*6.* Why is the extra day in leap year added to February and not to some other month?

7. How long is the day when the sun rises at 7 a. m. and sets at 4 p. m. ? How long, when it rises at 4 a. m. and sets at 7 p. m. ?

8. What instant is the exact middle of the week? Of July? Of November?

CIRCULAR AND ANGULAR MEASURE. LONGITUDE.

192. A circle is a plane figure bounded by a curved line, every point of which is equidistant from a point within called the **center**.
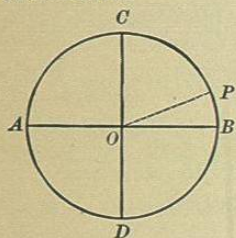
The **circumference** is the line which bounds the circle. A **quadrant** is one of the four equal parts into which a circumference is divided. Thus, if *BC* is one-fourth of the circumference *ACBD*, it is called a quadrant. The angle *BOC* is then a right angle. Each quadrant is subdivided into 90 equal parts called **degrees**.

An **angle** is the amount of opening between two lines which meet, as *COP*, or *POB*.

TABLE OF CIRCULAR MEASURE.

60 seconds (″) = 1 minute (′).
60 minutes = 1 degree (°).
360 degrees = 1 circumference (c.).

The angle at the center of a circle is regarded as containing the same number of degrees as the part of the circumference (arc) corresponding to it. Thus, if the arc *PB* contains 13°, the angle *POB* is also spoken of as an angle of 13°. Hence, a right angle, which corresponds to a quadrant, contains 90°.

193. Longitude.—Each great circle on the surface of the earth, as, for instance, the equator, is divided into 360 degrees. A degree of the earth's equator is called a degree of longitude. $\frac{1}{60}$ of a degree of longitude is called a geographical unit or *knot*.

Longitude is measured east or west from a fixed point or meridian (usually the meridian of Greenwich).

EXERCISE 82.

Reduce to seconds:

1. 35° 17′ 25″.   *3.* 205° 10′ 40″.
2. 150° 50″.   *4.* 330° 3′ 6″.

Reduce to higher denominations:

5. 21026″.   *6.* 270040″.   *7.* 398234″.

8. What part of the circumference is 30°? 45°? 60°? 90°? 120°? 150°? 225°? 300°? 330°?

9. What part of a semi-circumference is 30°? 60°? 45°? 90°? 120°? 135°? 150°?

10. Between two cities the longitude is 3° 47′ 15″. How many seconds are they apart?

11. If the earth's equator contains 24902.302 miles, how many miles in a degree? In 1″?

12. How many miles in one geographical mile (1′ on equator)?

ORAL.

1. How many minutes in 5°? In 80°? In 360″?

2. What is the difference between a quadrant and a right angle? How many degrees in 3 right angles? In $\frac{2}{3}$ rt. angles? In $\frac{2}{5}$ rt. angle? In $\frac{1}{2}$ rt. angle? In $\frac{1}{3}$ rt. angle? In $\frac{4}{5}$ rt. angles?

MISCELLANEOUS UNITS.

194. I. Lengths.

4 inches	= 1 hand.	6 feet = 1 fathom.
9 inches	= 1 span.	120 fathoms = 1 cable length.
3 feet	= 1 pace.	

195. II. Numbers in General.

12 units	= 1 dozen (doz.).
12 dozen	= 1 gross.
12 gross	= 1 great gross.
20 units	= 1 score.

III. Sheets of Paper.

24 sheets	= 1 quire.
20 quires	= 1 ream.
2 reams	= 1 bundle.
5 bundles	= 1 bale.

196. Capacity determined by Weight.—It is often more convenient to determine the number of bushels, or barrels, in a large quantity of material by weight than by direct measurement.

Some of the different equivalents vary in different states, but the following are representative :

1 bush. of wheat	= 60 lbs.	1 bush. of barley	= 48 lbs.
1 bush. of potatoes	= 60 lbs.	1 bush. of oats	= 32 lbs.
1 bush. of beans	= 60 lbs.	1 bush. of coarse salt	= 56 lbs.
1 bush. of clover-seed	= 60 lbs.	1 bbl. of flour	= 196 lbs.
1 bush. of shelled corn	= 56 lbs.	1 bbl. of pork or beef	= 200 lbs.
1 bush. of rye	= 56 lbs.	1 cental of grain	= 100 lbs.

EXERCISE 83.

1. How many fathoms in a mile? How many paces?

2. How many feet in 16 hands? In 5 spans? In 6 fathoms?

3. For what, and by whom, are the following units used : hand, span, fathom, dozen, score, quire, league?

4. How many pounds does a peck of wheat weigh? A peck of oats? Of corn? A quart of oats? 4 quarts of wheat?

5. How many units in 1 great gross? How many dozens in 9 scores?

6. Bought eggs at 45 cents a score and sold them at 30 cents a dozen. What is the gain on a great gross?

7. A box of pencils contains ½ gross. How many pencils in a score of boxes? In 5 dozen boxes?

8. How many sheets of paper in 1 ream? In one bundle?

9. Reduce 17904 sheets to higher denominations.

10. A dealer bought a bale of paper @ 30 cents a quire and sold it by the sheet so as to make $52. Find the rate of sale per sheet.

11. How many bushels of wheat worth 1½ cents per pound would equal in value 27 bbl. flour @ 2½ cents a pound?

12. What part of the weight of a bushel of corn is the weight of a bushel of oats?

13. Which is heaviest, 7 bu. barley, 5½ bu. wheat, 10 bu. oats, or 5⁶⁄₇ bu. rye? What is the combined value of the lot at a cent and a half a pound?

OPERATIONS WITH COMPOUND NUMBERS.

197. I. Reduction Ascending and Descending.—These processes have been considered in connection with the individual tables, but they may be conveniently renewed in connection with the following exercise of miscellaneous examples.

EXERCISE 84.
REVIEW.

