BRUCES' INTRODUCTION

TO THE

USE OF THE GLOBES.

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AN

INTRODUCTION

TO

THE USE OF THE GLOBES.

INTENDED AS A MEANS OF

INCULCATING THE PRINCIPLES

OF

GEOGRAPHY AND ASTRONOMY.

BY E. AND J. BRUCE.

ELEVENTH EDITION.

ILLUSTRATED WITH NUMEROUS WOODCUTS.

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PREFACE.

The authors of this Treatise, in the course of an extensive experience as instructors of youth, arrived at the conclusion, "That one of the best methods of becoming acquainted with the principles of Geography, and also of obtaining an exact knowledge of the situation of places upon the earth, is by the Use of the Globes." Upon this principle the following work was prepared. If to the careful study of it the perusal of the narratives of our chief navigators and travellers be added, little else will be required in order to obtain a correct view of the physical and political condition of the earth and its inhabitants.

In order to meet the views of those whose period of instruction is too limited to admit of the requisite course of reading, a compendium of descriptive geography was added to the later editions of the work. By degrees, that which was at first but a trifling appendage has swollen into a Treatise of some size. Under these circumstances, the publishers, in order to suit the convenience of all parties, have resolved upon publishing, in a separate form, that portion of the work which originally constituted the whole—the Treatise on the Use of the Globes.

In preparing this edition for the press, few changes have been made. The great features of the earth and the heavens do not vary with the revolutions of empires. The progress of astronomical discovery, however, has required the insertion of much important information which was unknown to the original authors of the work.

Newcastle-upon-Tyne,
Jan. 28, 1850.

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INTRODUCTION

TO

THE USE OF THE GLOBES.

PART I.

CONTAINING PROBLEMS ON THE TERRESTRIAL GLOBE.

DEFINITIONS.

1. The *terrestrial globe* is a representation of the earth on a globular surface, showing the relative situations of the places upon it.

2. A *map* is a representation of the earth, or of a part of it, upon a plane surface.

3. The *axis* of the earth is an imaginary line passing through its centre, round which it turns from west to east, once in 24 hours.

This is represented in globes by the wire which passes through them, and on which they turn.

4. The *poles* are the two ends of the axis: one is called the *north*, and the other the *south* pole.

5. The *equator* is that line supposed to be drawn round the middle of the earth, at an equal distance from both poles: it divides the earth into two equal portions, called the *northern* and *southern hemispheres*.

The equator, when referred to the heavens, is called the *equinoctial*: it is sometimes called the *line*, or *equinoctial line*.

6. *Meridians* are lines drawn from one pole to the other, directly across the equator.

They are so called, because when any of them is, by the motion of the earth, brought directly opposite to the sun, it is mid-day (*meridies*) there.

As each place is in succession presented to the sun, the meridians must be considered as indefinite in number. Not to obscure the surface, they are usually drawn only through every five or ten degrees. On maps they always run from top to bottom.

The brass circle on which the globe hangs, and which is called the *brazen meridian*, may be made to represent the meridian of any place. It is divided into four parts, of 90° each*. On one semicircle the degrees are numbered from the equator towards the poles; on the other from the poles to the equator. The former is used in finding the latitude of places, the latter in elevating the globe.

7. *Latitude* is the distance of any place, north or south, from the equator.

The latitude of a place can never exceed 90°, that being the distance of the poles from the equator. It is reckoned by degrees and minutes on the brass meridian, but in maps at the sides.

8. The *longitude* of a place is the distance of the meridian of that place, east or west, from the first meridian.

On globes it is reckoned on the equator; but in maps at the top or bottom. Geographers in different countries have fixed upon different places for the *first meridian*. The Dutch have fixed upon the Peak of Teneriffe; the French reckon from Paris; and the English from the meridian of Greenwich. The greatest longitude any place can have is 180°, or half the circumference of the globe.

9. *Parallels of latitude* are circles drawn parallel to the equator.

The circles on the globe drawn to represent the parallels of latitude become smaller the farther they are distant from the equator; that representing the parallel of 60°, is only half the size of the equator. In all maps they are the lines drawn from one side to the other.

SECTION I.

PROBLEM I.

To find the Latitude and Longitude of any place.

BY THE GLOBE.—Bring the given place to the brass meridian; then the degree of the meridian directly over it shows the latitude, and the degree of the equator under the meridian shows the longitude.

* Every circle is, by geometers, divided into 360 degrees.

BY MAPS.—Ascertain with a pair of compasses the distance from the nearest parallel and meridian when these are not drawn through the place, and at one side and at the top or bottom of the map the degree of latitude and longitude will be found.

To distinguish East from West Longitude.

RULE.—If the figures increase towards the right hand, the longitude is *east;* if towards the left, it is *west.*

EXAMPLES.

1. Required the latitude and longitude of Edinburgh.

Bring Edinburgh below the meridian; we find, over it nearly, the 56th degree of North latitude (55° 58′), and the point where the meridian cuts the equator is nearly $3\frac{1}{4}$ (3° 12′) degrees west of London.

Required the latitude and longitude of the following capital cities of Europe.

2 London	7 Amsterdam	12 Lisbon
3 Copenhagen	8 Vienna	13 Madrid
4 Stockholm	9 Berlin	14 Rome
5 Petersburg	10 Presburg	15 Naples
6 Paris	11 Berne	16 Constantinople

Of the following sea-ports in Europe.

17 Dunkirk	20 Nice	23 Port Mahon
18 Genoa	21 Revel	24 Rochelle
19 Malaga	22 Ismael	25 Tornea

Of the following places situated in Asia.

26 Astracan	31 Cashgar	35 Calcutta
27 Tobolsk	32 Samarcand	36 Delhi
28 Irkutsk	33 Aleppo	37 Ispahan
29 Pekin	34 Ava, in Burmah	38 Mecca, in Arabia
30 Lassa		

EXAMPLES FOR MAPS OF ENGLAND AND GERMANY.

39 Newcastle	43 Portsmouth	47 Ulm
40 Hull	44 Plymouth	48 Frankfort on the Maine
41 Yarmouth	45 Bristol	
42 Dover	46 Liverpool	49 Leipsic

50 Hanover	52 Munich	54 Olmutz
51 Dresden	53 Magdeburg	55 Stralsund

PROBLEM II.

Having the Latitude and Longitude given, to find the place.

BY THE GLOBE.—Bring the given longitude to the brass meridian; then, under the given latitude marked on the brass meridian, is the place sought.

BY MAPS.—The latitude and longitude being found at the sides and ends of the Map, imaginary lines may, with the aid of a pair of compasses and ruler, be extended from these points, which will meet at the place required.

EXAMPLES.

1. What place is situated in 48° 23′ N. L. and 4° 39′ W. L. from London? Answ. Brest in France.

Required the names of the places situated in Africa, whose latitudes and longitudes are as follow :—

2.	30°	3′ N.	31°	21′ E.
3.	36	47 N.	10	16 E.
4.	12	45 N.	37	30 E.
5.	14	0 N.	33	0 E.
6.	34	29 S.	18	23 E.

