter.

# ANSWERS TO THE QUESTIONS.

## ADDITION.

(1) 4200840.
(2) 250815.
(3) 185769.
(4) 986340.
(5) 130253.
(6) 254542.
(7) 1071614.
(8) 13436260.
(9) 84566879.
(10) 31031394.

### EXERCISES.

(1) 365 days.
(2) 3238 years.
(3) 1118 years.
(4) 1593, A. D
(5) 1752, A. D.
(6) 2099 years.
(7) 1919 years.
(8) 5836 years.
(9) 209 days.
(10) £27339.
(11) 62 miles.
(12) 1222 bundles.

## SUBTRACTION.

(1) 22961652.
(2) 1215796.
(3) 84802716.
(4) 29979967.
(5) 88981.
(6) 10829.
(7) 11490891.
(8) 2672617.
(9) 146198104.
(10) 62086991.
(11) 6510309.
(12) 110960702.
(13) 100917.
(14) 707041.
(15) 29050909.

### EXERCISES.

(1) 90552 persons.
(2) 516 years.
(3) 1340, A. D.
(4) 1302, A. D.
(5) 475 years.
(6) £702.
(7) 924 years.
(8) 889321.
(9) 16197; 54533; 69.
(10) *A* 96; *B* 139; *C* 191; *D* 138.
(11) £64.
(12) 6994.

## MULTIPLICATION.

(1) 350437382695394 8.
(2) 438046728369 : 435.
(3) 5256560740430922.
(4) 6132654197169409.
(5) 7008747653907896.
(6) 7884841110646383.
(7) 8760934567384870.
(8) 9637028024123357.
(9) 10513121480861844.

(1) 1865393904.
(2) 2073178662.
(3) 3543845449.
(4) 559637361.
(5) 236544528.
(6) 218571668.
(7) 475347033.
(8) 345937600.
(9) 3489514378.
(10) 2919418520.
(11) 3552714396.
(12) 445886497875.
(13) 607369475505.
(14) 56621293970.
(15) 3426931200 0.
(16) 27391418000.
(17) 772698400000.
(18) 130860996357.
(19) 117609920400.
(20) 5963879065.
(21) 4302538210.
(22) 11710800315.
(23) 2975019839.
(24) 220752444649.

(1) 118446555.
(2) 202023672.
(3) 59819532.
(4) 598816784.
(5) 23404608.
(6) 64594512.
(7) 77499504.
(8) 57159344.
(9) 692146944.
(10) 946721520.
(11) 400135120.
(12) 813084048.

### EXERCISES.

(1) 960 farthings.
(2) 240 pence.
(3) 56940 strokes per year.
(4) 321600 yards.
(5) 3024 yards.
(6) 7541520 revolutions.
(7) 18468 bricks.
(8) 30240 inches.
(9) 217008 spindles.
(10) 316800 feet.
(11) 239400 yards.
(12) 63360 inches.
(13) 3836160 bricks.
(14) 5016 stretches.
(15) 66653280 inches.
(16) 57600000 *lbs.*
(17) 144 feet.

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## DIVISION.

(1) 812824724 + 3.
(2) 1219237086+3.
(3) 1625649449.
(4) 696706906+5.
(5) 4347037193.
(6) 1738814877+1.
(7) 1086759298+2.
(8) 966008265+1.

(1) 353388 + 5.
(2) 135212 + 10.
(3) 21106 + 30.
(4) 18492 + 39.
(5) 13140 + 54.
(6) 8723 + 37.
(7) 112165 + 66.
(8) 42731 + 69.
(9) 12900 + 57.
(10) 30449 + 18.
(11) 49251 + 94.
(12) 34491 + 48.
(13) 7158 + 13.

(1) 2772128 + 2.
(2) 2545255 + 2.
(3) 726216 + 6.
(4) 292296 + 9.
(5) 545527 + 22.
(6) 697454 + 12.
(7) 1419485 + 23.
(8) 806819 + 60.
(9) 683636 + 16.
(10) 721908 + 84.
(11) 536484 + 103.
(12) 125034 + 178.
(13) 70200 + 38.
(14) 3404 + 1599.
(15) 4226 + 7646.
(16) 4900 + 2360.

EXERCISES.

(1) $62\frac{1}{2}$ *lbs.*
(2) 840 yards.
(3) 560 stretches.
(4) 24000 threads.
(5) 375.
(6) 39 yards.
(7) 320 hanks.
(8) 296 hanks in 1 *lb.*
(9) 3072 ounces.
(10) 2520 ends.
(11) 720 hanks.
(12) 623 miles.
(13) 38000000 deaths.

SUPPLEMENT TO MULTIPLICATION.

(1) 22694.
(2) 18312.
(3) 35568.
(4) 6838.
(5) 4550.
(6) $3282\frac{2}{3}$.
(7) 67201.
(8) $110937\frac{3}{8}$.
(9) 60976.
(10) $36786\frac{1}{3}$.
(11) $4231\frac{1}{8}$.
(12) $41675\frac{8}{12}$.

SUPPLEMENT TO DIVISION.

(1) $19142\frac{2}{3}$.
(2) 11361 + 11.
(3) 12656 + 8.
(4) 12956 + 37.
(5) 4050 + 18.
(6) 3955.
(7) 3309 + 45.
(8) 1609 + 987.
(9) 29394 + 12.

CONTRACTIONS IN MULTIPLICATION.

(1) 243765.
(2) 2939700.
(3) 43692500.
(4) 1034205.
(5) 5176350.
(6) 112557000.
(7) 2243350.
(8) 6963500.
(9) 506925.
(10) 5961000.
(11) 21132500.
(12) 92587500.

(1) 62218.
(2) 148818.
(3) 109984.

(4) 571584.
(5) 275311.
(6) 501030.

(7) 3738504.
(8) 971461.
(9) 715288.

(1) 871794.
(2) 9972336.
(3) 212232.
(4) 39468.

(5) 7059045.
(6) 471537.
(7) 8385606.
(8) 3422352.

(9) 74882511.
(10) 3528690.
(11) 897291027.
(12) 2157174.

(1) 2289523904.
(2) 4290473202.
(3) 97585344.

(4) 412753439.
(5) 432144540.
(6) 254795086.

(7) 2736389496.
(8) 1854897975.
(9) 3563775780.

### CONTRACTIONS IN DIVISION.

(1) 94605.
(2) 59708 + 12.
(3) 1949 + 14.
(4) 1839 + 22.
(5) 1316 + 65.
(6) 878 + 37.

(7) 637 + 18.
(8) 70 + 250.
(9) 3137 + 146.
(10) 625 + 222.
(11) 5357 + 138.
(12) 11040 + 27.

(1) 474060+536. | (2) 48581+1838. | (3) 834585+20531.

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## REDUCTION.

(1) 3617280 farthings.
(2) 97460 threepences.
(3) 219440 sixpences.

(4) 119892 farthings.
(5) 866 farthings.
(6) 983791 farthings.

The next six are reversed.

### RULE 2.

(1) £5006..8.
(2) 39979 guineas, 1 shilling.
(3) 13761 guineas, 19 shill.
(4) 4197 of each, 11 remainder.
(5) 173 *lbs.* 7 *oz.* 6 *dr.* 16 *grs.*
(6) 2793599 grains.
(7) 1 *lb.* 2 *oz.* 11 *dwts.* 16 *grs.*
(8) 5760 grains.
(9) 192 *lbs.*
(10) 5303 grains.
(11) 92232 grains.

(12) 284 *lbs.* 11 *oz.* 14 *dwts.*
(13) 826 *lbs.* 3 *oz.* 19 *dwts.* 17 *grs.*
(14) 17905 *oz.* 15 *dwts.* 3 *grs.*
(15) 394882 *lbs.* 10 *oz.*
(16) 2143 *lbs.* 4 *oz.* 3 *dwts.* 6 *grs.*
(17) 573440 drams.
(18) 14239646 drams.
(19) 918287 drams.
(20) 73280 ounces.
(21) 6412 drams.

(22) 430092 ounces.
(23) 1386 *t.* 7 *cwt.* 1 *qr.* 5 *lbs.* 13 *oz.*
(24) 169 *cwt.* 2 *qrs.* 21 *lbs.* 7 *oz.*
(25) 19972 *qrs.* 7 *lbs.*
(26) 2530 *lbs.* 13 *oz.* 7 *drs.*
(27) 14 *t.* 19 *cwt.* 2 *qrs.* 27 *lbs.* 11 *oz.* 15 *drs.*
(28) 5760 grains.
(29) 2522898 grains.
(30) 79704 scruples.
(31) 151 *lbs.* 3 *oz.* 2 *drs.* 1 *scr.*
(32) 14 *lbs.* 8 *oz.* 7 *drs.* 1 *scr.* 16 *grs.*
(33) 9945 *lbs.* 2 *oz.*
(34) 3980 nails.
(35) 745362 inches.
(36) 214 half nails.
(37) 5422 yards.
(38) 15221 *yds.* 12 *in.*
(39) 93232 *yds.* 2 *qrs.*
(40) 35007 *ells,* 1 *qr.*
(41) 2469 ells.
(42) 30240 inches.
(43) 836784 inches.
(44) 24 *hks.* 4 *le.* 37 *th.* 30 *in.*
(45) 9815 *hks.* 4 *le.* 65 *th.*
(46) 307132 leas.
(47) 922670 *hks.* 4 *le.*
(48) 2511 *hks.* 3 *le.* 21 *th.* 51 *in.*
(49) 2160000 inches.
(50) 90000 yards.
(51) 115218 threads.
(52) 362400 yards.
(53) 216 *bu.* 7 *sl.* 5 *le.*
(54) 632 *sl.* 4 *le.* 66 *th.*
(55) 36339 *bu.* 14 *sl.* 0 *le.* 74 *th.* 34 *in.*
(56) 99 *bu.* 2 *sl.* 6 *le.* 26 *th.*
(57) 360 hanks.
(58) 140 yards long.
(59) 115 yards long.
(60) 320 hanks.
(61) 120 yards.
(62) 20160 inches.
(63) 866880 inches.
(64) 554634 inches.
(65) 612 *hks.* 2 *le.* 55 *th.* 18 *in.*
(66) 827 *le.* 5 *th.* 74 *in.*
(67) 3840438 leas.
(68) 67670 *hks.* 2 *le.*
(69) 321 *hks.* 5 *le.* 51 *th.*
(70) 570240 barley-corns.
(71) 2827467 barley-corns.
(72) 2995 *m.* 7 *fur.* 166 *yds.* 5 *in.* 2 *b. c.*
(73) 164005 *leag.* 986 *yds.*
(74) 614 *m.* 5 *fur.* 131 *yds.* 9 *in.*
(75) 58400 perches.
(76) 23184 perches.
(77) 1346488 yards.
(78) 1369673 *r.* 23 *p.*
(79) 27434 *a.* 2 *r.* 26 *p.*
(80) 4742 *r.* 21 *p.* $3\frac{3}{4}$ *yds.*
(81) 1296 inches.
(82) 373236 inches.
(83) 33738 inches.
(84) 2414 *ft.* 78 *in.*
(85) 9525 *yds.* 8 *ft.* 126 *in.*
(86) 46656 inches.
(87) 938 *yds.* 1 *ft.* 891 *in.*
(88) 9072 pints.
(89) 6368 quarts.
(90) 435456 pints.
(91) 16128 quarts
(92) 26 *bar.* 6 *gal.*
(93) 12312 quarts.
(94) 6046 quarters.
(95) 12735 pints.
(96) 951 *qrs.* 6 *bu.* 3 *pks.* 1 *gal.* 2 *qts.*
(97) 31556929 seconds.
(98) 184 days.
(99) 91 days.
(100) 91 days.
(101) 144 *t.* 12 *cwt.* 3 *qrs.* 12 *lbs.*

## COMPOUND ADDITION.

(1) £265..12..9. | (2) £280..18..8¾. | (3) £783..11..2¼.