Reduce :

1. 5 cwt. 46 lb. 12 oz. to ounces.
2. 7 yr. 261 da. 19 hr. 51 min. to minutes.
3. 2 mi. 100 rds. 4 yds. 2 ft. 8 in. to inches.
4. 8° 44′ 19″ to seconds.
5. 3 A. 75 sq. rds. 14 sq. yds. 7 sq. ft. to square feet.
6. 2 ba. 3 bun. 1 r. 17 qu. 15 sh. to sheets.
7. 7 t. 19 cwt. 56 lb. to pounds.
8. 43 da. 15 hr. 14 min. 55 sec. to seconds.
9. 25 bu. 3 pk. 6 qt. 1 pt. to pints.
10. 7 bbl. 14 gal. 3 qt. 1 pt. to pints.
11. 3 cu. yd. 18 cu. ft. 560 cu. in. to cubic inches.
12. 5 A. 104 sq. rd. 26 sq. yd. to square yards.
13. 135 rd. 3 yd. 1 ft. 11 in. to inches.
14. 7 lb. 9 oz. 15 pwt. 10 gr. to grains.
15. 1 mi. 141 rd. 5 yd. 2 ft. 9 in. to inches.
16. 9 lb. 7 ℥ 5 ℨ 2 ℈ 16 gr. to grains.

Change to higher denominations :

17. 17058 ft.	*23.* 44456 gr. **Ap.**
18. 16501¼ sq. yds.	*24.* 175036 cu. in.
19. 254020 oz. Av.	*25.* 239728″.
20. 565 pts. d.-m.	*26.* 51764 gr. **T.**
21. 1334380 sec.	*27.* 60855 in.
22. 2441 pts. l.-m.	*28.* 39997½ sq. ft.

29. How many pills of 2 gr. each can be made from 2 lb. 6 ℥ 3 ℨ 3 ℨ 2 ℈ of quinine?

30. How many times will a wagon-wheel 12 ft. 10 in. in circumference, revolve in going 4 mi. 50 rds.?

31. How long, working 8 hrs. a day, will it require to count $1000000 at the rate of $50 a minute?

32. How many half-gill ink wells can be filled from 7 gallons of ink?

33. If the income from a store averages 5 cents a minute, what will it amount to during the three summer months?

34. Sound travels about 1100 feet per second. How far away was a flash of lightning when the sound of the thunder reached me $6\frac{3}{4}$ sec. later than I saw the flash?

35. A farm 230 rds. long and 180 rds. wide is worth a cent per. sq. yd. What is its total value?

36. From 3 T. 18 cwt. of grain a dealer sells sacks containing 16 lbs. 4 oz. How many such sacks will there be?

37. If the grain in the last example were oats, and the sacks contained 1 bushel 2 pecks 4 quarts each, how many would there be?

198. II. In the **addition of compound numbers** it is necessary to set *similar units in the same column; add each column, beginning at the right; simplify the sum of each column by reduction ascending.*

Ex. 1. Add:

	mos.	das.	hrs.	min.
	5	12	15	22
	6	5	17	48
	3	18	16	17
		6	0	8
1 yr.	3	13	1	35

EXPLANATION.—The sum of the minutes is 95, which reduces to 1 hour and 35 minutes. We set down the 35 min. and add 1 hr. with the hrs. column. The sum of the hours is 49, which reduces to 2 das. and 1 hr. We set down the 1 hr. and carry the 2 das. to the column of das. Proceeding in like manner, the entire sum is 1 yr. 3 mos. 13 das. 1 hr. 35 min.

Ex. 2. Add:

This process is the same as in Ex. 1, except that the $\frac{1}{2}$ yd. obtained as part of the sum of the yds. column is reduced to 1 ft. 6 in. and added with the ft. and in.

	mi.	rds.	yds.	ft.	in.
	4	120	3	2	2
	12	18	1	1	6
	5	212	2	2	8
	22	31	$2\frac{1}{2}$	0	4
			$(\frac{1}{2} =)$	1	6
	22	31	2	1	10

EXERCISE 85.

Add:

1.

5 cwt.	81 lbs.	14 oz.
9 cwt.	70 lbs.	8 oz.
4 cwt.	97 lbs.	12 oz.

2.

7 yr.	123 da.	9 hr.	17 min.	40 sec.
3 yr.	96 da.	13 hr.	44 min.	53 sec.
5 yr.	215 da.	21 hr.	52 min.	28 sec.

3.

lb.	oz.	pwt.	gr.
15	10	18	14
9	4	13	21
23	9	7	6
1	11	15	22

4.

lb.	℥	ʒ	∋	gr.
3	7	5	2	15
4	10	6	1	17
11	9	4	2	8
7	0	3	0	19

5.

bu.	pk.	qt.	pt.
7	3	5	1
4	2	6	0
10	3	7	1
15	0	4	0

6.

bbl.	gal.	qt.	pt.	gi.
5	27	3	1	2
4	19	1	0	3
16	21	2	1	0
20	5	0	1	2

7.

£	s.	d.	far.
5	10	6	1
3	15	11	3
7	14	8	2
9	5	9	0

8.

cu. yd.	cu. ft.	cu. in.
7	20	1115
3	19	1076
10	13	263
17	26	709

9.

mi.	rd.	yd.	ft.	in.
10	255	4	1	10
33	163	3	2	7
28	75	0	0	9
17	239	5	2	5
22	190	4	1	6

10.

A.	sq. rd.	sq. yd.	sq. ft.	sq. in.
5	145	26	6	109
3	108	30	7	128
7	95	17	3	105
4	82	21	8	96
10	150	11	7	117

11. 7 T. 5 cwt. 63 lb. 4 oz.; 10 T. 16 cwt. 90 lb. 13 oz.; 17 T. 8 cwt. 48 lb. 9 oz.; 8 T. 14 cwt. 56 lb. 10 oz.