Of these in America :—

7.	46°	47′ N.	71°	10′ W.
8.	39	57 N.	75	13 W.
9.	39	0 N.	77	10 W.
10.	19	26 N.	100	6 W.
11.	29	58 N.	89	59 W.
12.	0	13 S.	77	55 W.
13.	12	1 S.	76	49 W.
14.	34	35 S.	58	31 W.
15.	22	54 S.	44	44 W.
16.	6	0 N.	55	30 W.
17.	4	56 N.	52	15 W.

Of these islands in the Atlantic:—

18.	32°	37′ N.	16°	56′ W.
19.	37	47 N.	25	42 W.
20.	27	47 N.	17	46 W.
21.	15	10 N.	23	5 W.
22.	1	30 S.	7	20 W.
23.	7	57 S.	13	59 W.
24.	15	55 S.	5	49 W.

EXAMPLES FOR A MAP OF FRANCE.

Places seated on the River Seine.

25.	48°	18′ N.	4°	4′ E.
26.	48	34 N.	2	40 E.
27.	48	50 N.	2	20 E.
28.	49	26 N.	1	10 E.

Places on the Loire.

29.	46°	59′ N.	3°	9′ E.
30.	47	54 N.	1	54 E.
31.	47	24 N.	0	40 E.
32.	47	13 N.	1	33 W.

Places on the Rhone.

33.	45°	46′ N.	4°	49′ E.
34.	45	0 N.	4	50 E.
35.	43	57 N.	4	48 E.

PROBLEM III.

To find the Difference of Latitude between two places.

1. If the latitudes are of the same name, substract the less from the greater; if of contrary names, add them together.

In doing this and the next problem, either *globes, maps,* or *tables of latitude and longitude,* may be used.

When the two places are in opposite hemispheres, their latitudes being reckoned *different* ways, their sum must be taken; but when they are in the same hemisphere, their latitudes being reckoned the *same* way, their difference only must be taken.

EXAMPLES.

1. What is the difference of latitude between North Cape and C. Matapan in Europe? Ans. 34° 40′.

2. Between Tunis and C. of Good Hope? Ans. 71° 16′.

3. The middle of Nova Zembla and C. Comorin?

4. The mouth of Copper-Mine R. and Acapulco?

5. Between Cape Vela and Cape Horn, in S. America?

6. The south Cape of N. Holland and Torres Strait?

7. Between Cape Wrath and Lizard Point?

8. Dunkirk and Perpignan? 9. Madrid and Mexico?

10. Between London and Botany Bay?

11. St. Jago, one of the Cape Verd Is., and St. Helena?

12. The Cape of Good Hope and Cape Comorin?

13. Calcutta and Batavia? 14. Manilla and Canton?

What is the difference of latitude between the following sea-ports in Europe?

15. Archangel and Bergen?
16. Christiana and Gottenburg?
17. Stockholm and Tornea?
18. Petersburg and Dantzic?
19. Copenhagen and Hamburg?
20. Amsterdam and Dunkirk?
21. Brest and Bordeaux?
22. Corunna and Oporto?
23. Lisbon and Cadiz?
24. London and Genoa?
25. Newcastle and Leghorn in Italy?

Required the difference of latitude between,

26. St. Salvador and Surinam.
27. Porto Bello and Magellan's St.
28. Trinidad and Trincomalee.
29. Vera Cruz and Cape Horn.
30. St. Helena and Manilla in the Philippine Islands.

PROBLEM IV.

To find the Difference of Longitude and of Time between two places.

1. If the longitude of both places be of the same name, subtract the less from the greater; if of different names, add them together for the difference of longitude.

The distance of two places can never be greater than half the circumference of the globe, or 180°; when, therefore, at adding, the sum exceeds that, subtract it from 360°, for the true difference.

2. To find the difference of time, divide the number of

degrees thus ascertained by 15 for the answer in hours; if there be a remainder, multiply it by 4 for minutes.

To reduce Hours into Degrees.—Multiply them by 15.

The principle of these rules is this: the sun, in his apparent motion round the earth, does his daily journey of 360° in 24 hours, which is at the rate of 15° in an hour, or 1° in 4 minutes.

3. Another and perhaps easier way of reducing difference of longitude to time is the following:—Multiply the degrees and minutes by 4, and the product will be the answer in minutes and seconds. Thus, the difference of longitude between Lisbon and Philadelphia being,

$$\begin{array}{r r} & 66^\circ \quad 9' \\ & 4 \\ \hline 60) & 244 \quad 36 \\ \hline & 4\text{h.} \quad 24\text{m.} \end{array}$$

36s., the difference of time between the two places. Conversely; divide the time in minutes and seconds by 4, and the quotient will be the answer in degrees and minutes.

EXAMPLES.

1. What is the diff. of long. and time between Lisbon and Philadelphia? Ans. 66° 9'=4 hrs. 24 min.
2. What is the difference of longitude and time between Newcastle and Moscow? Ans. 39° 9'=2 hrs. 36 min.
3. Between Constantinople and Pekin?
4. Otaheite and Tongataboo, in the Pacific Ocean?
5. London and Quebec? 6. Acapulco and Macao?
7. Port Sir Francis Drake, in America, and Nankin?
8. Pico, one of the Azores, and Botany Bay?
9. Vera Cruz and Siam? 10. Bergen and Bombay?
11. Bermudas Islands and Island of Rhodes?
12. Mount Hecla and Mount Vesuvius?
13. Constantinople and Batavia?
14. Juan Fernandez and New Caledonia?
15. Easter Island and Tongataboo?
16. Marquesas and Navigators' Islands?
17. Christmas Island and the Pelew Islands?

18. Owhyhee and the Ladrone Islands?

19. Oonalashka, on the north-west coast of America, and Jesso, on the north-east coast of Asia?

EXAMPLES FOR A MAP OF EUROPE AND ASIA.

What is the difference of longitude between the following places?

20. Gibraltar and Barcelona?
21. Malaga and Naples?
22. Toulon and Venice?
23. Rome and Athens?
24. Corinth and Akerman?
25. Marseilles and Ancona?
26. Bilboa and Leghorn?
27. Genoa and Azof?
28. Bombay and Calcutta?
29. Smyrna and Canton?
30. Calicut and Aracan?
31. Ormuz and Okhotsk?
32. Mocha and Pondicherry?
33. Rhodes and Nankin?
34. Iscanderoon and Madras?
35. Surat and Batavia?

PROBLEM V.

To find all those places that have the same Latitude with a given place.

By the Globe.—1. Bring the given place to the brass meridian, and observe the latitude.

2. Turn the globe round, and all places that pass under the latitude will be those required.

By Maps.—1. If a parallel of latitude be drawn through the given place, observe all those places which lie on it.

2. If not, an imaginary line may be drawn evenly with the nearest parallel.

The variety of the seasons, and the difference of the lengths of the days and nights, depending upon the difference of latitude, all places that have the same latitude have their seasons exactly alike, except what difference may arise from the local situation of the place: they have also the days and nights of the same length at the same time; but the hours of the day are different.

EXAMPLES.

1. What places have the latitude of Stockholm?

Answ. Petersburg; Vologda; Narym and Okhotsk, in Asia; Lake Athabasca; Churchill Fort, on Hudson's Bay; Cape Chidley, in Labrador; Cape Farewell, in Greenland; and Mainland, one of the Shetland Islands.

2. What places have nearly the same lat. as Edinburgh?

Answ.—Elsinore, Memel, Polotsk, and Moscow, in Europe; Casan and Tomsk, in Asia; Behring's Island; and Alashka and Severn House, in America.