(1) £13858..8..2.
(2) £10079..4..5¾.
(3) £9935..13..9.
(4) 148 *lbs.* 8 *oz.* 3 *dwts.* 9 *grs.*
(5) 656 *t.* 1 *cwt.* 1 *qr.* 14 *lbs.* 3 *oz.* 13 *drs.*
(6) 325 *lbs.* 3 *oz.* 6 *drs.* 0 *scr.* 3 *grs.*
(7) 920 *yds* 1 *qr.* 1 *n.*
(8) 3502 *hks.* 6 *le.* 7 *th.* 24 *in.*
(9) 5475 *bu.* 17 *sl.* 0 *le.* 114 *th.* 86 *in.*
(10) 1520 *hks.* 5 *le.* 66 *th.* 4 *in.*
(11) 995 *lea.* 1 *m.* 2 *fur.* 11 *p.* 3 *yds.* 2 *ft.* 9 *in.* 1 *b* *c.*
(12) 1106 *a.* 3 *r.* 29 *p.* 23¼ *yds.* 0 *ft.* 37 *in.*
(13) 1699 *t.* 1 *hhd.* 17 *gal.* 3 *qts.*
(14) 280 *qrs.* 0 *bu.* 2 *pks.*
(15) 9257 *yrs.* 2 *m.* 2 *wks.* 1 *d.* 3 *hrs.* 53 *m.* 7 *sec.*

### EXERCISES.

(1) £532..18..10¼.
(2) 4188 years.
(3) £941..14..9¼.
(4) 19 *cwt.* 3 *qrs.* 18 *lbs.*
(5) £8749..2..7.
(6) 885 yards.
(7) 264 *t.* 2⅛ *cwt.*
(8) 601730 men.
(9) 1656 years.
(10) 3323 years.
(11) 6 years, 6 months.

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## COMPOUND SUBTRACTION.

(1) £431..6..6.
(2) £9787..3..9½.
(3) £5129..18..1.
(4) ¼.
(5) £899 .0..10½.
(6) £29886..19..11.
(7) 938 *lbs.* 8 *oz.* 17 *dwt.* 24 *g.*
(8) 298 *tons*, 16 *cwt.* 2 *qrs.* 27 *lbs.* 14 *oz.* 12 *drs.*
(9) 10 *yds.* 3 *qrs.* 3 *n.*
(10) 277 *hks.* 3 *le.* 73 *th.* 42 *in.*
(11) 2737 *bds.* 16 *sl.* 8 *le.* 52 *th.* 85 *in.*
(12) 4737 *hks.* 2 *leas*, 75 *thr.* 18 *in.*
(13) 13 *m.* 7 *f.* 34 *p.* 3⅛ *yds.* 2 *ft.* 11 *in.*
(14) 7 *a.* 3 *r.* 23 *p.* 29⅛ *yds.*
(15) 9 *t.* 1 *hhd.* 54 *gal.* 3 *p.*
(16) 40 *yrs.* 11 *m* 0 *w.* 5 *d.* 19 *h.* 44 *m.* 26 *s.*

### EXERCISES.

(1) £7928..11..8.
(2) 358 years.
(3) £15900030.
(4) £3240625.

(5) 11 *cwt.* 1 *qr.* 22 *lbs.*
(6) £158..10.
(7) 211 years.
(8) £14347.
(9) 3 years, 9 weeks, 5 days.
(10) 6160 leagues.
(11) 220 *a.* 2 *r.* 24 *p.*
(12) £14..18..10½.
(13) 2 *yrs.* 6 *m.* 0 *w.* 2 *d.* 8 *h.*
(14) 84000 yards.
(15) 600 pounds.

## COMPOUND MULTIPLICATION.

(1) £12..9..6.
(2) £25..2..1½.
(3) £58..10..7.
(4) £262..5..2½.
(5) £5..8..4½.
(6) £109..15..9¾.
(7) £64. 7..8.
(8) £234..0..6¾.
(9) £1019..19 9½.
(10) £838..11..6¾.
(11) £9..10..6.
(12) £303..14..3.
(13) £720..10..9.
(14) £763..10..9.
15) £866..5..2¾.
(16) £11..16..6.
(17) £976..13. 11½.
(18) £312..7.
(19) 70 *lbs.* 6 *oz.* 14 *dwt.* 8 *gr.*
(20) 339 *l.* 12 *cwt.* 2 *qrs.* 9 *lb.* 3 *oz.* 10 *drs.*
(21) 527 *lbs.* 10 *oz.* 3 *dr.* 1 *sc.* 4 *grs.*
(22) 161 *yds.* 1 *qr.*
(23) 480 *hks.* 0 *l.* 38 *th.* 20 *in.*
(24) 629 *bdl.* 1 *sl.* 9 *le.* 59 *th.* 72 *in.*
(25) 192 *m.* 7 *fur.* 19 *p.* 1 *yd.* 1 *ft.* 7 *in.* 2 *b. c.*
(26) 1023 *a.* 1 *r.* 17 *p.* 2¾ *yds.* 7 *ft.* 64 *in.*
(27) 71 *l.* 3 *hhd.* 7 *gal.* 3 *qt.* 1 *p.*
(28) 483 *bar.* 9 *gal.* 3 *qt.* 1 *p.*
(29) 574 *qrs.* 2 *bu.* 2 *p.* 0 *gal.*
(30) 454 *yrs.* 5 *m.* 0 *w.* 5 *d.* 0 *h.* 57 *mi.* 35 *sec.*

### RULE II.

(1) Worked in example.
(2) Ditto.
(3) £267..18.
(4) £315 .16..2¼.
(5) £800..14..7½.
(6) £17..3. 6.
(7) £2518..15..6¼.
(8) £5239..0. 3.
(9) £6606..6..9.
(10) £4577..9..9½.
(11) £670..19.
(12) £1153..0..8.
(13) £2264..5..11¼.
(14) £6186..8.
(15) £71..18..6.
(16) £1009..1.
(17) £1449 .9.
(18) £1074..18.
(19) 374 *lbs.* 11 *oz.* 6 *dwt.* 0 *g.*
(20) 1305 *cwt.* 1 *qr.* 26 *lbs.* 12 *oz.*
(21) 5742 *hks.* 5 *lea.* 77 *th.* 42 *in*
(22) 15721 *m.* 7 *fur.* 19 *p.* 3½ *yds.*
(23) 2605 *yrs.* 6 *m.* 3 *w.* 6 *d.*

### RULE III.

(1) Worked in example.
(2) Ditto.
(3) £226..2..8½.
(4) £115..14..10¼.
(5) £228..1..7.
(6) £672..6..0¾.
(7) £39..19..6½.
(8) £1620..13..1½.
(9) £2995..14..2¾.
(10) £8907..2..2½.
(11) £8078..1..4¼.
(12) £1847..5..5.
(13) £10900..4.
(14) £7586..1..1.
(15) £659..18..7.
(16) £1852..10..3¾.
(17) £9956..9..4½.

### EXERCISES.

(1) £309..18.
(2) £7..17..2.
(3) £1..10..8½.
(4) £3..16..6.
(5) £4..19..4½.
(6) £12..1..6.
(7) £15..15.
(8) £3..1..10½.
(9) £1..13..3.
(10) £172..7..6.
(11) £7..14..10½.
(12) £9..19..7¾.
(13) £112..15..11½.
(14) £139..6..11.
(15) £923..3.
(16) £15..15..4½.
(17) £515.
(18) £270..8..11.
(19) £16..8..6½.
(20) £84..16..3.
(21) £134..6..8.
(22) £52..3.
(23) £170..19..3.
(24) £31..9..7½.
(25) £31..7..9.
(26) £564..17..7½.
(27) £6..3..9.
(28) £198.
(29) £458..18.
(30) £32..5..3¾.
(31) £43..17..6.
(32) £91..15..11¼.
(33) £60..18..9.
(34) £32..18.
(35) £5..3.
(36) £158..6..8.
(37) £24..4..4¼.
(38) £15..14..6¼.
(39) £1..13..5½.
(40) £1..15..2¼.
(41) £18..2..3.
(42) £315.
(43) £97..13.
(44) £11..0..1.
(45) £85..10.
(46) £8..15..7.
(47) £15..11..8.
(48) £5..13..7.

(1) 219 *cwt.* 2 *qrs.* 14 *lbs.*
(2) £2..18..1.
(3) 100 miles, 100 yards.
(4) 40319 *t.* 14 *cwt.* 3 *qrs.* 2 *lbs.* 12 *oz.* 10 *dr.*
(5) 3 *hks.* 0 *l.* 76 *th.*
(6) 1440 hanks.
(7) 72 hours, 48 minutes.
(8) 5 skins.
(9) 596088000 miles.

(10) 1080 hanks.
(11) 151800 per day.
(12) £4894..2..3¾.
(13) 25 miles.
(14) 12 *lbs.* 6 *oz.*
(15) 171 inches.
(16) 8 *cwt.* 2 *qrs.* 28 *lbs.*
(17) 26136 *lbs.*
(18) 4860 threads.
(19) 4 hanks 274 yards.
(20) 1182 hanks 6 leas.

## COMPOUND DIVISION.

(1) £15..19..8.
(2) £9..14..6.
(3) £39..2..5½.
(4) £25..2..4¼.
(5) £8..9..2.
(6) £8..18..6½.
(7) £43..9..6¾.
(8) £2..7..4.
(9) £21..9..6¾.
(10) £3..19..9⅜.
(11) £60..4..2½.
(12) £2..11..2½.
(13) £17..7..8⅜.
(14) £8..19..4¾.
(15) £49..14..11¾.
(16) 15 *cwt.* 2 *qrs.* 14 *lbs.* 3 *oz.* 10 *dr.*
(17) 3 *lbs.* 6 *oz.* 19 *dwt.* 7 + *gr.*
(18) 2 *lbs.* 7 *oz.* 7 *dr.* 2 *sc.* 19 *gr.*
(19) 6 *yds* 2 *qrs.* 2 + *nails.*
(20) 43 *hks.* 0 *l.* 74 *th.* 48 *in.*
(21) 39 *yds.* 1 *ft.* 11½ *in.*
(22) 11 *m.* 5 *fur.* 23 *p.*
(23) 4 *hhds.* 59 *gal.* 6 *p.*
(24) 6 *t.* 5 *cwt.* 0 *qrs.* 7 *lbs.* 1 + *oz.*
(25) 5 *m.* 3 *fur.* 25 *p.* 4 *yd.* 2 *ft.*
(26) 23 *hks.* 1 *l.* 73 *th.* 13 *in.*
(27) 7 *a.* 3 *r.* 24 *p.* +.
(28) 8 *hhds.* 0 *gal.* 3 *p.* +.
(29) 6 *lbs.* 3 *oz.* 3 *dr.*
(30) 57 *cwt.* 0 *qrs.* 13 *lbs.* 6 *oz.*
(31) 27 *yrs.* 1 *m.* 1 *w.* 2 *d.* +
(32) £1..3..7¾.
(33) £2..13..9½.
(34) £8..10..4½.
(35) 5*s.* 9*d.*
(36) £4..7..3¾.
(37) £1..3..11¼.
(38) £2..8..6½.
(39) £3..13..1.
(40) £9..17..6¼.
(41) 18*s.* 2⅜*d.*
(42) £1..14..10.
(43) £3..17..9.
(44) £1..5..4.
(45) £1..19..4¼.
(46) £5..2..3¼.
(47) 2 *cwt.* 2 *qrs.* 25 *lbs.*
(48) 5 *yds.* 1 *ft.* 3 *in.*
(49) 1 *bar.* 10 *gal.* 2 *pt.*
(50) 10 *hks.* 3 *l.* 57 *th.* 48 *in.*
(51) 3 acres.
(52) 5 miles, 29 perches.
(53) 19 *yrs.* 7 *m.* 23 *d.*
(54) 19 *t.* 5 *cwt.* 21 *lbs.*
(55) 2 *lbs.* 8 *oz.* 4 *dwt.*
(56) 6 *hhds.* 17 *gal.*
(57) 4 *yds.* 2 *qrs.*
(58) 6 *yrs.* 44 *w.* 73 *h.*