12. 8 mi. 156 rd. 4 yd. 2 ft. 6 in.; 7 mi. 97 rd. 3 yd. 10 in.; 5 mi. 2 yd. 1 ft. 9 in.; 296 rd. 4 yd. 2 ft.; 3 mi. 4 yd. 2 ft. 8 in.

13. 5 yr. 153 da. 9 min. 59 sec.; 24 yr. 260 da. 8 hr. 45 sec.; 270 da. 15 hr. 58 min.; 13 yr. 21 hr. 43 min. 28 sec.; 60 da. 55 min.

14. 23° 14′ 15″; 68° 23′ 44″; 13° 46′ 35″; 9° 1′ 7″.

15. 1 A. 30 sq. yd. 5 sq. ft. 112 sq. in.; 9 A. 80 sq. rd. 7 sq. ft.

38 sq. in.; 31 A. 136 sq. rd. 8 sq. ft. 100 sq. in.; 75 sq. rd. 47 sq. in.

16. 7 lb. 9 ℨ 7 ℥ 2 Ə 16 gr.; 3 lb. 5 ℨ 9 gr.; 8 ℨ 3 ℥ 1 Ə; 30 lb. 11 ℨ 1 Ə 11 gr.

199. III. **Subtraction of compound numbers.**

Ex.   From   5 mi. 32 rds. 4 yds. 2 ft.
      Subtract 3 mi. 125 rds. 5 yds. 1 ft.

OPERATION.

mi.	rds.	yds.	ft.
5	32	4	2
3	125	5	1
1	226	4½	1
		(½ =)	1 6 in.
1	226	4	2 6 in.

EXPLANATION.

We write similar units in the same column, and begin with the right-hand column. 1 ft. from 2 ft. leaves 1 ft.; 5 yds. is more than 4 yds.; hence, it is necessary to borrow 1 rd. (or 5½ yds.) from 32 rds. Adding 5½ yds. to 4 yds., we get 9½ yds.; 5 yds. subtracted from 9½ yds. leaves 4½ yds. Similarly, we borrow 1 mile, or 320 rds., from 5 miles, and add it to 31 rds., and then subtract 125 rds. from 351 rds., giving 226 rds. as a remainder. Hence, we obtain, 1 mi. 226 rds. 4½ yds. 1 ft. as the difference; it is necessary, however, to reduce ½ yd. to 1 ft. 6 in. to get the result in the most convenient shape, which gives as a final result

1 mi. 226 rds. 4 yds. 2 ft. 6 in.

200. Difference between Two Dates.—In finding the interval of time between two dates, 30 days are usually reckoned as 1 month, and 12 months as 1 year. If hours are included, the reckoning is made to begin at 12 o'clock midnight.

Ex. How many years, months, and days between Oct. 19, 1895, and June 6, 1898?

yrs.	mos.	das.	
1898	6	6	
1895	10	19	
2	7	17,	*Result.*

EXERCISE 86.

Subtract:

1.					*2.*					*3.*				
bbl.	gal.	qt.	pt.		T.	cwt.	lb.	oz.		lb.	℥	ℨ	Ə	gr.
9	24	2	1		8	11	47	10		5	8	5	2	7
1	19	3	0		4	15	50	8		2	10	6	0	15

4.				*5.*				*6.*		
cu. yd.	cu. ft.	cu. in.		gal.	qt.	pt.	gi.			
55	14	328		27	2	0	3	.48°	19′	7″
41	23	1518		18	3	1	2	39°	41′	32″

7.					*8.*				
mi.	rd.	yd.	ft.	in.	A.	sq. rd.	sq. yd.	sq. ft.	sq. in.
38	111	3	2	5	75	108	21	5	46
26	244	4	2	8	38	150	6	7	125

9.			*10.*			*11.*				
						mi.	rd.	yd.	ft.	in.
180°	0′	5″	180°	0′	0″	120	251	0	2	0
76°	34′	48″	125°	39′	46″	89	300	4	2	9

12. From 7 bbl. 9 gal. 1 qt. take 3 bbl. 25 gal. 1 pt. 2 gi.

13. From 99 mi. 4 yd. 6 in. take 30 mi. 166 rd. 5 yd. 2 ft. 10 in.

14. From 83 A. 115 sq. rd. take 76 A. 139 sq. rd. 25 sq. yd. 118 sq. in.

15. From 17 T. take 3 T. 16 cwt. 49 lb. 15 oz.

16. From 360° take 315° 46′ 50″.

17. From the sum of 9 mi. 4 yd. 2 ft. 8 in. and 18 mi. 130 rd. 1 ft. 10 in. take 25 mi. 275 rd. 5 yd. 2 ft. 11 in.

18. From the difference between 5 A. and 85 sq. rd. 19 sq. yd. 108 sq. in. take the sum of 1 A. 99 sq. rd. 130 sq. in. and 2 A. 83 sq. rd. 19 sq. yd. 8 sq. ft. 116 sq. in.

Find the difference in years, months, and days between the following pairs of dates.

19. Feb. 18—Nov. 30. | *20.* Mch. 25—Dec. 5.

21. June 8, 1875—Oct. 15, 1879.

22. Feb. 22, 1732—Dec. 14, 1799.

23. Dec. 14, 1834—Jan. 13, 1858.

24. Dec. 5, 1870—June 23, 1897.

25. Oct. 12, 1887—Aug. 9, 1892.

26. Apr. 30, 1817—Feb. 2, 1903.

27. Add to Aug. 25, 1900, 7 yrs. 4 mo. 15 da.

28. When was a man born who died Oct. 18, 1875, aged 92 yrs. 11 mo. 26 da.?

29. A man was born Jan. 23, 1810, and lived 71 yrs. 3 mo. 24 da. What was the date of his death?

30. Mr. Smith was born Nov. 8, 1850, and his son, Jan. 17, 1877. On what day is the son half as old as his father? How old was each Jan. 1, 1901?

201. III. **Multiplication of compound numbers.**

Ex. If one lot is 5 rds. 2 yds. 2 ft. wide, how wide are 7 lots?