What places have nearly the same latitude as,

3. London?
4. Philadelphia?
5. Jerusalem?
6. Jamaica?
7. Quito?
8. St. Helena?
9. Cape of Good Hope?
10. Cook's St. in New Zealand?
11. Tranquebar?
12. Batavia?

PROBLEM VI.

To find all those places that have the same Longitude with a given place.

By the Globe.—Bring the given place to the brass meridian, and mark all the places then under the meridian, for the answer required.

By Maps.—Find the longitude of the given place; then observe all those places that are upon the same meridian, or that are situated at the same distance from the nearest meridian as the given place.

All places that have the same longitude have noon and midnight at the same time; the other hours of the day also correspond.

EXAMPLES.

1. What places have nearly the same longitude as London? *Answ.* Poictiers, in France; Valencia and Alicant, in Spain; Oran; and Cape Coast, in Africa.

2. What places have nearly the same longitude as Genoa? *Answ.* Christiansand, Bremen, Berne, Corsica, Sardinia, and Tunis.

What are the places whose longitude is nearly the same as that of the following?

3. Cape of Good Hope?
4. Petersburg?
5. Ispahan?
6 Pekin?
7. Jamaica?
8. Quebec?
9. Dublin?
10. Sandwich Islands?
11. Pelew Islands?
12. Stockholm?
13. Bombay?
14. Isle of Tinian?

QUESTIONS FOR EXERCISE IN SECTION I.

What are the latitudes and longitudes of,

1. Bergen?	5. Turin?	9. Candia?
2. Moscow?	6. Upsal?	10. Jeddo?
3. Elsinore?	7. Alexandria?	11. Lubeck
4. Barbadoes?	8. Prague?	12. Mocha?

What places correspond to the following latitudes and longitudes?

13.	33° 20′ N. L.	44° 24′ E. L.
14.	6 15 S. L.	106 25 E. L.
15.	36 31 N. L.	6 12 W. L.
16.	51 6 N. L.	13 31 E. L.
17.	49 59 N. L.	19 50 E. L.
18.	30 12 N. L.	91 20 E. L.

19. Lord Nelson obtained a victory over the French fleet near lat. 31° 11′ N., long. 30° 22′ E.: point out the place on the globe.

20. What places are in the same longitude as Moscow?

21. What places have the same longitude as Delhi?

22. What places have the same longitude as Astracan?

23. What places have the same longitude as Malacca?

24. Where else is it midnight when it is midnight at Lima?

25. In the summer of 1827 Captain Parry arrived at 82° 45′ N. lat. 20° E. long.: point out the place.

QUESTIONS FOR EXAMINATION IN SECTION I.

Into how many degrees is a circle divided? What is the axis of the earth? What are the poles? What is the equator? What are meridians? What is the brazen meridian? How is it divided and numbered? How are meridian lines drawn on maps?

What is latitude? How many kinds of latitudes are there? What is the greatest latitude any place can have? Are there any places that have no latitude?

What is longitude? Which is the first meridian? How is longitude marked upon the globe and upon maps? What are parallels of latitude? How are parallels of latitude drawn on maps?

How are the latitude and longitude of any place found upon the globe? How are they found upon maps? How may east longitude be distinguished from west?

The latitude and longitude of a place being given, how is the place found? How is the difference of latitude between places found? How is the difference of longitude found? What is the greatest difference of longitude that can be between two places? If, in finding the difference of longitude between two places of different names, the sum is more than 180°, how is the true difference found?

How are degrees reduced into hours, and the contrary? How are all those places found which have the same latitude as any given place? How are all those places found which have the same longitude with a given place? Have places of the same longitude the same hours of the day at the same time?

SECTION II.

DEFINITIONS.

1. The *horizon* is either *rational* or *sensible*.

2. The *rational horizon* is a great circle, dividing the upper from the lower hemisphere.

3. The *sensible horizon* is that circle which is the boundary of our sight, or which separates the visible from the invisible portion of the earth's surface.

The sensible horizon increases in proportion to the elevation of the spectator; thus a person at the top of a mountain has a more extensive prospect than another person at the bottom.

The horizon of a place varies according to its latitude and longitude.

The horizon, on the globe, is a circular flat piece of wood, which sustains the globe, and which represents the rational horizon. It contains several circles: the innermost is marked with the points of the mariner's compass; the next exhibits the twelve signs of the zodiac: beyond which is a calendar, showing the months and days of the months, corresponding with the signs and their respective degrees; these show the sun's place in the ecliptic, called the *sun's longitude,* for any given day.

4. The *zenith* is that point in the heavens directly over our heads, and is at an equal distance from all points of the horizon.

5. The *nadir* is that point in the heavens opposite the zenith, and is directly under our feet.

The zenith and nadir are the poles of the horizon, being each 90° distant from it.

The *quadrant of altitude* is a thin slip of brass or other material, divided into 90°, and is used to measure the distance of places, altitudes of the sun or stars, &c.

6. *Antœci* (from the Greek αντι-οικοι, dwelling opposite) are those who live under the same meridian but on

different sides of the equator, and at equal distances from it; or they are those that have the same longitude but opposite latitudes.

The appearances to the antœci are these:—

They have the same hours, but contrary seasons at the same time: thus, when it is noon to the one it is noon to the other, and when it is summer with the one it is winter with the other.

The days of the one are equal to the nights of the other; and the nights of the one to the days of the other.

The stars that never set to the one never rise to the other; and contrariwise.

Those who live at the equator have no antœci.

7. *Periœci* (from the Greek περι-οικοι, dwelling about or over) are those who live under opposite meridians but on the same side of the equator, and at equal distances from it; or they are those who have the same latitude but opposite longitudes.

The appearances to the periœci are these:—

The hours of the day, though nominally the same, are really contrary; for when it is noon with the one it is midnight with the other; and when it is two in the morning with the one, it is two in the afternoon with the other, &c.

They have the same seasons of the year at the same time.

The length of the day or night at any place is always the same as it is to the periœci of that place.

The sun and stars rise to both places on the same point of the horizon, and are the same number of hours above or below it.

The same stars that never rise or set to the one place never rise or set to the other.

Those who live at the poles have no periœci.

8. The *Antipodes* (from the Greek αντι-ποδες having the feet opposite) are those who live diametrically opposite to each other; or they are those who have both opposite latitudes and opposite longitudes.

A line, supposed to be drawn from any place through the centre of the earth, and continued to the opposite side, will point out the antipodes of that place. The north and south poles are antipodes to each other.

The appearances to the antipodes are these:—

The hours of the day are contrary, it being noon to the one when it is midnight to the other.

They have contrary seasons at the same time.

The days of the one are equal to the nights of the other; hence the shortest day to the one is the longest day to the other.

The sun and stars rise to the one when they set to the other, all the year round,—for they have the same horizon; but the zenith to the one is the nadir to the other.

Those stars that are always above the horizon of the one place are always under the horizon of the other.

PROBLEM VII.

To find the Antœci of any given place.

By the Globe.—Bring the given place to the meridian; and having found its latitude, count as many degrees from the equator towards the contrary pole, and the point thus arrived at will be the antœci required.