### EXERCISES.

(1) £1..2..6$\frac{3}{4}$.
(2) 4$\frac{1}{3}$*d.*
(3) £5.
(4) 125 counts.
(5) 3 *cwt.* 2 *qrs.* 14 *lbs.*
(6) 120 hanks.
(7) 120 cannisters.
(8) 25 weeks.
(9) 15 velocity per minute.
(10) 1 lea, 73 threads.
(11) 7$\frac{1}{3}$ per second.
(12) 7733 + stars.
(13) 80 yards.
(14) 10*s.* 6*d.*
(15) 10*s.* a man, 3*s.* 4*d.* a woman.
(16) 2*s.* 3$\frac{1}{2}$*d.* per week.
(17) £94..15..8$\frac{1}{4}$.
(18) 43 ounces.
(19) 882 impressions.
(20) 76 ounces.
(21) $72\frac{8}{15}$ gallons.
(22) 72 teeth.
(23) 4 times.
(24) 27$\frac{1}{2}$ strokes.

### QUESTIONS.

(1) £17..3..5$\frac{1}{2}$.
(2) £44..8..6$\frac{3}{4}$.
(3) 134 *t.* 6 *cwt.* 2 *qrs.* 13$\frac{1}{3}$ *lb.*
(4) 417 *hks.* 3 *l.* 71 *th.* 41$\frac{1}{3}$ *in.*
(5) 106 *hhds.* 62 *gal.* 4 *p.*
(6) £11..1..9$\frac{1}{2}$.
(7) £15..5..3$\frac{3}{4}$.
(8) £3..4..4$\frac{3}{4}$.
(9) 23 *cwt.* 3 *qrs.* 20 *lbs.*

(1) £5..16..3.
(2) £8..18..9.
(3) £241..6..11$\frac{1}{4}$.
(4) $11\frac{6\,0\,7}{5\,5\,3\,4}$*d.*
(5) 31 *cwt.* 1 *qr.* 22 *lbs.*
(6) £362..10..6$\frac{1}{2}$.
(7) 7 parcels $\frac{1\,8\,9}{2\,5\,5\,6}$.
(8) 96912 bricks.
(9) $12\frac{4\,5}{1\,1\,8}$ moons.
(10) $60\frac{2\,1}{3\,3\,7}$ yards.
(11) £491..6..6.
(12) £35..16.
(13) £1..11..6.
(14) £309..18..4.
(15) 15 *cwt.*
(16) 14 *cwt.*
(17) 20 planks.
(18) 36 cards.
(19) 42 inches broad.
(20) 15 tokens.
(21) 1365 *tons*, 2 *cwt.*

### AVERAGES.

(1) 58$\frac{6}{7}$.
(2) 104$\frac{1}{2}$.
(3) $18\frac{6}{11}$.
(4) 3 *cwt.* 2 *qrs.* 0$\frac{1}{7}$ *lb.*
(5) 29 hanks.
(6) 2 *hks.* 1 *l.* 30 *th.*
(7) 84.
(8) 20$\frac{1}{2}$ feet.
(9) 4 feet 11$\frac{1}{4}$ inches.
(10) 18 tons.
(11) 15$\frac{1}{2}$ tons.

## PRACTICE.

### CASE 1.

(1) £4687.
(2) £4217..10.
(3) £1975..6..8.
(4) £1081..15.
(5) £1787.
(6) £649..6..8.
(7) £810..17..6.
(8) £473..18.
(9) £747..15.
(10) £470..18..8.
(11) £172..8..9.
(12) £187..13.
(13) £118..9.
(14) £136..16..6.
(15) £158..18.
(16) £85..14..3.
(17) £49..11.
(18) £39..18..7½.
(19) £32..14..6.
(20) £20..2..4½.
(21) £17..18..1.
(22) £9..16..7.
(23) £19..11..10.
(24) £339..10..7½.
(25) £691..14.
(26) £491..4..6.
(27) £28..16..6.
(28) £23..18.
(29) £121..14..2¼.
(30) £18..13..6½.
(31) £4..19..8.
(32) £930..5.
(33) £146.
(34) £474..8..9.
(35) £54..11..8.
(36) £14..5..9¾.

### CASE 2.

(1) £19..10..8¾.
(2) £67..11..10½.
(3) £47..12..5.
(4) £95..12..7½.
(5) £36..11..4¼.
(6) £66..19..6.
(7) £41..14..0¼.
(8) £66..17..6.
(9) £59..7..9¾.
(10) £71..10.
(11) £180..3..9¾.
(12) £206..1..10½.
(13) £88..0..5.
(14) £76..3..3.
(15) £98..5..11½.
(16) £84..8..1½.
(17) £119..18..7½.
(18) £120..15..10½.
(19) £97..14..3½.
(20) £359..18..4.
(21) £243..15..6¼.
(22) £288..14..5.
(23) £87..6..10½.
(24) £244..9..3.
(25) £270..4..3¾.
(26) £142..7..3.
(27) £326..11..6¼.
(28) £179..17..7.
(29) £390..5..11.
(30) £190..9..0¾.

### CASE 3.

(1) £156..18..9.
(2) £452..16..8.
(3) £195..8..0¾.
(4) £445..11..5½.
(5) £340..8..4¼.
(6) £213..10..10½.
(7) £192..11..1¼.
(8) £521..1..10½.
(9) £540..2..5¾.
(10) £619..2..9¾.
(11) £1139..15..2½.
(12) £169..0..6½.
(13) £245..2..2¼.
(14) £86..16..1.
(15) £243..11..6¾.
(16) £680..4..7½.
(17) £95..9..1¼.
(18) £267..13..7¾.
(19) £395..16..8.

CASE 4.

(1) £376.
(2) £855..12.
(3) £2279..14.
(4) £1512..16.
(5) £2267.
(6) £3262..4.
(7) £4548..12.
(8) £2687..4.
(9) £6811..4.

CASE 5.

(1) £1721..19..2.
(2) £660..14..3.
(3) £928..11..10½.
(4) £947..4..6½.
(5) £1616..13..7½.
(6) £6280..7.
(7) £1569..18..11½.
(8) £1741..8..1½.
(9) £1752..3..6.
(10) £5324..19..0¾.
(11) £2511..3..1½.
(12) £2602..14..7.

CASE 6.

(1) £5911..3..9.
(2) £13931..13..4.
(3) £15212..12..6.
(4) £5852..3..4.
(5) £5051..0..7½.
(6) £9462..6..11¼.
(7) £6189..5..7½.
(8) £5962..2..10½.
(9) £26547..3..10½.
(10) £16109..9..10½.
(11) £11024..8..9¼.

CASE 7.

(1) £961..4..2.
(2) £1900..15..7½.
(3) £1879..18..7½.
(4) £1847..17..5.
(5) £3411..7..10½.
(6) £5666..7..11¾.
(7) £19943..2..3.
(8) £6147..13..10½.
(9) £15317..10..5¼.
(10) £2982..4..10¾.
(11) £10955..17..11¼.
(12) £13542..18..10½.
(13) £62605..2..10½.

CASE 8.

(1) £142..10..6¼.
(2) £75..15..11¼.
(3) £40..4..2.
(4) £43..18..4.
(5) £6..18..9.
(6) £281..19..1¼.
(7) £121..6..2¼.
(8) £8. 5..8½.
(9) £81..17..10.
(10) £181..7..9¼.
(11) £89..3..2¼.
(12) £219..15..6.

CASE 9.

| | *feet.* | *in.* | *p.* | *v* | *m* |
|---|---|---|---|---|---|
| (1) | 27 | 1 | 6 | 0 | 0 |
| (2) | 38 | 6 | 11 | 0 | 0 |
| (3) | 72 | 6 | 0 | 0 | 0 |
| (4) | 27 | 7 | 5 | 0 | 0 |
| (5) | 43 | 1 | 6 | 0 | 0 |
| (6) | 17 | 6 | 10 | 0 | 0 |
| (7) | 25 | 8 | 6 | 2 | 3 |
| (8) | 79 | 11 | 0 | 6 | 6 |

| | *feet.* | *in.* | *p.* | *v* | *m* |
|---|---|---|---|---|---|
| (9) | 730 | 7 | 8 | 0 | 0 |
| (10) | 854 | 7 | 0 | 0 | 0 |
| (11) | 543 | 9 | 9 | 0 | 0 |
| (12) | 1319 | 3 | 9 | 0 | 0 |
| (13) | 3117 | 10 | 4 | 0 | 0 |
| (14) | 11402 | 2 | 4 | 11 | 11 |
| (15) | 2988 | 2 | 10 | 4 | 6 |

EXERCISES.

(1) £375..19..1.
(2) £170..13..2¾.
(3) £12477..6..6.
(4) £1770..9.
(5) £5327..7.
(6) £1943..3..2½.
(7) £23..19..3.
(8) £234..0..9½.
(9) £5..4..8¼.
(10) £58..6..5¼.
(11) £58..4..1¾.
(12) £13084..7..6.

## ALLOWANCES ON GOODS.

(1) 574 *cwt.* 3 *qrs* 24 *lbs.*
(2) 63 *cwt.* 3 *qrs.* 24 *lbs.*
(3) 3792 *lbs.*
(4) 87 *cwt.* 1 *qr.* 26 *lbs.*
(5) 2304 *lbs.*
(6) 329 *cwt.* 2 *qrs.* 7 *lbs.*
(7) 406 *cwt.* 0 *qr.* 5 *lbs.*
(8) 196 *cwt.* 3 *qrs.* 5 *lbs.*
(9) 551 *cwt.* 3 *qrs.* 19 *lbs.*
(10) 280 *cwt.* 1 *qr.* 23 *lbs.*
(11) 296 *cwt.* 1 *qr.* 9 *lbs.*
(12) 145 *cwt.* 0 *qr.* 26 *lbs.*
(13) 49 *cwt.* 0 *qr.* 8 *lbs.*
(14) 16 *cwt.* 1 *qr.* 15 *lbs.*
(15) 27 *cwt.* 1 *qr.* 23 *lbs.*
(16) 29 *cwt.* 0 *qr.* 2 *lbs.*
(17) $221\frac{11}{15}$ gallons.
(18) 70 *lbs.* 10 *oz.* $18\frac{2}{11}$ *dwt.*
(19) $598\frac{1}{2}$ *lbs.*
(20) 3465 *lbs.*
(21) 16 *cwt.* 1 *qr.* 24 *lbs.*
(22) 550 bushels.
(23) £2590..10.
(24) 1603 *lbs.*

## PROPORTION.

(1) 18*s.*
(2) 3*s.*
(3) 24 yards.
(4) 125 counts.
(5) 720 minutes
(6) 300 hanks.