OPERATION.			EXPLANATION.
rds.	yds.	ft.	We write the multiplier under the lowest
5	2	2	unit of the multiplicand. 7 times 2 ft. are
		7	14 ft., or 4 yds. and 2 ft. We set down the
38	1½	2	2 ft. and reserve the 4 yds. to be added to the
	(½ =)	1 6 in.	next product.
38	2	0 6	

7 times 2 yds. gives 14 yds.; 14 yds. + 4 yds. = 18 yds., or 3 rds. and 1½ yds. We set down 1½ yds. and add 3 rds. to the product of 5 rds. by 7, obtaining 35 rds. + 3 rds., or 38 rds. Hence, the product in its first form is 38 rds. 1½ yds. 2 ft. Reducing ½ yd. to 1 ft. 6 in., this result simplifies into 38 rds. 2 yds. 0 ft. 6 in.

EXERCISE 87.

Multiply:

1. £8 15 s. 9 d. 3 far. by 6.

2. 11 T. 13 cwt. 95 lb. 12 oz. by 5.

3. 5 bbl. 25 gal. 3 qt. 1 pt. 2 gi. by 3.

4. 15 yr. 247 da. 19 hr. 25 min. 40 sec. by 8.

5. 27 lb. 8 ʒ 5 ʒ 1 Ə 9 gr. by 13.

6. 12 mi. 45 rd. 3 yd. 2 ft. 8 in. by 10.

7. 9 mi. 156 rd. 2 ft. 10 in. by 15.

8. 8 A. 125 sq. rd. 26 sq. yd. 7 sq. ft. 131 sq. in. by 9.

9. 12 A. 130 sq. rd. 18 sq. yd. 5 sq. ft. 88 sq. in. by 7.

10. 7° 17′ 45″ by 15. | *11.* 82 bu. 3 pk. 7 qt. 1 pt. by 13.

12. If a dealer cart 27 T. 5 cwt. 85 lb. of coal one day, how much will he cart in 3 weeks?

13. If a farmer plow 3 A. 107 sq. rd. 3 sq. yd. 5 sq. ft. in one day, how much will he plow in 8 days?

14. A certain coil of wire contains 280 rds. 4 yd. 1 ft. 3 in., how much will 25 such coils contain?

202. IV. The **division of compound numbers** may be of two kinds:

(1) The division of a compound number *by an abstract number,* that is, into a number of equal parts;

(2) The division of one compound number *by another compound number.*

Ex. 1. Divide 52 gal. 3 qt. 1 pt. by 9.

SOLUTION.			EXPLANATION.
gal.	qt.	pt.	We write the divisor to the left and divide the
9)52	3	1	highest denomination first. 9 is contained in 52 gals.
5	3	1	5 times, with a remainder of 7 gal. We set down the

5 and convert the 7 gals. into quarts, giving 28 qts. 28 qts. + 3 qts. = 31 qts. 9 is contained in 31 qts. 3 times, with a remainder of 4 qts. We set down the 3 and convert 4 qts. into 8 pts. 8 pts. + 1 pt. = 9 pts. 9 is contained in 9 pts., once. Hence, the quotient is 5 gals. 3 qts. 1 pt.

Ex. 2. Divide 56 lbs. 9 oz. 12 pwt. by 9 lbs. 5 oz. 12 pwt.

Reducing each compound number to the same lowest denomination.

$$56 \text{ lb. } 9 \text{ oz. } 12 \text{ pwt.} = 13632 \text{ pwt.}$$
$$9 \text{ lb. } 5 \text{ oz. } 12 \text{ pwt.} = 2272 \text{ pwt.}$$

2272)13632(6, *Quotient.*
13632

EXERCISE 88.

Divide:

1. 69 bu. 3 pk. 5 qt. 1 pt. by 5.

2. 14 yr. 128 da. 20 hr. 34 min. 44 sec. by 4.

3. 59 T. 4 cwt. 93 lb. 10 oz. by 6. | *4.* 228 gal. 1 qt. 1 gi. by 15.

5. 43 mi. 11 rd. 3 yd. 2 ft. 2 in. by 8.

6. 90 mi. 186 rd. 4 yd. 1 ft. 9 in. by 11.

7. 33 A. 116 sq. rd. 13 sq. yd. 6 sq. ft. 107 sq. in. by 7.

8. 53 A. 115 sq. rd. 8 sq. yd. 8 sq. ft. 108 sq. in. by 9.

9. 84 lb. 1 ℨ 6 ʒ 2 ϶ 11 gr. by 13.

10. From a bin of grain containing 325 bu. 3 pk. 7 qt., how many sacks may be filled, each holding 1 bu. 3 pk. 5 qt. ?

11. From a lot of wine amounting to 16 bbl. 2 gal. 1 qt., bottles containing 3 qt. 1 pt. 2 gi. are filled. How many are there?

12. If a lumberman get out 3 cd. 7 cu. ft. 712 cu. in. of wood a day, how many days will he require to prepare 55 cd. 5 cu. ft. 720 cu. in. ?

13. A farm containing 92 A. 50 sq. rd. 7½ sq. yd. is divided into house lots, each having an area of 20 sq. rd. 15 sq. yd. 5 sq. ft. How many will there be?

14. A lad walks 2 mi. 275 rd. 4 yd. an hour, how long will it take him to walk 22 mi. 285 rd. 4 yd. 1½ ft. ?

15. How many prescriptions, each weighing 1 ʒ 2 ϶ 10 gr., can a druggist make from 7 lb. 3 ℨ 7 ʒ 2 ϶ 8 gr. of quinine ?

16. If a nugget weighs 1 lb. 1 oz. 1 pwt. 1 gr., how many similar nuggets will be required to weigh 522 lbs. 1 oz. ?

APPLICATION TO LONGITUDE AND TIME.