By Maps.—Having found the latitude and longitude of the place, find another place of the same longitude whose latitude is equal to the former, but of a contrary name.

EXAMPLES.

Required the antœci of the following places:—

1. Malta. *Answ.* Cape of Good Hope, nearly.
2. Potosi, in South America. *Answ.* Hispaniola.
3. Quebec. *Answ.* Patagonia, in South America.
4. Van Diemen's Land.
5. Madagascar (south point).
6. Cape Horn.
7. Juan Fernandez.
8. Kerguelen's Land.
9. Is. of Bermudas.
10. Falkland Isles.
11. Boston, U. S.
12. Azof.
13. Sandwich Is.

14. A ship in the Indian Ocean was in longitude 80° E. and in latitude 13° S.: required the antœci to that place.

Required the antœci to the following longitudes and latitudes:—

15.	114° E.	22° S.	21.	156° W.	20° S.
16.	30 E.	60 S.	22.	150 W.	17 N.
17.	41 E.	$21\frac{3}{4}$ S.	23.	173 W.	20 N.
18.	9 W.	39 S.	24.	151 E.	34 N.
19.	76 W.	18 S.	25.	165 E.	20 N.
20.	25 W.	15 S.	26.	$88\frac{1}{2}$ E.	$22\frac{1}{2}$ S.

PROBLEM VIII.

To find the Periœci of any given place.

By the Globe.—Bring the given place to the brass meridian, and set the index to 12.

Turn the globe till the index point to the other 12; that place, below the meridian, whose latitude is equal to that of the given place is the periœci required.

By Maps.—Subtract the longitude of the given place from 180, and the remainder will be the longitude of the periœci of a contrary name.

Find, by Prob. I., a place whose longitude is equal to this, and whose latitude is the same with that given.

EXAMPLES.

1. What place has its inhabitants the periœci of Newcastle-upon-Tyne? *Answ.* The Aleutian, or Fox Islands.

2. What place has its inhabitants the periœci of Quito? *Answ.* Podang, in the island of Sumatra.

3. Who are the periœci of California, in N. America?

Required the periœci of the following places:—

4. St. John's, Newfoundland.
5. Philadelphia.
6. Gulf of Siam.
7. Cook's Strait.
8. Mindanao.
9. Petersburg.
10. Sandwich Islands
11. Society Islands.
12. Martinique.

Required the periœci to the following latitudes and longitudes:—

13.	$179\frac{1}{2}$° E.	45° N.		17.	116° W.	40° N.
14.	132 W.	46 N.		18.	$102\frac{1}{2}$ W.	$28\frac{1}{2}$ N.
15.	$158\frac{1}{2}$ W.	45 N.		19.	84 E.	19 N.
16.	143 W.	$35\frac{1}{2}$ N.		20.	$127\frac{1}{2}$ E.	$47\frac{1}{2}$ N.

PROBLEM IX.

To find the Antipodes of any place.

Bring the given place to the brass meridian, observe the latitude, and set the index to 12. Turn the globe round till the index point to the other 12, count as many degrees from the equator towards the contrary poles as are equal to the latitude, and the place thus arrived at will be the antipodes required.

Or find the antœci of the given place, and the periœci of this will be the antipodes of the first place.

Or, bring the given place to any part of the horizon, and the place at the opposite point of the horizon will be the antipodes.

EXAMPLES.

1. What place is that the inhabitants of which are the antipodes to Pekin? *Answ.* Near the mouth of the river Sauces, or Colerado, in Patagonia.

2. Where are the antipodes of London? *Answ.* A little S. of New Zealand, in long. 180°, and 51° 30′ S. lat.

What are the antipodes of the following places?

3. Cape Horn.
4. Otaheite.
5. New Caledonia.
6. Buenos Ayres.
7. Falkland Islands.
8. Madrid.
9. Juan Fernandez.
10. Friendly Isles.
11. Philippine Isles.
12. Sierra Leone.
13. Pelew Islands, in the Eastern Archipelago.

14. A ship, in the Pacific Ocean, found its lat. $51\frac{1}{2}$° S. and long. 180°,—required the antipodes.

15. Suppose a line drawn from the island of Jamaica through the centre of the earth, in what part would this line meet the surface of the earth on the opposite side?

16. Required the antipodes to the Bermudas.

Required the antipodes of the following longitudes and latitudes :—

17.	73° W.	6° N.	23.	106° W.	15½° S.
18.	157 W.	37½ S.	24.	103 E.	12 N.
19.	98 E.	23 S.	25.	144½ W.	32 S.
20.	174 E.	16 N.	26.	165 E.	28 S.
21.	166 W.	38 S.	27.	175 E.	36 S.
22.	162 W.	60 S.	28.	177 E.	56 S.

PROBLEM X.

To elevate the Globe for the Latitude of any place.

Elevate the pole, which is of the same name with the latitude, as many degrees as are equal to it, and bring the given place to the brass meridian.

When the globe is rectified for the latitude of any place, that place is in the zenith, and the wooden horizon represents the rational horizon of the place.

EXAMPLES.

1. Elevate the globe for Lisbon.

Ans. The latitude of Lisbon is 39° N.; hence the north pole must be raised 39° above the horizon, and Lisbon brought to the brass meridian.

2. Elevate the globe for the Cape of Good Hope.

Ans. The Cape of Good Hope has 35° S. L.; hence the south pole must be raised 35° above the horizon, and the Cape of Good Hope brought to the meridian.

PROBLEM XI.

To find the Distance between two Places.

Case I.—When the distance is less than 90°.

1. Lay the quadrant of altitude over both the places, so that the division marked 0 may be on one of the places; then the degree cut by the other place will show the distance in degrees.

2. Multiply these degrees by 69½, and the product will be the distance in English miles.

It will in general be sufficiently accurate to multiply by 70.

Case II.—When the distance is greater than 90°.

1. Find the antipodes of one of the places, and by Case I, measure the distance between it and the other.

2. Subtract this distance from 180, and the remainder will be the whole distance required.

EXAMPLES.

Required the distance between London and

1. Copenhagen. *Ans.* 9°, = 625 miles.
2. Stockholm. *Ans.* 13°, = 903 miles.
3. Petersburg.
4. Amsterdam.
5. Paris.
6. Berlin.
7. Vienna.
8. Berne.
9. Lisbon.
10. Rome.
11. Constantinople.
12. Grand Cairo.
13. Jerusalem.
14. Madras.
15. Botany Bay.
16. Otaheite.
17. Manilla.
18. Navarino.

19. What is the length of Europe, from Lisbon, in the west, to the Uralian mountains, in the east?

20. How far is Constantinople from Pekin?

21. What is the breadth of N. America from the Promontory of Alashka to Cape Charles?

22. What is the breadth of S. America from Cape Blanco, in Peru, to Cape St. Roque, in Brazil?

23. What is the breadth of Africa from Cape Verd, in the west, to Cape Guardafui, in the east?

24. What is the distance between Cape Verd, in Africa, and Cape St. Roque, in America?

25. What is the distance between Panama, in America, and Manilla, one of the Philippine islands?

26. Between Bombay and Nootka Sound?

B

27. What is the distance between Newcastle and Malta, by way of Gibraltar?

28. The following is the track pursued by Captain Cook, in his first voyage,—required its length.

From Portsmouth to Cape Verd Isles.
Cape Verd Isles to Cape Horn.
Cape Horn to Otaheite.
Otaheite to New Zealand, Cape South.
Cape South to Port Hicks, in New Holland.
Port Hicks, in New Holland, to Endeavour Straits.
Endeavour Straits to Batavia, in Java.
Batavia, in Java, to the Cape of Gope Hope.
Cape of Good Hope to Ascension Island.
Ascension Island to the Azores.
Azores to England.