(7) 42 inches diameter
(8) 250 grains.
(9) 2 hanks in the *lb.*
(10) 35 teeth.
(11) 100 hanks, 4 remainder
(12) 580 hanks.
(13) 955 hanks.
(14) 39 inches diameter
(15) 659 hanks, 2 remainder
(16) 4 *lbs.*
(17) 3 *lbs.* 11 *oz.* 4 *rem.*
(18) 819 *lbs.*
(19) 1680 ends.
(20) 72 teeth.
(21) 1584 hanks.
(22) $4\frac{1}{2}$ inches diameter.
(23) 2240 inches.
(24) 40 yards.
(25) 923 hanks.
(26) 384 bricks
(27) 76 *lbs.* $12\frac{4}{5}$ *oz.*
(28) 140 flags.
(29) 520 yards.
(30) 34 doffings $2\frac{1}{2}$ hanks.
(31) 288 *lbs.*
(32) $21\frac{1}{2}$ hanks in the *lb.*
(33) 45 *lbs.*
(34) $129\frac{3}{5}$ hanks.
(35) 2 *lbs.* 7 *oz.* nearly.
(36) $78\frac{6}{25}$ hanks.
(37) 384 yards long.
(38) 360 gallons.
(39) 240 hanks in 1 *lb.*
(40) 30 inches diameter.
(41) 1200 *lbs.*
(42) 1932 *lbs.*
(43) $26\frac{9}{11}$ inches diameter.
(44) 114 revolutions.
(45) $1066\frac{2}{3}$ revolutions.
(46) 70 *lbs.*
(47) $4\frac{1}{6}$ *cwt.*
(48) $548\frac{4}{7}$ *lbs.*
(49) 12 cogs.
(50) $9\frac{9}{11}$ inches diameter.
(51) $37\frac{1}{2}$ inches diameter.
(52) 730 *lbs.*
(53) 27 inches.
(54) $30\frac{2}{3}$ *lbs.*
(55) 250 feet.
(56) 88 *lbs.*
(57) 480 inches long.
(58) $15644\frac{4}{9}$ bricks.
(59) $23466\frac{1}{3}$ bricks.
(60) 15000 bricks.
(61) 10 hours $8\frac{1}{3}$ minutes.
(62) 36 inches.
(63) 3 *cwt.* 3 *qrs.* 21 *lbs.*
(64) 378 men.
(65) 7 inches.
(66) 26 pinion
(67) 54 bevil.
(68) $52\frac{1}{2}$ inches long.
(69) 4 *lbs.* $9\frac{1}{4}$ *drs.* weight of one cut.
(70) 100 picks.
(71) 300 *lbs.*
(72) 576 *lbs.*

## VULGAR FRACTIONS.

### REDUCTION.

#### PROBLEM I.

$\frac{4}{11}$. $\frac{5}{10}$. $\frac{585}{8482}$. $\frac{4552}{4498}$. $\frac{148}{1733}$. $\frac{991}{1810}$. $\frac{161}{252}$. $\frac{8}{4}$. $\frac{5}{6}$.

PROBLEM II.

$\frac{18}{120}$. $\frac{16}{360}$. $\frac{180}{84}$. $\frac{56}{63}$. $\frac{50}{88}$.

PROBLEM III.

$4\frac{3}{8}$. $6\frac{1}{3}$. $14\frac{1}{4}$. $15\frac{5}{7}$. $12\frac{5}{8}$. $7\frac{1}{2}$. $11\frac{1}{7}$. $17\frac{2}{3}$.

PROBLEM IV.

$\frac{55}{6}$. $\frac{19}{3}$. $\frac{57}{4}$. $\frac{198}{7}$. $\frac{101}{8}$. $\frac{15}{2}$. $\frac{78}{7}$. $\frac{87}{5}$.

PROBLEM V.

(1) $\frac{48}{48}$. $\frac{40}{48}$.
(2) $\frac{6}{12}$. $\frac{4}{12}$. $\frac{9}{12}$.
(3) $\frac{500}{560}$. $\frac{515}{560}$. $\frac{520}{560}$. $\frac{524}{560}$.
(4) $\frac{810}{1287}$. $\frac{1144}{1287}$. $\frac{594}{1287}$.
(5) $\frac{1400}{2802}$. $\frac{1980}{2802}$. $\frac{2695}{2802}$.
(6) $\frac{2288}{8580}$. $\frac{7865}{8580}$. $\frac{1980}{8580}$. $\frac{780}{8580}$.
(7) $\frac{1428}{1785}$. $\frac{765}{1785}$. $\frac{1547}{1785}$. $\frac{1050}{1785}$.
(8) $\frac{175}{560}$. $\frac{200}{560}$. $\frac{64}{560}$.

PROBLEM VI.

(1) $\frac{99}{132}$. (2) $\frac{80}{81}$. (3) $\frac{99}{132}$. (4) $\frac{84}{87}$.

PROBLEM VII.

(1) $\frac{52}{63}$. $\frac{50}{63}$.
(2) $\frac{70}{105}$. $\frac{84}{105}$. $\frac{45}{105}$.
(3) $\frac{106}{210}$. $\frac{140}{210}$. $\frac{126}{210}$. $\frac{120}{210}$.
(4) $\frac{50}{60}$. $\frac{48}{60}$. $\frac{55}{60}$.
(5) $\frac{24}{60}$. $\frac{250}{60}$. $\frac{45}{60}$.

PROBLEM VIII.

The answers in the first 10 questions are the terms given in the next 10.

The answers in the questions under the note are the terms given in Problem 9.

PROBLEM X.

(2) 4032. (3) 2160.

PROBLEM XI.

The questions are worked.

PROBLEM XII.

RULE 1. (1) $\frac{24}{44}$. (2) $\frac{12}{21}$. (3) $\frac{45}{81}$.

RULE 2. (1) $\frac{9}{15}$. (2) $\frac{12}{21}$. (3) $\frac{45}{81}$.

## ADDITION.

(1) $2\frac{3}{7}\frac{9}{8}$.
(2) $1\frac{8}{11}$.
(3) $1\frac{1}{1}\frac{9}{4}\frac{8}{3}\frac{7}{3}$.
(4) $2\frac{5}{1}\frac{4}{4}\frac{1}{6}\frac{1}{7}$.
(5) $\frac{5}{4}\frac{9}{4}\frac{1}{0}$.
(6) $2\frac{3}{4}\frac{8}{5}\frac{9}{3}\frac{4}{4}$.
(7) $2\frac{1}{2}\frac{3}{1}\frac{9}{8}\frac{1}{0}$.
(8) $20\frac{1}{3}\frac{8}{0}$.
(9) $34\frac{7}{1}\frac{}{2}$.
(10) $73\frac{6}{3}\frac{1}{6}\frac{}{4}$.
(11) $8s.\ 1\frac{3}{4}\ \frac{1}{1}\frac{}{1}$.
(12) £1..11..3.
(13) 3 *oz.* 3 *dwt.* $10\frac{5}{3}\frac{4}{3}$ *grs.*
(14) £1..1..$4\frac{3}{4}\ \frac{5}{5}$.
(15) 13 *cwt.* 11 *lbs.* $\frac{8}{1}\frac{}{5}$.
(16) 5 bushels $2\frac{7}{1}\frac{}{5}$ pecks.
(17) 4 *d.* 10 *h.* 36 *m.*
(18) £103..6..$7\frac{7}{6}\frac{5}{1}\frac{}{6}$.
(19) 544 *lbs.* 10 *oz.* $9\frac{5}{7}$ *drs.*
(20) $\frac{1}{1}\frac{1}{6}$.

## SUBTRACTION.

(1) $\frac{8}{6}\frac{5}{0}$.
(2) $\frac{5}{1}\frac{9}{4}\frac{}{4}$.
(3) $\frac{8}{8}\frac{3}{7}\frac{9}{4}$.
(4) $\frac{6}{1}\frac{3}{0}\frac{3}{5}\frac{}{0}$.
(5) $\frac{1}{1}\frac{7}{5}\frac{3}{1}\frac{}{2}$.
(6) $\frac{7}{1}\frac{5}{1}\frac{}{3}$.
(7) $1\frac{8}{5}$.
(8) $3\frac{1}{1}\frac{1}{2}$.
(9) $4\frac{1}{4}$.
(10) $14\frac{4}{7}$.
(11) $12\frac{5}{8}$.
(12) $9\frac{1}{5}\frac{7}{6}$.
(13) $12s.\ 1\frac{1}{5}\ \frac{1}{1}\frac{0}{1}$.
(14) $14s.\ 5\frac{1}{2}\ \frac{0}{7}$.
(15) £2..3..$5\frac{1}{2}\ \frac{1}{1}\frac{0}{1}$.
(16) $\frac{9}{1}\frac{7}{5}\frac{}{2}$.
(17) $\frac{5}{7}\frac{9}{6}$.
(18) 1 *dwt.* $18\frac{1}{3}\frac{7}{2}$ *grs.*

## MULTIPLICATION.

The answers to the first 13 in Multiplication form the dividends to the first 13 in Division.

(14) $11s.\ 9\frac{1}{2}\ \frac{2}{3}$.
(15) $19s.\ 5\frac{3}{4}\ \frac{5}{7}\frac{}{7}$.
(16) £6..7..$0\frac{1}{4}\ \frac{5}{1}\frac{}{1}$.
(17) £0..4..$3\frac{3}{4}\ \frac{}{7}$.

## DIVISION.

(14) $5s.\ 0\frac{1}{4}\ \frac{8}{9}$.
(15) $16s.\ 9\frac{1}{9}\frac{}{5}$.
(16) $\frac{1}{1}\frac{8}{2}\frac{}{1}$ part day.
(17) $1926\frac{4}{6}\frac{6}{6}\frac{8}{7}$.

## PROPORTION.

(1) £400..14..$3\frac{1}{4}$ $\frac{6}{7}$.
(2) $108\frac{7}{75}$ planks.
(3) 200 feet, $5\frac{5}{11}$ inches.
(4) 441 *lbs.*
(5) £75..10..$8\frac{1}{2}$ $\frac{2}{7}$.
(6) 2 feet, $10\frac{2}{4}\frac{2}{5}\frac{2}{5}$ inches.
(7) $\frac{27}{50}$ inch thick.
(8) $2861\frac{2}{5}$ *lbs.*
19) $26\frac{1}{4}$ *lbs.*
(10) $8\frac{3}{4}$ *lbs.*
(11) $7\frac{7}{10}$ inches long.
(12) $\frac{1}{2}$ inch long.
(13) $1\frac{3}{4}$ inch diameter.
(14) $3\frac{1}{2}$ inches diameter.
(15) $2\frac{1}{2}$ inches diameter.
(16) $5\frac{1}{10}$ inches diameter.
(17) $60\frac{0}{1}\frac{0}{1}$ or 61 pinion.
(18) $32\frac{0}{3}\frac{0}{3}$ or 33 pinion.
(19) $10\frac{7}{10}$ *lbs.*
(20) 323, 527, 589 turns of each.
(21) 73 hours when all come to the same point.
(22) 17 nimbler, $16\frac{1}{2}$ slower.

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## DECIMAL FRACTIONS.

### ADDITION.

(1) 6637·872625.
(2) 104·30009.
(3) 966·653554.
(4) 246·0884.
(5) 105·2592494.

### SUBTRACTION.

(6) 35·77.
(7) 80·438504.
(8) 2·18693.
(9) ·2978.
(10) ·215846.
(11) 3·627.
(12) ·000691.

### MULTIPLICATION.

(1) 50387·0389.
(2) 59728·5838.
(3) ·0646263.
(4) ·0009282.
(5) 2·7321.
(6) 17·586.
(7) 6·19014.
(8) ·633654.
(9) ·000312.
(10) 18·164.
(11) 448·8.
(12) 641·52.
(13) 781·4.
(14) 9851·6.
(15) 6871460.