203. Relation of Longitude and Time.—The earth revolves on its axis from West to East once in every 24 hours. As a result the sun appears to go round the earth from East to West in the same time. Hence, if we take a station on the earth at a given place, at all places east of that place any particular time, as noon, is earlier, since the sun arrives there earlier ; at all places to the west time is later, since the sun arrives there later.

Since the sun passes over 360° of longitude in 24 hours, in 1 hour it passes over $\frac{1}{24}$ of 360°, or 15° of longitude. In 1 minute of time it passes over $\frac{1}{60}$ of 15°, or 15' of longitude ; in 1 second of time it passes over $\frac{1}{60}$ of 15', or 15'' of longitude.

Stating these relations as a table :

15° of longitude = 1 hour of time.

15' of longitude = 1 minute of time.

15'' of longitude = 1 second of time.

By means of this table, if we know the difference of longitude between two places, we may determine this difference in time ; and, *vice versa*, if we know their difference in time, we may determine their difference in longitude.

In an old, well-settled country, of which maps have been made, the former relation is likely to be of use to the traveler, since he can obtain the difference in longitude between two places from a map or table, and then compute the difference in time. On the other hand, in exploring a new country the difference in time between places is known by the aid of chronometers, and it is necessary to determine the difference in longitude in order to make a map of the country, to determine distances in miles between places, etc.

EXERCISE 89.

ORAL.

1. On what and from what is latitude reckoned ?

2. On what and from what is longitude reckoned ?

3. What is the greatest latitude a place may have ? Where is that place ?

4. What is the greatest longitude a place may have ?

5. What is the least latitude a place may have ? Where are such places ?

6. What is the least longitude a place may have ? Where are such places ?

7. What point on the earth has neither latitude nor longitude ?

8. What class of men use latitude and longitude the most ? For what do they use it ?

9. What difference in longitude corresponds to a difference in time of 3 hours ? Of 5 hours ? Of 2 hrs. 3 min. ? Of 40 min. ? Of 50 min. ? Of 1 hr. 10 min. ? Of 30 sec. ? Of 10 min. 40 sec. ?

10. What difference in time corresponds to a difference in longitude of 30° ? Of 60° ? Of 45' ? Of 1° 30' ? Of 2° 30' ? Of 4° 30' ? Of 75° ? Of 135° ?

11. In which direction is the earth revolving on its axis ? Which direction does the sun appear to be moving ?

12. When it is noon at Chicago, is it morning or afternoon at Boston ?

At Denver? At New York? At Omaha? At San Francisco? At London? At Paris? At Washington, D. C.? At Galveston? At St. Louis? At Montreal? At Havana? At your home?

13. Arrange the places of Example 12 in a column, putting the city at which the sun rises first at the top and the city at which the sun rises last at the bottom, and the rest in order between.

204. I. **Given the difference in time of two places to determine their difference in longitude.**

Ex. The difference of time between Boston and Washington is 23 min. 47 sec. What is the difference of longitude?

Solution.

23 min. difference in time corresponds to 15' × 23,
or 5° 45' difference in longitude.
47 sec. difference in time corresponds to 15'' × 47,
or 11' 45'' difference in longitude.

Adding, 5° 45'
11' 45''
5° 56' 45'', *Difference in longitude.*

205. II. **Given the difference in longitude of two places, to determine the difference of time.**

Ex. The difference in longitude between New York and San Francisco is 48° 23' 45''. Find the difference in time.

Solution.

48° difference in longitude corresponds to $\frac{48}{15}$ hr.,
or 3 hr. 12 min. difference in time.
23' difference in longitude corresponds to $\frac{23}{15}$ min.,
or 1 min. 32 sec. difference in time.
45'' difference in longitude corresponds to $\frac{45}{15}$ sec.,
or 3 sec. difference in time.

Adding 3 hr. 12 min., 1 min. 32 sec., and 3 sec.,
we obtain 3 hr. 13 min. 35 sec., *Difference in time.*

If two places are both in east longitude, or both in west longitude, subtract in order to get their difference of longitude; if one is in east, the other in west longitude, add their longitudes in order to get the difference in longitude.

EXERCISE 90.

Determine the difference of longitude, having given the difference of time, as follows:

1. 1 hr. 25 min. 10 sec.
2. 5 hr. 0 min. 42 sec.
3. 7 hr. 55 min. 49 sec.
4. 9 hr. 31 min. 59 sec.

Find the difference of time between two places when the difference of longitude is as follows:

5. 43° 10'.
6. 77° 40' 15''.
7. 12° 7' 45''.
8. 69° 33' 30.''

9. The difference of time between New York and Paris is 5 hr. 5 min. 20 sec. What is the difference of longitude? At which city is it noon first?

10. The difference of time between Canton, China, and Cincinnati is 10 hr. 49 min. 52 sec. What is the difference of longitude?

11. The difference of longitude between two cities is 42° 8' 30'', what is the difference in time? When it is noon at the Western city, what is the time at the Eastern? When it is 10 A. M. at the Eastern city, what time is it at the Western?

12. When it is noon at the western of two points, whose difference of longitude is 75° 4' 45'', what is the time at the other? When it is 6.30 P. M. at the Eastern city, what is the time at the other?

13. When it is 12 o'clock at San Francisco it is 2 hr. 58 min. 23⅓ sec. P. M. at Rochester. What is the difference of longitude?

14. A ship's chronometer set at Greenwich points to 8 hr. 14 min. 56 sec. P. M. when the sun is on the meridian. What is the longitude of the ship?

15. Longitude of Galveston is 94° 46' 34'' W. and of Mobile is 88° 1' 19'' W. When it is 10 A. M. at Mobile, what time is it at Galveston?

16. When it is noon at San Francisco (long. 122° 26' 45'' W.)

it is 3 hr. 9 min. 7 sec. P. M. at Philadelphia. What is the longitude of Philadelphia?

[Note.—First find difference of longitude.]

17. Chicago is in long. 87° 37' 30" W. and Calcutta is 88° 23' 15" E. At 7 P. M. in Chicago what is the time in Calcutta? At 6 A. M. in Calcutta, what is the time in Chicago?