29. How many miles will be gone over in the following route:—from Newcastle to Carlisle, Lancaster, Liverpool, Shrewsbury, Birmingham, Gloucester, Bristol, Oxford, and London?

QUESTIONS FOR EXAMINATION IN SECTION II.

What are the antœci, and what is observed of their hours of the day and seasons of the year? What are the periœci, and what is observed of their hours of the day and seasons of the year? What are the antipodes, and what is observed of their hours of the day and seasons of the year?

How is the horizon distinguished? What is the sensible horizon? What is the rational horizon? What is the wooden horizon? Does it represent the sensible or rational horizon? What circles are marked upon the wooden horizon, and what is their use?

What is the zenith of any place, and what is the nadir? What is the quadrant of altitude, into how many degrees is it divided, and what is its principal use?

How are the antœci, the periœci, and the antipodes of any place found upon the globe, and how upon maps? Where must those people live who have no antœci? What point upon the globe has no periœci? Where are the antipodes to the north pole?

How is the globe elevated for the latitude of any place?

How is the distance of two places found, when that distance is less than 90°? How is the distance of two places found, when it is more than

90°? Why must degrees be multiplied by 69½ to bring them to English miles?

QUESTIONS FOR EXERCISE IN SECTION II.

Required the antœci answering to the following:

	Longitude.		Latitude.	
1.	33°	16′ E.	34°	30′ S.
2.	72	18 W.	19	46 S.
3.	170	0 W.	14	0 N.
4.	13	43 E.	38	10 S.

Required the periœci answering to the following:

5.	20°	0′ W.	56°	0′ N.
6.	83	2 W.	17	0 N.
7.	100	8 W.	11	42 N.

Give the antipodes corresponding to the following:

8.	171°	30′ E.	52°	0′ S.
9.	160	0 E.	63	20 S.
10.	176	6 W.	39	51 S.

11. Required the shortest distance between Africa and America.

12. Required the number of miles that an East India ship sails in her voyage from London to Madras.

13. How many miles must a ship sail in going from St. John's, in Newfoundland, to Nootka Sound,—and what is the difference between this distance and the direct distance between the two places

14. How many miles does a ship sail in her voyage from London to Botany Bay, supposing her to go in as straight a course as possible?

15. What is the distance between the north and south Poles?

Measure the distances between the following places on a map.

16. Ushant Island and Strasburg.
17. Calais and Montpellier.
18. Bordeaux and Narbonne.
19. Caen and Geneva.
20. Havre de Grace and Nice.
21. St. Maloe and Marseilles.
22. Toulouse and Paris.

SECTION III.

DEFINITION.

The *horary*, or *hour* circles, are small circles on the globe, placed at the north and south poles, having the hours of the day marked upon them, with an index to each.

THE TIME OF DIFFERENT PLACES COMPARED.

The earth, turning on its axis from *west* to *east*, causes a different part of its surface to be successively presented to the sun. When the meridian of a place is directly opposite the sun, it is noon to all places on that meridian.

The meridians which lie to the east will come opposite to the sun before those that lie to the west; and hence the people there will have noon so much sooner,—the other hours of the day will be proportionably advanced.

The earth taking 24 hours to turn round on its axis, the rate at which it turns per hour may be found by dividing 360 (the number of degrees in the circumference of the globe) by 24: the quotient, 15, is the number of degrees the earth turns in an hour. Thus, a place that lies 15° to the east will have noon one hour sooner; if it lie 30° or 45°, it will have noon two or three hours sooner; and so on in the same proportion.

Places that lie 15°, 30°, or 45° to the W. will have noon one, two, or three hours later; and so on in proportion.

PROBLEM XII.

The Hour being given at any Place, to find what Hour it is in any Part of the World.

1. Bring the place, at which the time is given, to the meridian, and set the index to the given hour.

2. Turn the globe till the other place come to the meridian, and the index will show the time required.

By Calculation.—Find the difference of longitude between the two places, and reduce it to time.

Add this difference of time to the given hour, if the place at which the time is required lie to the east; but subtract it, if it lie to the west.

1. If, in adding, the sum is greater than 12, take 12 away, and change the name from morning to afternoon hours, or *vice versa*.

2. If, in subtracting, the difference of time be greater than the given hour, add 12 to the given hour, and change the name.

3. By this problem the longitude of places is determined; for if by astronomical observation, or any other means, it can be known what hour it is at London, and at the place whose longitude is to be determined,

this difference of time, reduced to degrees, will give the longitude of that place; and which will be east or west, according as the time is sooner or later.

EXAMPLES.

1. What hour is it at Boston, in America, when it is 3 *p.m.* at London? *Ans.* 18 min. past 10 *a.m.*

This example performed without the globe.

The longitude of Boston is 70° 30′, which, in this example, is the difference of longitude = 4 hrs. 42 min. diff. of time.

Boston lying to the west, this must be subtracted; but the difference here being greater than the hour given, add 12 to the given hour, as directed in note 2, and change the name from *p.m.* to *a.m.*

Thus	3 hrs.	0 min.	*p.m.* given hour.
	12	0	added.
	15	0	
	4	42	difference of time, subtracted.
Ans.	10 hrs.	18 min.	*a.m.*

2. What is the hour at Pekin, when it is 9 *a.m.* at Lisbon? *Ans.* 22 min. past 5 *p.m.*

The difference of longitude is 125° 33′ = 8 hrs. 22 min.; and as Pekin is east of Lisbon, this must be added.

	9 hrs.	0 min.	*a.m.* given hour.
	8	22	difference of time.
	17	22	
	12	0	subtracted.
Ans.	5 hrs.	22 min.	*p.m.*

Having the hour given at one place, required the hour at the other place given in the following examples:

Place where time is given.	*Given time.*	*Place where time is required.*
3. Newcastle,	11 *a.m.*	Port Royal.
4. ———	7 *a.m.*	Madras.
5. ———	6 *p m.*	Pelew Islands.
6 ———	5 *a.m.*	Nootka Sound.

Place where time is given.	*Given time.*	*Place where time is required.*
7. London,	Noon	Society Isles.
8. Cairo,	9 *a.m.*	Botany Bay.
9. Lisbon,	11 *p.m.*	Canton.
10. Port Royal,	11 *a.m.*	Owhyhee.
11. Oporto,	6 *a.m.*	Damascus.
12. Warsaw,	10 *p.m.*	Astracan.
13. Naples,	9 *a.m.*	Lassa (Tibet).
14. Geneva,	4 *a.m.*	Quito.
15. Lyons,	Midn.	Mexico.
16. Edinburgh,	3 *p.m.*	Delhi.
17. Presburg,	6 *p.m.*	Surat.
18. Cherson,	1 *a.m.*	Charleston.
19. Venice,	2 *a.m.*	New York.
20. Constantinople,	8 *p.m.*	Lima.
21. Calcutta,	7 *a.m.*	Cayenne.
22. London,	Noon.	Nankin.
23. ———	4 *p.m.*	Rome.
24. ———	4 *p.m.*	Madras.
25. ———	4 *p.m.*	Barbadoes.