### DIVISION.

(1) 13·31.
(2) ·61436.
(3) 79·347.
(4) 416·1857.
(5) 3·157947.
(6) ·003596.
(7) 3138758.
(8) 116648·$16\frac{2}{3}$.
(9) 111·$359\frac{7}{17}$.
(10) 1105·36.
(11) 22·92.
(12) 7·48635.

## REDUCTION.

### PROBLEM I.

(1) 125.
(2) ·625.
(3) ·25.
(4) ·75.
(5) ·875.
(6) ·3.
(7) .1.
(8) ·83.
(9) ·16.
(10) ·5625.
(11) ·2.
(12) ·013.
(13) ·00053.
(14) ·63.
(15) ·72.
(16) ·4.
(17) ·81.
(18) ·142857
(19) ·27.
(20) ·076923.
(21) ·01.
(22) ·20372.
(23) ·6.
(24) ·94117647.

### PROBLEM II.

(1) $\frac{1}{8}$.
(2) $\frac{1}{4}$.
(3) $\frac{3}{4}$.
(4) $\frac{1}{8}$.
(5) $\frac{5}{9}$.
(6) $\frac{17}{20}$.
(7) $\frac{3}{8}$.
(8) $\frac{121}{200}$.
(9) $\frac{59}{500}$.

### PROBLEM III.

(1) £ ·0375.
(2) £ ·0416.
(3) £ ·875.
(4) £ ·634375.
(5) £ ·9989583.
(6) £ ·714583.
(7) £ ·16.
(8) £ ·3.
(9) £ ·6.
(10) £ ·04583.
(11) £ ·01875.
(12) £ ·003125.
(13) ·0625 *cwt.*
(14) ·0714285 *cwt.*
(15) ·007589 ton.
(16) ·9058 ton.
(17) ·9875 *lb.* troy.
(18) ·05694 *lb.* troy.
(19) ·275 *oz.* troy.
(20) ·00439 *cwt.*
(21) ·671875 *lb. avoir.*
(22) ·30972 *lb.* troy.
(23) ·75 yard.
(24) ·375 yard.

(25) ·765625 mile.
(26) ·56875 acre.
(27) ·8 foot.
(28) ·916 shilling.
(29) ·83 shilling.
(30) ·625 shilling.
(31) ·59027 guinea.
(32) 1·085 pole.
(33) ·019863$\frac{1}{3}$ year.
(34) ·297916 hour.
(35) ·3675.
(36) ·4767857+.
(37) ·0428+.
(38) ·2.
(39) ·0357+.
(40) ·5714+.

PROBLEM IV.

(1) 9*d.*
(2) 9$\frac{3}{4}$. ·936.
(3) 17*s.* 6*d.*
(4) 12*s.* 8$\frac{1}{4}$*d.*
(5) 19*s.* 11$\frac{1}{2}$ ·999968.
(6) 14*s.* 3$\frac{1}{4}$ ·99968.
(7) 3*s.* 2$\frac{1}{4}$ ·6.
(8) 6*s.*
(9) 12*s.*
(10) 10$\frac{3}{4}$ ·9968.
(11) 4$\frac{1}{2}$*d.*
(12) $\frac{3}{4}$ *qrs.*
(13) 7 *lbs.*
(14) 7·9999936 *lbs.*
(15) 17·6 + *lbs.*
(16) 18 *cwt.* 12 *lbs.* 15 *oz.* 13·952 *drs.*
(17) 11 *oz.* 17 *dwt.*
(18) 13 *dwt.* 15·9744 *grs.*
(19) 5 *dwt.* 12 *grs.*
(20) 7 *oz.* 13·984768 *drs.*
(21) 10 *oz.* 12 *drs.*
(22) 3 *oz.* 14 *dwt.* 7·9872. *gr.*
(23) 3 *qrs.* yard.
(24) 1 *qr.* 2 *n.*
(25) 6 furlongs, 5 perches.
(26) 2 roods, 11 perches.
(27) 9·6 inches.
(28) 10$\frac{3}{4}$*d.* ·968.
(29) 9$\frac{3}{4}$*d.* ·84.
(30) 7$\frac{1}{2}$*d.*
(31) 12*s.* 4$\frac{1}{2}$*d.* ·99216.
(32) 14 *cwt.* 1 *qr.* 12·88672. *lbs.*
(33) 1·79025 foot.
(34) 7·249995 days.
(35) 7 hours, 8 minutes ·976.
(36) 22·05 minutes.
(37) 2 leas, 57 threads.
(38) 38 threads, 32 + inches
(39) 20$\frac{1}{4}$ inches.
(40) 6$\frac{3}{4}$ inches.

## INTERMINATE DECIMALS.

### REDUCTION.

PROBLEM I.

$\frac{7}{9}$. $\frac{1}{3}$. $\frac{5}{11}$. $\frac{23}{27}$. $\frac{3}{7}$. $\frac{7}{12}$. $\frac{15}{44}$. $\frac{1}{6}$. $\frac{1}{132}$. $\frac{1785}{1700}$

PROBLEM II.

(1) 17*s.* 8*d.*
(2) 2*s.* 10*d.* ·12.
(3) 41 *lb.* 11 *oz.* 9·9 *drs.*
(4) 5 *fur.* 15 *per.* 4 *yds.* 4·72 *inches.*
(5) 14*s.* $1\frac{3}{4}$ ·12.
(6) 1 *qr.* 19·002 *lbs.*
(7) 15*s.* $0\frac{1}{2}d.$ +
(8) 3 *r.* 15 *per.* 16 *yds.* +

PROBLEM III.

(1) ·363636.
(2) ·468468.
(3) ·485454545.
(4) ·762927927.
(5) ·33333333.
(6) ·264181818.
(7) ·405405405.

## ADDITION.

(1) 2·27447.
(2) 74·375.
(3) £28·597916.
(4) 1·903154673124970.
(5) 2·04807867273213.
(6) 2·461981.
(7) 3·40512821.

## SUBTRACTION.

(1) ·080207.
(2) ·1916.
(3) ·9697916.
(4) ·46428571.
(5) ·2619047.
(6) 13·72619047.
(7) 4·205128.
(8) 6·082.

## MULTIPLICATION.

(1) 1·16.
(2) 243·75.
(3) 21·146.
(4) 243·97916.
(5) 3983·3.
(6) 678222·2.
(7) 3·370.

(8) ·37592.

(9) 14·54.

(10) 2614·2857142.

(11) 5083·7645270.

(12) ·24553571428.

(13) ·2083.

(14) 6·7839506172.

(15) ·4131.

(16) 233·8771.

(17) ·415.

(18) ·14424.

(19) ·3.

(20) 49·725.

(21) 9·2507318.

(22) ·3936117.

(23) ·204960.

(24) 6·026.

(25) 25·35416.

(26) 4·9029484.

(27) 2·193732.

(28) 24·788.

(29) 5·38.

(30) ·260.

## DIVISION.

(1) 1·2916.

(2) ·481.

(3) ·11342.

(4) 11·746.

(5) 10·04.

(6) 3386·6.

(7) 135·48.

(8) ·1458.

(9) 52·875.

(10) 26·8.

(11) 7·52.

(12) 19·8.

(13) ·0065448.

(14) 20·571428.

(15) ·52117.

(16) ·83818125.

(17) ·10694.

(18) ·6090.

## PROPORTION.

(1) ·0408 hank.

(2) ·6857 *oz.*

(3) ·010279 hank.

(4) 7328·5 + deals.

(5) 6907·9787 hanks.

(6) 10·83 days.

(7) 1·0078 tons long end, 1·4294 tons short end.+

(8) ·7$\frac{3}{7}$ inches.

(9) 5·805 inches.

(10) 13·55 velocity of the less to the greater.

(11) 5·74 to 1 force.

(12) 14·5 + hanks.

(13) 9·85 + draft.

(14) 5·45 + ounces.

(15) 76·07 gallons.

(16) 1·215 *lb.* troy.

(17) ·823 *lb.* avoirdupois.

(18) ·3 inch thick.

## COMMISSION.

(1) £61..15..4$\frac{1}{2}$.
(2) £12..0..1$\frac{3}{4}$.
(3) £20..15..7$\frac{3}{4}$.
(4) £1..11..0$\frac{1}{2}$.
(5) £1..11..10$\frac{3}{4}$.
(6) £3..10..3$\frac{1}{4}$.
(7) £1..10..2$\frac{1}{4}$.
(8) £1..6..10$\frac{3}{4}$.
(9) 18*s*. 6$\frac{3}{4}$*d*.
(10) £398..3.
(11) £5..6..6.
(12) £49..10. commission.
£1395..15..4. proceeds.
(13) £18..2..4$\frac{3}{4}$. commission,
£677..0..8$\frac{3}{4}$. invoice.

## INSURANCE.

(1) £23..16..7$\frac{1}{4}$. premium.
(2) £65..9..6.
(3) £158..0..0$\frac{3}{4}$.
(4) £68..7..7$\frac{3}{4}$.
(5) £116..14..1$\frac{3}{4}$.
(6) £1..17..8.
(7) £1..1..8$\frac{3}{4}$.
(8) £44..8..3$\frac{1}{2}$.
(9) £4000. insured.
(10) £2904..9..8.
(11) £1038..8..7$\frac{1}{2}$.
(12) £1686..2..10$\frac{1}{2}$.
(13) £712..1..8$\frac{1}{4}$.
(14) £765..2..11$\frac{3}{4}$.
(15) £982..9..5$\frac{3}{4}$.
(16) £40000.
(17) £623..15..6$\frac{1}{2}$.
(18) £1525..10..5$\frac{1}{2}$.
(19) £942..12..3$\frac{3}{4}$.
(20) £828..1..11$\frac{3}{4}$.
(21) £895..10..7.
(22) £3984..2..11.

## STOCKS.

(1) £825..6.
(2) £917..7..4.
(3) £672..19.
(4) £700.
(5) £3772.
(6) £5882..8.
(7) £1160..8..2$\frac{1}{4}$.
(8) £754..14..4.
(9) £1943..6..4$\frac{3}{4}$.
(10) £436..19..5$\frac{3}{4}$.
(11) £1304..6..11$\frac{1}{2}$.
(12) 5$\frac{6}{9}$ interest per cent.
(13) 4$\frac{8}{9}\frac{8}{9}$ interest per cent.
(14) 5$\frac{5}{17}\frac{5}{3}$ interest per cent.
(15) 7$\frac{1}{7}$ interest per cent.
(16) £54..10..10$\frac{3}{4}$.
(17) £2187..10.
(18) Interest 5$\frac{1}{3}$ per cent.
(19) £115..6..8.

## CREDIT, AND THE TIME WHEN BILLS BECOME DUE.

(1) June 1st.
(2) July 16th.
(3) April 28th.
(4) October 29th.
(5) December 19th.
(6) Bill 16th July, in cash 19th September.
(7) 57 days to run.
(8) November 26th.
(9) October 19, due in cash.
(10) October 12th.
(11) December 1st.
(12) December 21st. due in cash.

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## INTEREST.

(1) £30..3..9¼.
(2) £375..18..3¼.
(3) £307..18.
(4) £1..3..11½.
(5) £1030..8..11½.
(6) £4..18..9¾.
(7) £3..0..3½.
(8) £13..11..10.
(9) £16..4..10½.
(10) £7..12..8¼.
(11) £3..1..2¾.
(12) £3..16..10½.
(13) £9..9..3.
(14) £4..9.
(15) £10..0..11¾.
(16) £5..7..8¼.
(17) £2..10..3¼.
(18) £1..16..5¼.

*Interest for Months, at £5. per cent.*

(1) £0..13..4.
(2) £4..5..1½.
(3) £11..19..4½.
(4) £70..7..6¾.
(5) £217..5..7½.