18. When it is 8 hr. 12 min. 48 sec. A. M. at Jerusalem (long. 35° 32' E.) it is 6 A. M. at Paris. Find long. of Paris.

19. When it is noon at Rome (long. 12° 27' 15" E.) it is 7 hr. 20 min. 59 sec. P. M. in Manila Bay. What is the longitude of Manila Bay?

20. The longitude of St. Joseph is 109° 41' 44" W. and of Canton is 113° 14' 1" E. What is their difference of longitude? Of time?

21. The difference of time between St. Paul (long. 93° 5' W.) and Havana is 42 min. 45 sec. What is Havana's longitude?

22. The difference of time between Boston (long. 71° 3' 30" W.) and Stockholm is 5 hr. 56 min. 28 sec. Find long. of Stockholm.

206. Standard Time.—Since 15° of longitude correspond to 1 hour of time, it has been found convenient to divide the territory of a country into belts 15° wide, the time in each belt being determined by a meridian approximately central in the belt. Time determined in this way is called Standard or Railway time. The standard meridians in the United States and Canada are the 75th, 90th, 105th, and 120th (west from Greenwich), and the corresponding belts are said to have Eastern, Central, Mountain, and Pacific time. Standard time in the eastern part of a belt may thus be as much as a half hour ahead of true local time; and in the western part of a belt may be a half hour behind. Travelers in passing from one belt to another must change their time by one hour. The boundaries of belts have been made somewhat irregular, owing to the configuration of the country, local conveniences, etc. On the opposite page is a map showing the standard time belts in the United States.

MAP SHOWING STANDARD TIME BELTS
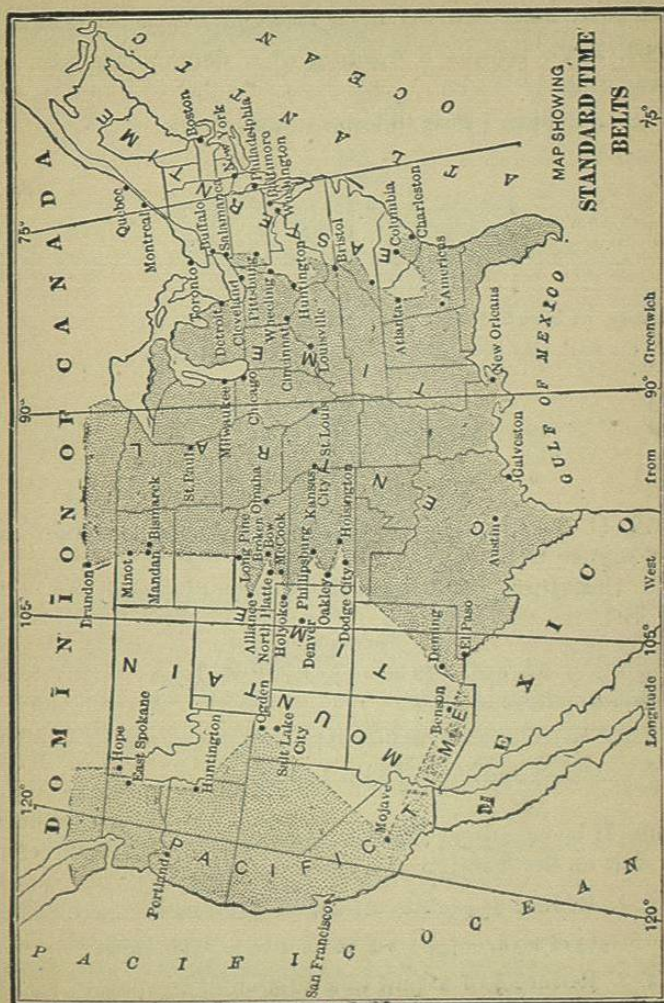
COMMON FRACTIONS AND DENOMINATE NUMBERS.

207. I. To reduce a fraction of a denominate unit to lower units.

Ex. 1. Reduce $\frac{2}{3}$ mile to lower units.

Solution.

$\frac{2}{3}$ of a mi. $= \frac{2}{3} \times 320$ rods. $= 213\frac{1}{3}$ rds.

$\frac{1}{3}$ of a rd. $= \frac{1}{3} \times 5\frac{1}{2}$ yds. $= 1\frac{5}{6}$ yds.

$\frac{5}{6}$ of a yd. $= \frac{5}{6} \times 3$ ft. $= 2\frac{1}{2}$ ft.

$\frac{1}{2}$ of a ft. $= 6$ in.

Hence, we have 213 rds. 1 yd. 2 ft. 6 in., *Result.*

Or the work may be expressed as an example in division.

Operation.

mi.	rd.	yd.	ft.	in.
3)2	0	0	0	0
0	213	1	2	6, *Result.*

208. II. To express a denominate number as a fraction of a higher unit.

Ex. 1. Express 2 ft. 8 in. as the fraction of a yard.

Solution.

2 ft. 8 in. $= 32$ in. $= \frac{32}{36}$ yd. $= \frac{8}{9}$ yd., *Result.*

Or we may proceed as follows:

8 in. $= \frac{2}{3}$ ft.

$2\frac{2}{3}$ ft. $= \frac{2\frac{2}{3}}{3}$ yd. $= \frac{8}{9}$ yd., *Result.*

209. It is sometimes required to express the fraction of one unit as the fraction of a lower or higher unit.

Ex. 1. Reduce $\frac{1}{720}$ yd. to a fraction of an inch.

$\frac{1}{720}$ of 1 yd. $= \frac{1}{720} \times 3 \times 12$ of 1 in. $= \frac{1}{20}$ in., *Result.*

Ex. 2. Reduce $\frac{8}{9}$ of a pint to a fraction of a gallon.

$\frac{8}{9}$ pt. $= \frac{8}{9} \times \frac{1}{2} \times \frac{1}{4}$ of a gal. $= \frac{1}{9}$ gal., *Result.*

EXERCISE 91.