PROBLEM XIII.

Having the Hour given at any place, to find where it is Noon.

By the Globe.—Bring the given place to the meridian, and set the index to the given hour.

Turn the globe till the index point to 12 at noon, and the places then under the meridian are those required.

By Calculation.—Reduce the number of hours between the given time and noon into degrees, and it will be the difference of longitude between the places.

When the given hour is in the morning, the place where it is noon will lie so many degrees to the eastward; hence the difference of longitude must be added to the longitude of the given place, if it be E.; but substracted from it, if it be W.

When the hour is in the evening, the places where it is noon will lie to the westward of the given place : hence the difference of longitude must be added, if the longitude of the given place be W.; but subtracted if it be E.;—and the sum, or difference, will be the longitude of the places required.

1. If, in subtracting, the difference of longitude be greater than the longitude of the given place, subtract the latter from the former—and the remainder of a *contrary name* will be the longitude required.

2. If, in adding, the sum exceeds 180°, subtract it from 360°, and the remainder will be the required longitude, but of a *contrary name*.

3. By this problem, it may also be found where it is in any other given hour; only, instead of turning the globe till the index point to 12, turn it till it point to the given hour.

EXAMPLES.

1. Where is it noon, when is it 5 *p.m.* at Paris?

Calculation.—5 hours = 75° the difference of longitude. As the given hour is evening, the places where it is noon will lie to the west. The longitude of Paris is 2° 20′ E.: from this, according to the rule, 75° ought to be subtracted; but as that cannot be done, subtract 2° 20′ from 75° (as directed in note 1), and the remainder, 72° 40′, will be the longitude of the places required, and will be W., being of a contrary name. It will therefore be noon at Labrador, New England, Pennsylvania, St. Domingo, Terra Firma, Peru, &c.

2. Where is it noon, when it is 9 *a.m.* at Newcastle?

Answ. Nisney Novogorod, in Russia; Armenia and Georgia; Bagdad; the middle parts of Arabia; Mocha; the Strait of Babelmandeb; the north-east part of Africa; and the western coast of Madagascar.

3. When it is 7 *a.m.* at Kingston, in Jamaica, where is it noon? *Answ.* At London, and all other places which are situated under the meridian of London.

4. At 40 m. past 2 *p.m.* at Ispahan, where is it noon?

5. Where is it noon, when it is 1 *a.m.* at New Zealand?

6. Where is it noon, when it is midnight at London?

7. When it is 7 *a.m.* at Jerusalem, where is it noon?

8. When it is midnight at Mexico, where is it 9 *a.m.*?

9. Where is it noon, when it is 4 *a.m.* at Botany Bay?

10. Where is it midnight, when it is ½ past 10 *a.m.* at Bencoolen, in Sumatra?

11. When it is $4\frac{3}{4}$ *p.m.* at Paris, where is it noon?

12. At $\frac{3}{4}$ past 7 *a.m.* at Shiraz, where is it noon?

13. Being noon at London, where is it $\frac{1}{2}$ past 8 *a.m.*?

14. When it is 2 o'clock in the afternoon at London, at what place is it $\frac{1}{2}$ past 5 in the afternoon?

15. Being noon at Bombay, where is it $\frac{1}{2}$ past 6 *a.m.*?

16. When it is midnight at Brusa, where is it 3 *p.m.*?

17. When it is $\frac{1}{2}$ past 6 in the morning at Quebec, where is it 11 in the forenoon?

QUESTIONS FOR EXAMINATION IN SECTION III.

What are the horary circles? How does the earth turn on its axis? What is it that produces noon at any place? Do the meridians that lie to the east, or those that lie to the west, come sooner opposite to the sun?

How long is the earth in turning on its axis? At what rate does it turn per hour? How is that found? How many degrees of longitude make an hour's difference of time? To places that lie in 30° E. L. are the hours of the day more or less advanced than they are at London?

Having the hour given at any place, how is it found what hour it is a any other place? Having the hour given at any place, how is it found where it is noon?

QUESTIONS FOR EXERCISE IN SECTION III

When it is	*At*	*What time is it at*
1. 10 *a.m.*	London,	Calcutta and Canton?
2. 8 *a.m.*	Dublin,	Pelew Is., Barbadoes, and Lima?
3. Midnight	Rome,	Owhyee and Easter Is.?
4. 9 *a.m.*	London,	Botany Bay?
5. 1 *p.m.*	Dublin,	Boston, U. S.?

9. How much are the clocks at Barbadoes behind ours?

7. Where is it noon, when it is 3 *a.m.* at Newcastle?

8. Where is it noon, when it is 7 *p.m.* at Pekin?

9. When it is midnight at Mexico, where is it noon?

10. When it is 11 *p.m.* at Jamaica, where is it noon?

11. When it is 3 *a.m.* at Paris, where is it noon?

12. My watch was well regulated at London, and when I arrived at Madras, which was after a five months' voyage, it was 4 hours 50 min. slower than the clocks there. Had it gained or lost during the voyage, and how much?

13. When it is 7 *p.m.* at Edinburgh, what is the hour at Washington?

14. When it is 5 *p.m.* at Philadelphia, where is it midnight?

15. Are the clocks at Calcutta faster or slower than the clocks at London, and how much ?

SECTION IV.

DEFINITIONS.

1. The *ecliptic* is the circle described by the earth in its annual motion round the sun ; or it is that circle in which the sun *appears* to move.

The ecliptic is proper only to the celestial globe ; but, on account of its great use in performing many geographical problems, it is always drawn on the terrestrial : it crosses the equator obliquely, and extends 23° 28′ to the north of it on one side, and 23° 28′ to the south of it on the other side. The angle which it makes with the equator is called the *obliquity* of the *ecliptic.*

It is called the ecliptic, because eclipses happen when the moon is in or near this circle : it is divided into 12 equal parts, called signs, each containing 30 degrees ; they are thus marked and named :

Northern.

Spring.	Aries, or the Ram . . .	♈	Summer.	Cancer or the Crab . . .	♋
	Taurus, or the Bull . .	♉		Leo, or the Lion . . .	♌
	Gemini, or the Twins . .	♊		Virgo, or the Virgin . .	♍

Southern.

Autumn.	Libra, or the Balance . .	♎	Winter.	Capricornus, or the Goat .	♑
	Scorpio, or the Scorpion .	♏		Aquarius, or the Waterman	♒
	Sagittarius, or the Archer	♐		Pisces, or the Fishes . .	♓

The winter and spring signs are termed *ascending,* and the summer and autumnal *descending.*

2. The *tropics* are parallel to the equator, and distant from it 23° 28′ : that which lies on the north side is called the *tropic of cancer ;* and that which lies on the south side is called the *tropic of capricorn.*

The obliquity of the ecliptic determines the distance of the tropics rom the equator; as they are drawn parallel to the equator, through those two points of the ecliptic which are at the greatest distance from it. The northern tropic is called the tropic of cancer, because it passes through the sign cancer ; the southern, the tropic of capricorn, because it passes through the sign capricorn.