*Interest for Years and Months, at £5. per cent.*

(1) £92..18..9.
(2) £9..11..8.
(3) £4..10..6½.
(4) £32..6..9.
(5) £53..0..6½.
(6) £0..13..4.
(7) £4..5..2.
(8) £17..15.
(9) £4..6..10½.
(10) £5..9..1¼.

*For Months, at any rate per cent.*

(1) £2..15..3½.
(2) £4..13..7⅕.
(3) £99..1..8.
(4) £74..2.
(5) £2..8..7¾.
(6) £30..8..4.
(7) £7..14..2½.
(8) £8..6..8.
(9) £6..12..1¾.

*For Days, at any rate per cent.*

(1) £4..15..1¾.
(2) £11..10..6¾.

*For Days, at £5. per cent.*

(1) £3..18..11.
(2) £36..9..8½.
(3) £16..1..7.
(4) £3..8..5½.
(5) £1..7..5¼.
(6) £1..12..3¾.

### *Partial Payments.*

(1) £7..6..8½. | (2) £8..6..10. | (3) £13..13..2¼.

### *Accounts Current.*

(1) £8..13..7½. balance of interest.
£255..13..7½. balance of account.

(2) £1..5..8. balance of interest.
£122..4..8. balance of account.

(3) 14*s.* 7½*d.* balance of interest.
£31..10..7½. balance of account.

(4) 19*s.* 6*d.* balance of interest.
£86..11..6. balance of account.

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## COMMERCIAL DISCOUNT.

(1) £3 .14..4.
(2) £2..13..4.
(3) £..0..7.
(4) £7..9..0.
(5) commission 3*s.* 2¼*d.*
discount 18*s.* 11*d.*
(6) £1..4..7. balance of dis.
£1..5..0. commission.
£497..10..5. neat.
(7) £442..5..6. balance in cash.

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## TRUE DISCOUNT.

(1) £12..18..5. | (3) £97..5..1.
(2) £62..0..7¾. | (4) £3840..19..3½.

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## BILLS OF PARCELS AND INVOICES.

(1) £19..12..11. | (4) £208..9..8¾. | (7) £54..18..1¼.
(2) £53..4..10. | (5) £3..13..9. | (8) £135..17..7¼.
(3) £669..18..2¼. | (6) £1509..5..10. | (9) £329..4..11.

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## EQUATION OF PAYMENTS.

¹ays. | (2) 238¼⁴⁄₇ days. | (3) 188⅔ days.

## PROFIT AND LOSS.

(1) £33..17..8. gain.
(2) £21..7..6. gain.
(3) 5*s*. $5\frac{5}{17}$*d*. selling price.
(4) 4*s*. $5\frac{1}{4}$*d*. buying price.
(5) 582 *yds*. 1 *qr*. $1\frac{1}{8}$ *n*.
(6) 25 *cwt*. 1 *qr*. $26\frac{4}{7}$ *lbs*.
(7) 242 *cwt*. 3 *qrs*. 12 *lbs*.

(1) $9\frac{1}{11}$ per cent. gain.
(2) 10 per cent. loss.
(3) $26\frac{6}{19}$ per cent. profit.
(4) $13\frac{7}{11}$ per cent. loss.
(5) £11..15..1. or $56\frac{2}{3}$ per cent.
(6) $20\frac{5}{8}$ per cent.
(7) $19\frac{17}{20}$ gain per cent.
(8) 4*s*. selling price.
(9) 13*s*. 6*d*. selling price.
(10) 12*s*. selling price.
(11) 4*s*. 9*d*. selling price.
(12) 9*d*. per *lb*. selling price.
(13) 4*s*. 10*d*. per *lb*. selling price.
(14) 3*s*. 8*d*. prime cost.
(15) 15*s*. prime cost.
(16) 5*s*. 6*d*. prime cost.
(17) $5\frac{3}{4}$*d*. prime cost.
(18) 4*s*. prime cost.
(19) 9*s*. 6*d*. prime cost.
(20) $34\frac{2}{3}$ per cent. profit.
(21) $19\frac{3}{5}$ per cent. loss.
(22) $24\frac{3}{5}\frac{3}{5}$ per cent. gain.
(23) $\frac{1}{7}$ per cent. loss.
(24) £896. prime cost.
(25) £872..10. prime cost.
(26) £5..4..8 $\frac{8}{17}$. bought at; £5..7..9$\frac{3}{4}$. sold at.
(27) $2345\frac{5}{11}$ *lbs*.
(28) $1536\frac{1}{6}\frac{2}{5}$ *lbs*.
(29) £1..14..4$\frac{3}{4}$. $\frac{1}{16}\frac{7}{3}$. pr. cost.

## PARTNERSHIP.

### CASE 1.

(1) 30, 40, 50.
(2) *A*'s £48.; *B*'s £112.
(3) *P*'s £300.; *Q*'s £480.; *R*'s £420.
(4) *B*'s stock £287..11..1$\frac{1}{4}$. 6 rem. *C*'s £431..6..8. *D*'s £575..2..2$\frac{1}{2}$. 12 rem. *B*'s gain £63..18..0$\frac{1}{4}$. 10 rem. *C*'s £95..17..0$\frac{1}{4}\frac{3}{5}$. 6 rem. *D*'s £27..16..0$\frac{1}{2}\frac{1}{3}$. 2 rem.
(5) *A*'s £94..15..4$\frac{1}{2}\frac{6}{7}$. *B*'s £59..4..7$\frac{1}{4}\frac{6}{7}$.
(6) *A*'s £60. *B*'s £70. *C*'s £100. *D*'s £130.
(7) *A*'s £33..16. *B*'s £39. *C*'s £31..4. *D*'s £28..12. *E*'s £23..8.
(8) *G*'s £102..17..1$\frac{1}{2}\frac{9}{7}$. *H*'s £85..14..3$\frac{1}{4}\frac{5}{7}$. *I*'s £90. *K*'s £81..8..6$\frac{2}{4}\frac{5}{7}$.
(9) 100 hanks Turkey red; 66$\frac{2}{3}$ hanks blue; 133$\frac{1}{3}$ hanks white.

(10) First 12 revolutions; second 20; third 28; fourth 40.
(11) 30 inches short end; 90 long end.
(12) $31\frac{1}{2}\frac{8}{9}$ inches smaller wheel; $73\frac{7}{7}\frac{8}{9}$ larger.
(13) 17 greater wheel; 40 lesser wheel.
(14) 45 hanks white; $22\frac{1}{2}$ green; $11\frac{1}{4}$ red; $11\frac{1}{4}$ blue.
(15) $285\frac{5}{7}$ white; $142\frac{9}{7}$ green; $85\frac{5}{7}$ blue; $85\frac{5}{7}$ red.
(16) 19·2 long end; 4·8 short end.

CASE 2.

(1) *A*'s £60..18..$3\frac{1}{4}$. 93 rem. *B*'s £155..18..$9\frac{1}{4}$. 309 rem. *C*'s £263..2..$11\frac{1}{4}$. 189 rem.
(2) *D*'s £9..12. *E*'s £3..12. *F*'s £10..16.
(3) *G*'s £85. *H*'s £90. *I*'s £75. *K*'s £83.
(4) *A*'s £35..2. *B*'s £46..16. *C*'s £78. *D*'s £123..10. *E*'s £208. *F*'s £195.

## BARTER.

(1) $380\frac{1}{4}$ *lbs.*
(2) 2*s.* $9\frac{1}{2}\frac{3}{5}d.$
(3) 2571 pairs.
(4) Both equal.
(5) $26\frac{3}{4}\frac{7}{7}\frac{1}{3}d.$
(6) 45 *cwt.* 3 *qrs.* $1\frac{6}{7}$ *lb.*
(7) 1*s.* $9\frac{3}{4}d.$ per *lb.*
(8) 2880 *cwt.* 3 *qrs.* 4 *lbs.*
(9) $10\frac{3}{4}\frac{1}{3}d.$ per *lb.*
(10) 218 *cwt.* 0 *qr.* 18 *lbs.*

## EXCHANGE OF MONEY.

(1) 12587·5 francs.
(2) £1917..6..$10\frac{3}{4}$.+
(3) 138532 francs, 36 cents.
(4) 5529 florins, $39\frac{1}{2}$ cents.
(5) 7526 marks, 14 schill.
(6) 66573 francs, 61+ cents.
(7) 6056 florins, 25 cents.
(8) £11596..11..$4\frac{1}{2}$.
(9) 7323 mar. 14 sch. 10 pf.
(10) 41447 florins, 34 cents.
(11) 204055 francs, 42 cents.
(12) 41272 florins, 46 cents.
(13) 7757 marks, 8 schillings.
(14) £358..19..$7\frac{3}{4}$.
(15) 18042 m. b. 4 sch. 5 pf.
(16) 9219 m. banco, 15 schill.
(17) £805..1..$9\frac{3}{4}$.
(18) 8044·88125 m. currency.
(19) 3336 Prussian dollars.
(20) £1156.12..$6\frac{1}{4}$.
(21) 5426 Prussian dollars, $16\frac{1}{2}$ groshen.
(22) £647..13..$3\frac{1}{2}$.
(23) 18938 rubles, 98 copecs.
(24) £818..14..4.+
(25) 5120 silver rubles.
(26) 6285 silver rubles, 63 copecs.

(27) 4005·39 reichsgeld, or rix dollar.
(28) £500.
(29) 5497 florins, 8 + kreuzer.
(30) £498..19..2¼.
(31) 15000 lire Austriacha.
(32) 3956 lires, 44+ cents.
(33) £264..0..6¼.
(34) £215..5..4¼.+
(35) 3402 dollars, 53 groshen.
(36) 2913 dollars, 60 groshen.
(37) £500.
(38) £662..10.
(39) 296 oncie, 17 tari, 9 grani.
(40) 272 oncie, 3 tari, 6 grani.
(41) £495..16..8.
(42) £136..12..6½.
(43) 1979 pezze, 7*s.* 7*d.*
(44) £2010..8..4.
(45) 52602 reals of plate, 11 quartos.
(46) £165..8..5¼.
(47) £55..2..6¾.
(48) 4950 reals vellon, 12 maravedis.
(49) 4776119 reis.
(50) £2771..2..6.
(51) 1949 pezze, 7 tari, 1 scu. 17+ grani.
(52) £203..2..6.
(53) 3322 rix dol. 22 groshen.
(54) £149..15..3¾. sterling.
(55) £540 sterling.
(56) £800. currency.
(57) £277..15..6½. sterling.
(58) £540. currency.
(59) £428..11..5. sterling.
(60) £599..19..11¾.+sterling.
(61) £1281..15..2¾. currency.
(62) 5696 dollars, 72 cents.
(63) £789. 5*s* currency.
(64) £499..19..11½. sterling.
(65) £500. sterling.
(66) £982..14..4¾. sterling.
(67) 4826 dollars, 25 cents.
(68) £760..8..4.
(69) £13..0..10¼.
(70) 4726 dollars.
(71) 14089460 reis.
(72) £1099..17.
(73) £615..3..4½.
(74) £602..2.

## ARBITRATION OF EXCHANGE.

(1) 25 francs, 25 cents.
(2) 25 francs, 29 cents.
(3) 560 yards English, 210 yards Hamburgh.

## ALLIGATION.

(1) 9*d.*
(2) 8*s.*
(3) 7*s.* 9*d.*
(4) 5*s.* 9¼ ½*d.* per gallon.
(5) 4*s.* 9½*d.* per gallon.
(6) 2 bushels at 2*s.* 6*d.* and 3 bushels at 3*s.* 4*d.*
(7) Equal quantity.
(8) 1 *lb.* at 4*d.* 1 *lb.* at 6*d.* and 6 *lb.* at 9*d.*
(9) 6 *lbs.* at 8*s.* 1 each of the others.
(10) 16 gallons at 6*s.* 4 gallons of the others.