Reduce to lower denominations:

1. $\frac{7}{8}$ mi.
2. $\frac{2}{3}$ t.
3. $\frac{8}{9}$ lb. T.
4. £$\frac{19}{64}$
5. $\frac{8}{27}$ yr.
6. $\frac{25}{72}$ degree.
7. $\frac{7}{36}$ sq. rd.
8. $\frac{7}{96}$ bbl.
9. $\frac{11}{15}$ lb. Ap.
10. $\frac{7\frac{1}{2}}{}$ cu. yd.
11. $\frac{49}{64}$ bu.
12. $\frac{25}{29}$ acre.

13. $\frac{7}{3000}$ day to min.
14. $\frac{9}{1600}$ bu. to pts.
15. $\frac{13}{17820}$ sq. rd. to sq. in.
16. $\frac{19}{158400}$ mi. to in.
17. $\frac{17}{5840}$ yr. to hr.
18. $\frac{31}{1260}$ bbl. to pt.

Reduce:

19. 4 hr. 30 min. to the fraction of a day.
20. 3 pk. 4 qt. 1 pt. to the fraction of a bushel.
21. 8 oz. 13 pwt. 8 gr. to lb.
22. 248 rd. 4 yd. 2 ft. 8 in. to mi.
23. 47 sq. rd. 12 sq. yd. 2 sq. ft. 132 sq. in. to A.
24. 2 qt. 1 pt. 2 gi. to gallons.
25. 6 da. 17 hr. 16 min. 48 sec. to weeks.
26. 6 cwt. 43 lb. $9\frac{3}{5}$ oz. to ton.

Add:

27. $\frac{1}{3}$ mi. $\frac{1}{2}$ rd. $\frac{3}{4}$ ft.
28. $\frac{5}{9}$ yr. $\frac{3}{8}$ da. $\frac{7}{8}$ hr.
29. $\frac{2}{5}$ lb. $\frac{1}{3}$ oz. $\frac{1}{4}$ pwt.
30. $\frac{2}{3}$ A. $\frac{1}{4}$ sq. rd. $\frac{15}{16}$ sq. yd.

Find the difference between:

31. $\frac{19}{27}$ A. and $\frac{7}{8}$ sq. rd.
32. $\frac{1}{9}$ mi. and $\frac{10}{11}$ rd.

DECIMAL FRACTIONS AND DENOMINATE NUMBERS.

210. I. To reduce the decimal of a denominate unit to lower units.

The method of this reduction is best shown by an example.

Ex. Express 0.425 gal. as quarts and pints.

Solution.

0.425 gal. $= 4$ qt. $\times 0.425 = 1.7$ qt.

0.7 qt. $= 2$ pt. $\times 0.7 = 1.4$ pt.

1 qt. 1.4 pt., *Result.*

211. II. To express a denominate number as the decimal of a higher unit.

Ex. Express 5 mo. 12 da. as the decimal of a year.

SOLUTION.

$$12 \text{ da.} = \frac{12}{30} \text{ mo.} = 0.4 \text{ mo.}$$

$$5.4 \text{ mo.} = \frac{5.4}{12} \text{ yr.} = 0.45 \text{ yr.,} \textit{ Result.}$$

EXERCISE 92.

Reduce to integral values in lower denominations:

1. .875 wk.	*5.* .842 mi.	*9.* .375 cu. yd.
2. .925 lb. T.	*6.* .423 A.	*10.* .046 mi.
3. .8324 T.	*7.* .576 lb. Ap.	*11.* .45 bbl.
4. .575 bu.	*8.* .0813 yr.	*12.* .175 A.

13. Find the value of 2.1365 months.

14. What is the sum of .14 mi. and .26 rd. ?

15. What is the difference between .35 yr. and .48 mo. ?

Reduce to the decimal of the next higher unit:

16. 7' 50″.	*19.* 3 oz. 8 pwt. 12 gr.
17. 204 rd. 4 yd. 2 ft.	*20.* 3 da. 22 h. 4 min. 48 sec.
18. 16 cwt. 55 lb. 5 oz.	*21.* 2 pk. 4 qt. 1⅗ pt.

EXERCISE 93.

GENERAL. ORAL.

1. What will a rod of wire cost at a cent an inch ?

2. Bought a peck of nuts at 10 ct. a pt. Find the cost.

3. A grocer paid 18 ct. a doz. for some eggs and sold them at 35 ct. a score. What was his gain on each egg ? What was his gain on a dozen ? On a score ? On a hundred ?

4. How many pint bottles can be filled from 25 half-gal. jars of wine ? From 20 gallons ?

5. I bought calico at half a cent an inch, and sold it at 6 yards for a dollar. Did I gain or lose ? How much on a yard ?

6. A grocer buys tomatoes at 25 ct. a bushel and retails them at the rate of 2 qts. for 5 cents. How much does he gain on a bushel ?

7. How many dozen in 7 score and 10 ?

8. How many square inches on a surface 3 inches square ? On one 8 in. square ? 2 ft. square ?

9. How many cubic inches in a 4-in. cube ? In a 6-in. cube ? In a 1-ft. cube ? In half a cubic foot ?

10. A dealer buys a half dozen saws at $30 a score, and sells them so as to gain 50 cents apiece. What is the selling price of each ?

11. How many feet in 17 fathoms ? 28 fathoms ?

12. How many hands are equal to 6 ft. ? To 7½ ft. ?

13. Which are the next 3 leap years ? How do you tell the leap years ? Will 1926 be a leap year ?

14. What was the first day in the 18th century ? The last day ? Which century were you born in ? In which century is Dec., 1900 ? How many leap years in the 20th century ?

15. What is the greatest difference of longitude two places can have ? What is the longitude of your nearest city ? Its latitude ?