3. The *polar circles* are two circles which are parallel to the equator, and as far distant from the poles as the tropics are from the equator; that which lies towards the north pole is called the *arctic* circle, and that which is towards the south pole is called the *antarctic* circle.

The distance of the polar circles from the poles depends upon the obliquity of the ecliptic; their distance from the poles being 23° 28′, their distance from the equator is 66° 32′.

4. The *equinoctial points* are those points in which the equator and ecliptic cross each other; they are the first points of aries and libra.

5. The *solstitial points* are those two points of the ecliptic that are at the greatest distance from the equator, and at which the ecliptic touches the tropics: they are the first points of cancer and capricorn.

6. *Declination* of the sun is its distance north or south of the equator.

7. *Altitude* of the sun is its distance above the horizon.

8. The *analemma* is a calendar of the months, placed on some vacant part of the globe, extending from tropic to tropic: the months and days are so divided as to correspond to the sun's declination for every day in the year.

The days increase continually to all places in the northern hemisphere, whilst the sun is moving through the ascending signs, or from the first of capricorn to the first of cancer; *i. e.* from Dec. 21st to June 21st: but the contrary happens to all places in the southern hemisphere; the days there increasing whilst the sun moves from cancer to capricorn, or from June 21st to Dec. 21st.

As, at the equator, the days and nights are always equal, so, of all other places, those that are the nearer to the equator have the less inequality in their days and nights; and the greater the latitude of the place, the greater is the length of its longest day. The length of the longest day at any place is equal to the length of its longest night.

The sun's declination is *north* from March 21st to September 23rd, and *south* the remainder of the year. Its greatest declination, either north or south, is 23° 28′.

The sun's altitude, or height above the horizon, will be increasing to any place, whilst the days are increasing at that place; and its altitude on the same day will be different to places that have different latitudes: hence the sun's meridian altitude furnishes an easy method of determining the latitude of a place.

Of the length of the Days and Nights.

The sun shining upon the earth illuminates that half of it which is turned towards it; the enlightened part intercepts the sun's rays from the other half.

The horizon represents, on the globe, the boundary line between light and darkness.

In the problems respecting day and night, the sun is supposed to be in the zenith; his rays, therefore, which extend to the horizon, will spread exactly 90° in every direction.

As the earth turns round on its axis from W. to E., once in 24 hrs., every meridian will, in that time, successively enjoy the light of the sun, and be deprived of it.

Suppose a patch to be put upon a globe to represent any place, and the globe to be turned round from west to east; when the place comes to the western side of the horizon, the sun appears to the inhabitants of that place to be rising in the east; but it is more properly the inhabitants of that place rising in the west. Continue to turn the globe round, and the place will ascend higher towards the meridian, which causes the sun to appear to ascend in a contrary direction.

When the place has arrived at the meridian, it will then be noon there, and the sun will be at its greatest altitude for that day.

As you continue to turn the globe, the place will gradually recede from the meridian, and descend towards the eastern horizon,—which will cause the appearance of the sun descending towards the west. When the place has arrived at the eastern horizon, as it is then going below the terminator, or boundary of light and darkness, the sun will appear to be setting in the west.

The place having gone below the horizon, and being now at a greater distance than 90° from that point where the sun is vertical, is deprived of his light, and continues in darkness till, by the revolution of the earth, it arrive again at the western horizon,—when the sun will appear to rise as before.

It is evident that the sun will be rising at the same instant of time to all places that are on the western side of the horizon, and that it will be setting at the same time to all places that are on the eastern side.

Twice a year the days and nights are of the same length to all places upon the earth: these two days are when the sun is in the first of aries and libra, or March 21st, and September 23rd. These are called the *equinoxes*,—March 21st the *vernal*, and September 23rd the *autumnal equinox.*

On these days the sun's place is on the equator. Let the equator be placed in the zenith, and the poles be made to coincide with the horizon. Fix upon any number of places situated upon the same meridian of longitude, say the first, distinguish them by patches, bring them to the brass meridian, and set the index to 12 o'clock. Turn the globe till they come to the western horizon, and the index will then be six o'clock *a.m.*, which will be the hour of the sun's rising; continue to turn the globe from west to east, till the places have arrived at the eastern horizon, and the index will now point to six o'clock *p.m.*, the time of the sun's setting. Hence, the length of the day to all these places is twelve hours. Now if the same thing happens with any other places on any other meridian, say the opposite, it is evident that the days and the nights must be twelve hours to every place, or that they are equal all over the globe.

At all places under the equator the days and nights are always equal.

In proof of this it may be observed, that in whatever situation the equator may be placed, provided it be not parallel with the horizon, it is always cut by the horizon into two equal parts. The equator dips beneath the horizon on the one side exactly where it is marked east, and on the other where it is marked west; which two points are half a circle from each other.

In all places between the equator and the north pole the day is longest when the sun is in the first degree of cancer, June 21st,—and shortest when in the first of capricorn, Dec. 21st; but in those places between the equator and the south pole the contrary happens,—the day is shortest when the sun is in the first of cancer, and longest when in the first of capricorn. June 21st is called the *summer solstice*, it being then summer to all places in the northern hemisphere; and Dec. 21st, the *winter solstice*, it being then winter to the same places.

On the 21st of June, the sun is 23° 28′ to the north of the equator; his rays, which still extend 90° on all sides of him, will penetrate 23° 28′ farther north than they did when he was on the equator, and be withdrawn to the same extent from the south. To put the globe in the position which the earth will occupy with respect to the sun on the 21st June, raise the north pole 23° 28′ above the horizon. Then fix upon some places having the same longitude, taking care that one shall be in the south and another in the north frigid zone. On turning the globe from west to east it will be seen that the place in the north frigid zone never goes below the horizon, and that the one in the south frigid never rises above it, while of the other places, that will appear first upon the horizon whose latitude north is greatest. If the elevation of the north pole be diminished, it will be found that the length of the days to the places north of the equator lessens; and if the south pole be elevated, those parts possessing a southern latitude will have the same length of day which those of a northern latitude formerly enjoyed.

PROBLEM XIV.

To find the Sun's place in the Ecliptic.

1. Seek the given day in the calendar on the horizon, and against it, in the adjoining circle, will be found the sign and degree in which the sun is for that day.

2. Find the same sign and degree in the ecliptic, and this is the sun's place for that day at noon.

EXAMPLES.

What is the sun's place on the following days?

1. March 10th *Answ.* ♓ 20° 7′.
2. June 4th *Answ.* II. 13° 57′.
3. January 1st
4. February 2nd
5. March 3rd
6. April 4th
7. May 5th
8. June 6th
9. July 7th
10. August 8th

11. September 9th
12. October 10th
13. November 11th
14. December 12th
15. March 22nd
16. June 22nd
17. September 23rd
18. December 22nd.

PROBLEM XV.

To find the Sun's Declination.

Bring the sun's place for the given day to the brass meridian, and the degree over it will be the declination sought; or bring the day of the month marked on the analemma to the brass meridian, and the degree over it will be the declination, as before.

The sun's declination is given in several of the almanacks, and also in Table I. at the end of this work.

1. The declination of the sun being its distance N. or S. from the equator, this problem is the same as that for finding the latitude of a place.