(11) 20 at 9*s*. 10 at the rest.
(12) 6 *lbs*. at 5*s*. and 6*s*. 18 at the rest.
(13) 6 gallons at 8*s*. and 9*s*. 18 at the rest.
(14) 3 gallons at 4*s*. 6 at 6*s*. 12 at 5*s*. and 24 at 5*s*. 6*d*.

## POSITION.

### CASE 1.

(1) 60.
(2) 36.
(3) $1\frac{1}{8}$ day.
(4) £625.
(5) 8, 16, 48, revolutions of each shaft.
(6) *A* £90. *B*. £120. *C* £150.

### CASE 2.

(1) 20.
(2) 17, 71, 147, revolutions of each shaft.
(3) 20, 97, 473, revolutions of each shaft.
(4) £125. income of each.
(5) Son £577..15..$6\frac{1}{2}\frac{2}{3}$. daughter £422..4..$5\frac{1}{4}\frac{1}{3}$.
(6) *A* 36. *B* 24.
(7) 79 better sort, 46 inferior.
(8) 36 oxen, 100 sheep.
(9) 14·77 nearly.

## ARITHMETICAL PROGRESSION.

(1) 8 difference, 297 sum.
(2) £180. for interest.
(3) 4 difference, 351 revolutions.
(4) 198 sum.
(5) 8289 inches.
(6) 25 wheels, 1375 revolutions.
(7) 18 layers, 8289 inches.
(8) 31 rows, 961 trees.
(9) 29 teeth.
(10) 7 revolutions first shaft, 23 last shaft.
(11) 180 first layer, 741 last layer.
(12) 168 first revolutions, 84 last revolutions.
(13) 42 last wheel, 297 revolutions.
(14) 8 first wheel, 1572 revol.
(15) 84 last tooth, 3654 revolutions.

*Annuities, &c. in arrear at simple interest.*

(1) 480 principal, 108 interest.
(2) £340..4.

## GEOMETRICAL PROGRESSION.

(1) 384, 8th. term.
(2) 1215 revolutions.
(3) 28672 times its rarity.
(4) 3280 sum.

## DECREASING PROGRESSION.

(1) 72 miles.
(2) 100 revolutions.
(3) No: 400 miles would be the extent he could travel.

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## INVOLUTION.

(1) 331776.
(2) 1874161.
(3) 841 inches.
(4) 125 feet.
(5) 3375 cubes.

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## EVOLUTION.

(1) 24.
(2) 144.
(3) 789.
(4) 888.
(5) 1111.
(6) 70809.
(7) 9748.
(8) 123456789.
(9) 8070405.
(10) ·73.
(11) 2·42384.
(12) 698·343.+
(13) 956·49.+
(14) 2480·795.+
(15) 2·236067977.+
(16) 4·16.
(17) ·91.
(18) $\frac{7}{12}$, $\frac{9}{11}$, $\frac{25}{36}$.
(19) ·866.
(20) ·027.
(21) 28·00669.+
(22) 8·26639784.+
(23) 22·04792759.+
(24) ·0028.
(25) 3·31662479.+
(26) ·000073.

### PROBLEM I.

(1) 12 mean proportional.
(2) 9·539 mean proportional.
(3) 32 mean proportional.

### PROBLEM II.

(1) ·886 side of square.
(2) 21·9 side of square.
(3) 69·56 side of square.
(4) 13·416 diameter.
(5) 24·979 yards.
(6) 44 perches.
(7) 134·16 square feet.

PROBLEM III.

(1) 3, 4, 5.
(2) 215·4+ feet.
(3) 374·98+ feet.
(4) 334·18 feet.
(5) 99·87 miles.
(6) 97·75 leagues.

## PROPORTION,

*In which Square and Square Root are required.*

(1) 2450 threads.
(2) 273·4614 content.
(3) 22·61 inches deep.
(4) 3 *hrs.* 14 *m.* 24 *sec.*
(5) 200 hanks.
(6) 2400 reed.
(7) 33·75 turns.
(8) 2·12 inches diameter.
(9) 2 *oz.*
(10) 15·43 acres.
(11) 39 7 acres.
(12) 298·04 acres.
(13) 486·6 acres.
(14) 323·9 acres.
(15) 4 times hotter at *A*'s seat than at *B*'s.
(16) 15 *lbs.* 6 *oz.*
(17) 27·3 *lbs.*
(18) 1372 *lbs.* weight, £20..0..2. price.
(19) 22·136 inches.
(20) 2·378 inches diameter.
(21) 1·687 proportionate diameter.
(22) 7$\frac{1}{9}$ proportionate weight.
(23) 18·37 inches deep.
(24) 30 feet long.
(25) 4 inches thick.

*To find the length of a pendulum.*

(1) 125·2 vibrations.
(2) 9·8 inches long.
(3) 2202 difference of vibrations.

TO EXTRACT THE CUBE ROOT.

(1) 25.
(2) 276.
(3) 375.
(4) 7889.
(5) 111111.
(6) 4070809.
(7) ·345.
(8) 19·86228.+
(9) 1·44225.
(10) ·045.
(11) 9·2235.
(12) $\frac{6}{7}$, $\frac{5}{8}$, $\frac{18}{19}$.

PROBLEM I.

(1) 12 and 18 mean proportionals.
(2) 18 and 54 mean proportionals.
(3) 91 and 1183 mean proportionals.

PROBLEM II.

(1) 127 side of the cube. | (2) 262 side of the cube.

PROBLEM III.

(1) 17·306 side of the cube.
(2) 21·8 side.
(3) 180·28 keel, 36·05 midship, 21·6 depth in the hold.
(4) 99·202 keel, 19·84 midship, 11·906 depth in the hold.
(5) 31·498 inches the side.

## PROPORTION,

*In which the Cube and Cube Root are required.*

(1) 6 inches diameter.
(2) 35·15625 *cwt.*
(3) 12 inch cable.
(4) 1393·7 gallons.
(5) 85·16 *lbs.*
(6) 216 *lbs.*
(7) 98·2 feet length of the keel, 31·4 length of beam, 25·1 length of stern, 30·2 length of stern post.
(8) 6·03 inches diameter.
(9) 10·4 inches diameter.
(10) 8·04 inches deep.
(11) 21·78 inches long.

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## MENSURATION OF SUPERFICIES.

PROBLEM I.

(1) 1350·5625 square feet.
(2) 1313·625 square yards, £25..19..11½. per year.
(3) 62·059 feet long.

PROBLEM II.

(1) 376 feet, 9 inches.
(2) 6 *a.* 0 *r.* 12 *per.*
(3) 9 *a.* 0 *r.* 38 *per.*
(4) 84 feet area.

PROBLEM III.

(1) 2058 feet.
(2) 6347 ft. 36 square in.
(3) 230 feet, 67 square inches.

PROBLEM V.

(1) 1893·9975 area. | (2) 1969·7174 area.

PROBLEM VI.

(1) 37·6992 circumference.
(2) 109·956 circumference.
(3) 3·9258 diameter.
(4) 7964 miles.
(5) 3·927 circumference.
(6) 37·6992 circumference.
(7) 45·239 laths.
(8) 904·78 inches.
(9) 38 sheet cards.
(10) 45 feet.
(11) 2375·0496 inches.
(12) 47·124 inches difference.
(13) 4 inches each.
(14) 14·69 inches.
(15) 75398·4 *lbs.*
(16) 10·05312 feet.
(17) 5·4646 feet more in the round than the square tree.

PROBLEM VII.

(1) 113·0976 area.
(2) 5·4164+ area.
(3) 1134·1176 square inches.

PROBLEM VIII.

(1) 12·7278 side of the square.
(2) 29·6982 inches.
(3) 48·0828 inches.
(4) 164·396 difference.
(5) 123·61 difference.

PROBLEM IX.

(1) 64·42 length.
(2) 7·329 length.

PROBLEM XI.

(3) 225·277 area.
(4) ·58905 area.
(5) 16·2316 area.
(6) 13·585 area.

PROBLEM XII.

(1) 82·6952 area.

PROBLEM XIII.

(1) 15·708 area.
(2) 122·5224 area.

PROBLEM XIV.

(1) 69·397944 circumference.
(2) 66·64339 circumference.

PROBLEM XV.

(1) 339·2928 area.
(2) 687·225 area.

# ON COTTON SPINNING.

## PERMUTATION.

(1) 5040 days.
(2) 479001600 changes.
(3) $67\frac{1}{2}$ times the first length.
(4) 1547·974 length of yarn delivered from the mule.

### *On Wheels and Pinions.*

(1) 60 revolutions.
(2) $146\frac{1}{4}$ revolutions.
(3) 12 revolutions.
(4) 240 revolutions.
(5) $149\frac{1}{8}$ picks.
(6) $471\frac{5}{7}$ revolutions.
(7) 1440 *lbs.* raised by the last wheel.
(8) 147 *lbs.* power to be applied.
(9) 360, 144, 64 teeth in each.
(10) 108, 128, 72, 21 teeth in each.
(11) 320, 72, 56 in each.

### *On the Drafts of Rollers, &c.*

(1) 5·55 draft.
(2) 4·27 draft.
(3) 5·182 draft.
(4) 2·76 draft.
(5) 7·21 draft.
(6) 5·18 draft.
(7) 5·22 draft.
(8) 5·84 first draft, 6·13 second draft; 8·39 roving produced by the alteration.

### *Quantity of cotton delivered.*

(1) 188·496 inches.
(2) 1696·464 inches.
(3) 75·3984 inches.

### *Number of engines to one drawing frame.*

(1) 3·7699.

### *On Drafts required in Spinning.*

(1) 13·29 draft.
(2) 14·44 draft.
(3) 13·52 draft.
(4) 10 draft.
(5) 9·5 draft.
(6) 12·9 draft.

### *On the Hanks Roving.*

(1) 14·28 double roving.
(2) 14·28 double roving.
(3) 11·5 single roving.
(4) 19 single roving.

*One preparation to keep up with the other.*

(1) 16·66 revolutions of back roller.
(2) 19·5 revolutions of back roller.

*On the Counts of Yarn.*

(1) 156 hanks yarn.
(2) 249·9 hanks yarn.
(3) 392 hanks yarn.

*On the Mendoza Pulley.*

(1) 3·958 diameter.
(2) 4·61 diameter.
(3) 5·87 diameter.

*On Stretching and Gaining.*

(1) 12 inches stretching and gaining.
(2) 15·012 inches stretching and gaining.
(3) 5·87 inches stretching and gaining.

*Wheels necessary for the Draft.*

(1) 56 back roller, 32 change pinion, 120 stud wheel, 18 front roller pinion.

(2) 64 back roller wheel, 40 change pinion, 78 stud wheel, 24 front roller pinion.

*The Twist necessary per inch of Roving or Yarn.*

(1) 3·819 turns per inch.
(2) 55·25 revolutions per inch for twist.
(3) 48·75 for weft.
(4) 60 for twist, 52 for weft.
(5) 63·75 for twist, 55·25 for weft.
(6) 33·75 turns.
(7) 60 turns.
(8) 66·8 turns.

*Twist and Bevil wheels.*

(1) 61·7, 50·75.

*On Double Speed.*

(1) $\frac{4}{7}\frac{9}{8}$.

*The drafts in Carding Engines.*

(1) 45·84 draft.
(2) 32·26 draft.
(3) 31·2 draft.