16. Which is heavier, a pound of gold or a pound of meat ? An ounce of which of these is the heavier ?

17. How would you find the number of cu. in. in a barrel containing 31½ gallons ? In 10 bushels ?

18. How would you find the number of gallons that a bin, containing 100 bushels, will hold ?

19. Which is the greater quantity, 6 dozen dozen or half a dozen dozen ?

EXERCISE 94.

GENERAL REVIEW.

1. From ⅝ A. take 75 sq. rd. 27 sq. yd. 5 sq. ft. 75 sq. in.

2. Reduce 25 da. 16 hr. 50 min. to the decimal of a week.

3. Add .07 year, 1⅖ day, and ⅞ hr.

4. What would 8 gal. 2 qt. 1 pt. of wine cost at $6 a gallon ?

5. If a cubic foot of water weigh 62.5 lbs., how many cu. yds. in a ton of water ? How many ounces does a cu. in. of water weigh ?

6. How many steps, of 28 in. each, must a man take in walking 7 mi. 120 rds. ?

7. If a man walk 64 mi. 256 rds. in 20 hr. 15 min., how long will he require to walk 31 mi. 64 rds. ?

8. How far will the same gentleman walk in 6 hrs. 45 min. at the same rate ?

9. A baker pays $4.90 for a barrel of flour. He bakes it into 2-lb. loaves of bread, which he sells at 7 cents each. What is his gain?

10. When it is 15 min. after 10 A. M. at a certain city, what is the time at a western city if the longitude is 48° 7′ 30′′ greater?

11. At an observatory the sun is seen to have passed through 12° 51′ 45′′ since noon. What time is it?

12. A dozen spoons, each weighing 1 oz. 8 pwt. 20 gr., were sold at $1.50 an oz. What was the total price?

13. If I buy a 5-gal. can of oil for 45 cents and spill 2 pints, what do I really pay for each gallon that I use?

14. A wholesale grocer bought 2 T. 12 cwt. 60 lbs. cheese for $313.50, and retailed it at ¾ ct. an oz. Find his gain.

15. From a farm containing 80 A. 60 sq. rd. was sold a portion containing 38 A. 156 sq. rd., at $62.80 an acre, and the balance at $74.40. What was the total selling price?

16. What part of 4 gal. 3 qt. is 2 qt. 1 pt. 2 gi.?

17. What decimal of a rod is 1 ft. 7½ in.?

18. Find ⅞ of 5 bu. 2 pk. 6 qt. 1 pt.

19. How long is it between half-past nine P. M. of Jan. 17, 1834, and quarter before four A. M. of the following 4th of March? (Answer in days, hours, and minutes.)

20. If an express train travel 45 mi. an hour, how many feet does it move over each second?

21. If the diameter of a circle is 1 mile, the circumference is 3.141592 mi. Express this decimal in integers of lower units.

22. Which is the middle day of the year 1901?

23. If a family use 6 gas burners every evening of the winter months for 4 hours of each evening, and each burner consumes 18 ft. an hour, what will their gas bill be at $1.30 per thousand?

24. How many parcels, each weighing 3 lbs. 7 oz., can be made up from .924 T.?

25. If 6 horses eat 19 bu. 2¼ pk. of oats in 11 days, how long will 25 bu. 2 pk. 3 qt. supply 13 horses?

26. Take from 180° the sum of 71° 4′ 46′′ and 23° 55′ 39′′.

27. Find the value of 12⅘ cwt. + 39½ lb. + 7⅜ oz.

28. If 3 lbs. of wheat make 2 lbs. of flour, how many barrels of flour can be made from 343 bu. of wheat?

29. Reduce £1.0735 and .3764 mi. to integral values.

30. Change 11 oz. 18 pwt. 15 gr. to the decimal of a pound.

31. How many square feet in the surface of a box a yard long, 8 inches wide, and 18 inches deep?

32. A stream 25 yards wide and 25 feet deep flows 3 miles an hour. Find the number of cubic feet of water which passes a certain point in a minute.

33. How many revolutions will a wheel 9 feet 4 inches in circumference make in passing a field 54 rods 4 yards 2 feet 4 inches long?

34. Change 51830.7125 hours to years, days, hours, minutes, and seconds, reckoning 365 days to a year.

35. If a laborer dig a certain trench in 39 days, 4 hours, 10 minutes, how long will it require 8 laborers to dig a similar trench three times as long?

36. A box 7 feet long, 4 feet 4 inches wide contains 3½ cubic yards. How deep must it be?

37. A bin 12 feet 4 inches long and 6 feet 6 inches deep is to contain 100 bushels of grain. How wide must it be made?

38. If a mile of a certain wire weigh a ton, what is the weight in ounces of one foot of it?

39. Reduce 75 A. 95 sq. rd, 25 sq. yd. to the decimal of a square mile.

40. Change 2.12345 years to units of lower denominations.

41. From the sum of 17° 31′ 28′′ and 41° 19′ 22′′ take the difference between 81° 18′ 43′′ and 63° 31′ 52′′.

42. A cellar 20 yards long and 30 feet wide is to be dug. What depth will make 520 cubic yards?

43. When a locomotive is traveling 55 miles an hour, how many feet is it running each second?

44. If a train is running 40 feet 4 inches each second, how long will it require to run 90 miles?

45. Change 185 rods, 3 yards, 1 foot, 10 inches to the decimal of a mile.

46. Some numbers occur several times in the different tables of compound numbers. Collect all the times the number 12 occurs. Same for 8. Same for 60. Same for 3. Same for 24. Same for 16.

47. Change 3297.147 yds. to mi. rd. yd. ft. and in.

48. How many cubic feet in a box 4 ft. 3 in. wide, 4 ft. 6 in. long, and 8 in. deep?

49. From 180° take one-half the sum of 46° 18′ 39′′ and 57° 12′ 17′′. Also take one-half their difference from 180°.

50. The distance from the earth to the sun is 93,000,000 miles. How long would it take a boy who can run 11 ft. a second to traverse that distance? How long would it take a locomotive running a mile in 50 seconds?