*Weight of cotton on the lap frame to produce a given number of hanks per lb.*

21·36 oz.

*Filleting required for the doffing Cylinder.*

(1) 45·3786 feet. | (2) 118·6826 feet.

*Ratio of two Pulleys.*

(1) $\frac{50\cdot2656}{26\cdot272}$

*To produce the same counts of yarn.*

8·9 draft in each head of drawing.

## MECHANICS.

### ON BLOCKS AND PULLEYS.

(1) 36 *lbs.* | (2) 512 *lbs.*

### DUODECIMALS,

*Or Multiplication of Feet and Inches.*

| | *ft.* | *in.* | *p.* | | |
|---|---|---|---|---|---|
| (1) | 161 | 8 | 0 | | |
| (2) | 540 | 4 | 6 | | |
| (3) | 4341 | 7 | 7 | | |
| (4) | 966 | 11 | 0 | | |
| (5) | 8617 | 0 | 4 | | |
| (6) | 1279 | 8 | 3 | *sec* | |
| (7) | 5370 | 6 | 11 | 4 | |
| (8) | 444 | 5 | 10 | 6 | |
| (9) | 392 | 10 | 2 | 2 | |
| (10) | 671 | 9 | 5 | 1 | |
| (11) | 1036 | 0 | 10 | 8 | |
| (12) | 819 | 9 | 5 | 2 | |
| (13) | 1048 | 7 | 0 | 1 | |
| (14) | 606 | 10 | 7 | 6 | |
| (15) | 557 | 3 | 6 | 4 | *th.* |
| (16) | 881 | 7 | 0 | 9 | 9 |
| (17) | 249 | 9 | 0 | 5 | 4 |
| (18) | 4014 | 7 | 1 | 8 | 8 |

| | *ft.* | *in.* | *p.* | *sec.* | *th.* |
|---|---|---|---|---|---|
| (19) | 2960 | 9 | 4 | 1 | 4 |
| (20) | 4339 | 4 | 7 | 4 | 0 |
| (21) | 2463 | 4 | 3 | 10 | 8 |
| (22) | 5414 | 9 | 9 | 9 | 9 |

| | £. | *s.* | *d.* |
|---|---|---|---|
| (23) | 3 | 1 | 5 |
| (24) | 1 | 3 | 3 |
| (25) | 13 | 10 | $11\frac{1}{2}$ |
| (26) | 14 | 11 | $2\frac{1}{2}$+ |

(27) 280 feet difference, £18..18. amount.

(28) 81949 gallons.

(29) 3712·5 *lbs.* £50..12..$8\frac{1}{4}$.

(30) 2*s.* $9\frac{3}{4}\ 1\frac{5}{8}$.

(31) 25+ rods.

(32) 5 *r.* 166 *ft.* 6+ *in.*

(33) £48..12..7.

## BOARD MEASURE.

(1) 42 *ft.* 3 *in.* 6 *pts.*
(2) 10 *ft.* 2 *in.* 10 *pts.*
(3) 1*s.* 5*d.*
(4) £1..5..9½.
(5) 1058 *ft.* 11½ *in.*
(6) 34 *ft.* 7 *in.* 1 *pt.* 6″.
(7) 26½ feet.
(8) 41·278 feet.
(9) 37·33 feet.
(10) 31·109 feet.
(11) 30·76 feet.
(12) 102 *ft.* 11 *in.* 9 *pts.* 9″.
(13) 9·75 feet.
(14) 8 *ft.* 9 *in.* 9″.
(15) 561 *ft.* 9 *in.* 3′ 2″ 8‴.
(16) 20·5 feet.
(17) 131·82 feet.
(18) 122·88 feet.
(19) 122·88 feet.
(20) 54·424992 feet.

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## ON THE STRENGTH OF BEAMS TO BEAR WEIGHT.

(1) $641\frac{7}{10}$ *lbs.*
(2) 11733·33 *lbs.*
(3) 850 *lbs.*
(4) 10940·4 *lbs.*
(5) 1845·33 *lbs.*
(6) 7605·33 *lbs.*
(7) $2\frac{1}{12}$ longest support bears, $2\frac{1}{12}$ shortest support bears.
(8) 1·125 on the longest end for 3 tons, 1·875 on the short end for 3 tons, ·5 on the long end for 4 tons, 3·5 on the short end for 4 tons, 4·625 on the end bearing 4 tons, 2·375 on the end bearing 3 tons.
(9) 1 on the long end for 5 tons, 4 on the short end for 5 tons, ·9 on the long end for 6 tons, 5·1 on the short end for 6 tons, 6·1 weight at the 6 tons, 4·9 weight at the 5 tons.

## CAST IRON BEAMS.

(1) 2·58 inches broad.
(2) 4·44 inches broad.
(3) 5·46 inches broad.
(4) 3·7 inches broad.
(5) 15·1 inches deep.
(6) 10·04 inches deep.
(7) 15·9 inches deep.
(8) 19·7 inches deep.
(9) 11·2 inches deep, 2·8 broad.
(10) 10·9 inches deep, 3·6 broad.
(11) 16·2 inches deep, 3·24 broad.
(12) 1·46 inches broad.
(13) 3·29 inches broad.

(14) 3·17 inches broad.
(15) 10·8 inches deep, 5·4 broad.
(16) 12 in. deep, 4 broad.
(17) 18·6 inches deep, 4·65 broad.
(18) 5·76 inches broad.
(19) 4·28 inches broad.
(20) 2· inches.
(21) 2·3 inches.
(22) 1·73 inches.
(23) 9·5 inches diameter.
(24) 10·8 inches diameter.
(25) 6·5 diameter.
(26) 6·2 diameter.
(27) 7·58 diameter.
(28) 8·6 diameter.

## JOURNALS OF SHAFTS.

(1) 5·84 diameter.
(2) 4·36 diameter.
(3) 2·7 diameter.
(4) 48·6 horses' power.
(5) 10·8 horses' power.
(6) 9·6 horses' power.

## STRENGTH OF WHEELS.

(1) 4 depth.
(2) 5·4 depth.

*Power applicable to a wheel.*

(1) 9·9 horses' power.
(2) 7·3 horses' power.

## ON THE PITCH OF TEETH IN WHEELS.

(1) 62·8, say 63.
(2) 13·3 diameter.
(3) 1·5 pitch of teeth.
(4) 3·15 pitch, 1·8 length.
(5) 3·675 pitch, 2·1 length.
(6) 2·625 pitch, 1·5 length.

## GRAVITATION, OR THE FALLING OF BODIES.

(1) 257·33 velocity.
(2) 1029·33 velocity.
(3) 128·33 velocity.
(4) 30·476 velocity.
(5) 41·7335 velocity.
(6) 1029·33 velocity.

## HYDROSTATICS.

(1) 10500 *lbs.*
(2) 49500 *lbs.*
(3) 73500 *lbs.*
(4) 32000 *lbs.*
(5) 108 area.
(6) 112500 *lbs.*
(7) 144000 *lbs.*
(8) 283500 *lbs.*
(9) 108000 *lbs.*
(10) 208000 *lbs.*
(11) 112500 *lbs.*

## HYDRAULICS.

(1) 86·4 cubic inches.
(2) 39·816 cubic inches.
(3) 20·5 mean velocity.
(4) 30·5 mean velocity.
(5) 22·48 cubic feet.
(6) 8417·5 cubic feet.
(7) 762·587 cubic inches per second.
(8) 4403·7 cubic inches per second.

## WATER-WHEELS.

(1) 37·2 horses' power.
(2) 18·4 horses' power.
(3) 10·66 horses' power.
(4) 182·2 circumference of wheel, 360 velocity per minute, 3·6 area of buckets, 9 ft. shrouding, 1·97 revolutions per minute.
(5) 27 horses' power.
(6) 24 horses' power.

## SPECIFIC GRAVITY.

(1) $1228\frac{4}{5}$ cubic inches.
(2) $29\frac{5}{16}\frac{6}{1}$ cubic inches.
(3) $38\frac{1}{8}\frac{2}{3}\frac{8}{3}$ cubic feet.
(4) $683\frac{7}{18}$ tons.
(5) 18·49 *oz.*
(6) 11·4 *lbs.*
(7) $4335\frac{1}{18}\frac{5}{8}$ *lbs.*
(8) 3076 *lbs.*
(9) 600 *lbs.*
(10) 100 *lbs.* copper, 12 *lbs.* tin.

## CENTRE OF GRAVITY.

(1) 19·2 the distance from the end for 16 *lbs.* 4·8 the distance from the end for 4 *lbs.*
(2) $13\frac{85}{103}$ inches from the end where the 40 *lbs.* are hung, $22\frac{78}{103}$ inches from the end where the 20 *lbs.* are hung.
(3) 2·35 from the 90 *lbs.* 7·65 from the other end.
(4) 50 *lbs.*
(5) 12.
(6) 16.
(7) 36.
(8) 27.
(9) 30.
(10) 194·9.
(11) 46·45.
(12) 12·99.
(13) 40·75.
(14) 8.
(15) 14.
(16) 8.
(17) 12.

## CENTRE OF PERCUSSION.

(1) 13·24 centre of percussion.
(2) 58·7089 length.
(3) 32.
(4) 12.

## CENTRE OF GYRATION.

(1) 4·582.
(2) 5·83.
(3) 6.
(4) 31·185.
(5) 26·204.
(6) 9·89.
(7) 29·69.
(8) 1·26.

## ROTATORY MOTION.

(1) 11·2 centre of gyration.
(2) $3\frac{1}{8}$ *cwt.*
(3) $3\frac{1}{8}$ feet distance.
(4) 228 *cwt.*
(5) 3·84 seconds.
(6) 3·73 feet per second.

## CENTRAL FORCES.

(1) 9 tons, nearly.
(2) 16·58 tons.
(3) 8 radius of revolution.
(4) 6 radius of revolution.
(5) 4 tons weight of wheel.
(6) $3\frac{1}{2}$ *t.* weight of wheel.
(7) 24 feet velocity per second.
(8) 30·16 feet velocity per second.

## ON PUMPS.

(1) 40·5 *lbs.*
(2) 24 *lbs.*
(3) 2100 *lbs.*
(4) 121·5 gallons.
(5) 175 gallons.
(6) 12 horses' power.
(7) 55 horses' power.

(1) 17·43 inches diameter.
(2) 19·9 inches diameter.
(3) 19·2 gallons per stroke.
(4) 194·4 gallons per minute.
(5) 259·2 gallons per minute.

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## ON STEAM ENGINES.

(1) 16·37 gallons.
(2) 66·123 horses' power.
(3) 46·26 horses' power.
(4) 114·5 horses' power.
(5) 1157·89 area.
(6) 32·5 diameter.
(7) 21·6 diameter.
(8) 207·84 feet per minute, 34·64 strokes per min.
(9) 240 feet per minute, 30 strokes per minute.
(10) 293·9 feet per minute, 24·49 strokes per min.
(11) 160·36 horses' power.
(12) 146·6 horses' power.
(13) 12·3 diameter.
(14) 86·2 *cwt.*
(15) 130·8 *cwt.*
(16) 31·28 vibrations.
(17) 168·48 square feet.
(18) 6 stroke, 3 crank, 24 beam from centre to centre, 18 connecting rod, 2·75 straps.
(19) 23·76 horses' power.
(20) 56·32 horses' power.
(21) 6·6 depth, 15 length.
(22) 8·8 depth, 20 length.
(23) 17·15 *lbs.*
(24) 43·97 *lbs.*

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*Henry Mozley and Sons, Printers, Derby.*

PREPARING FOR THE PRESS,

## A KEY TO THE FOREGOING,

*In which the Working of all the Examples will be fully shown.*