2. The greatest north declination, 23° 28′, is when the sun enters cancer, June 21st, that being the greatest distance of the ecliptic north of the equator. The greatest south declination, 23° 28′, is when it enters capricorn, December 21st, that being the greatest distance of the ecliptic south of the equator.

EXAMPLES.

What is the sun's declination for the following days?

1. March 10th — *Answ.* 3° 54′ S.
2. January 31st — *Answ.* 17° 14′ S.
3. April 23rd
4. August 12th
5. August 1st
6. March 5th
7. July 23rd
8. October 19th
9. On what days has the sun no declination?
10. When has the sun the greatest declination north?
11. When has the sun its greatest declination south?
12. What is the sun's declination for to-day?

PROBLEM XVI.

To rectify the Globe for the Sun's place on any day.

1. Find the sun's declination for the given day.

2. Elevate the pole, which is of the same name as the declination, as many degrees as are equal to it.

When the globe is rectified for the sun's place, and the sun brought to the zenith, the horizon will be the *terminator,* or boundary circle of light and darkness; it will therefore be day with those places that are above the horizon, and night with all that are below it.

EXAMPLES.

1. Rectify the globe for the sun's place on June 4th.

Answ. On June 4th the sun's decl. is $22\frac{1}{2}°$ N.; the north pole must therefore be raised $22\frac{1}{2}°$ above the horizon.

2. Elevate the globe for the sun's place on October 6th.

Answ. The sun's decl. on October 6th is 5° S.; hence the south pole must be elevated 5° above the horizon.

PROBLEM XVII.

To find the Rising and Setting of the Sun, and the Length of the Day and Night.

1. Elevate the globe for the sun's declination, bring the given place to the meridian, and set the index to 12.

2. Turn the globe till the given place come to the eastern edge of the horizon, and the index will show the time of the sun's rising.

3. Bring the place to the western edge of the horizon, and the index will show the time of its setting.

4. Double the time of the sun's setting for the length of the day, and of the sun's rising for the night.

If the hour circle have a double row of figures, make use of that which increases towards the *east;* the sun's rising and setting may then be found at once, by bringing the place only to the eastern edge of the horizon, for the index will point in one row to the hour of rising, and in the other (that which increases towards the *west*) to the hour of setting.

This problem may also be performed thus.

1. Elevate the globe for the latitude of the place, bring the sun's place to the meridian, and set the index to 12.

2. Bring the sun's place to the eastern horizon, and the

index will show the time of the sun's rising, and to the western edge for the time of setting.

EXAMPLES.

1. Required the time of sun-rise and sun-set at Edinburgh on June 1.

Answ. Rises 3 h. 27 m.; sets 8 h. 33 m.

2. At what time does the sun rise and set at London on July 17th, and what is the length of the day and night?

Answ. The sun rises at 4, and sets at 8; the length of the day is 16 hours, and the night 8 hours.

Required the rising and setting of the sun at

3. Pekin, April 10.
4. Newcastle, Oct. 13.
5. Gibraltar, Jan. 22.
6. Petersburg, June 21.
7. Hamburg, Dec. 21.
8. North Cape, Dec. 21.
9. Botany Bay, May 25.
10. London, Aug. 29.

At Cape Horn, on the following days:

11. Jan. 20.
12. March 2.
13. March 22.
14. April 6.
15. June 21.
16. July 21.
17. August 29.
18. October 14.

At Edinburgh, on the following days:

19. January 29.
20. March 2.
21. March 22.
22. April 6.
23. June 21.
24. July 12.
25. August 29.
26. October 14.

27. At Archangel, London, Vienna, Jerusalem, Quito, and Cape of Good Hope, on March 21st and Sept. 23rd.

What is the length of the longest and shortest day, and the difference between them, at the following places?

28. Archangel.
29. London.
30. Owhyhee.
31. Quito.
32. Quebec.
33. Cape of Good Hope.
34. Vienna.
35. Lima.
36. Alexandria.
37. St. Helena.
38. Washington.
39. Pekin.

40. Madras.
41. Borneo.
42. Calcutta.
43. Okhotsk.

What is the length of the day, and of the night, on December 26th, at the following places?

44. Dresden.
45. Turin.
46. Adrianople.
47. Shiraz.
48. Medina in Arabia.

49. What is the hour of the sun's rising at Pekin, Naples, and Philadelphia, on August 29th?

50. How much longer is the sun above the horizon, on June 21st, to Edinburgh than to London?

51. How much longer is June 21st at Petersburg, than at Jerusalem?

52. At what time does the sun rise and set at Spitzbergen, on April 5th?

PROBLEM XVIII.

To find the Sun's Meridian Altitude for any Day.

By the Globe.—1. Elevate the globe for the latitude of the given place; find the sun's place for the given day, and bring it to the brass meridian.

2. Fix the quadrant of altitude on the zenith, and bring it over the sun's place; then the degree upon the quadrant cut by the sun's place will be its meridian altitude.

Note.—The sun's meridian altitude may be found without the quadrant, by counting upon the meridian the number of degrees intercepted between the horizon and the sun's place.

By the Analemma.—Elevate the globe for the latitude, and bring the analemma to the brass meridian. The number of degrees intercepted between the day of the month marked on the analemma, and the nearest point of the horizon, either north or south, will be the meridian altitude required.

By Calculation.—1. Find, from the Table, the sun's declination for the given day.

2. If the declination be of the same name as the latitude, their *difference* will be the zenith distance.

3. If the declination and latitude be of different names, their *sum* will be the zenith distance.

4. The zenith distance, taken from 90°, will give the altitude.

To know whether the Sun's Meridian Altitude be North or South.

Rule.—1. When the declination and latitude are of different names, i. e. the one north and the other south, the altitude is always of the same name as the declination.

2. When the latitude and declination are of the same name, if the declination be the greater, the altitude is also of the same name, otherwise it is of a name contrary to that of the declination.

EXAMPLES.

Required the sun's meridian altitude, June 21st.

(1.) *At Archangel.*

Lat.	64°	34′	N.
Dec.	23	28	N. subtract.
	41	6	zenith dist.
	90	0	
	41	6	subtract.
Ans.	48	54	m. alt. *south*, the latitude being greater than dec.

(2.) *At Bombay.*

Dec.	23°	28′	N.
Lat.	18	57	N. subtract.
	4	31	zenith dist.
	90	0	
	4	31	subtract.
Ans.	85	29	altitude N., the declination being greater.

3. What is the sun's meridian altitude at the Cape of Good Hope on May 15?

The lat. 34° 29′ S. *added* to the dec. 18° 46′ N. gives 53° 15′ zenith dist., and this taken from 90 = 36° 45′ altitude N., being of the same name with the declination.

4. What is the sun's meridian altitude at Corinth, on March 21st?

On March 21st the sun has no declination; hence the zenith distance is equal to the latitude, 37° 30′; which taken from 90° gives 52° 30′ south altitude.

5. Required the sun's meridian altitude at Newcastle:
Dec. 21. March 21. June 21.

6. What is the sun's meridian altitude at Cairo, on
Dec. 21? March 21, or Sept. 23? June 21?

7. What is the sun's meridian altitude at Port Royal?
Dec. 21? March 21, or Sept. 23? June 21?

8. Required the sun's meridian altitude for the following places on December 21st and June 21st?

Bergen.	Mocha (Arabia).	Botany Bay.
Quebec.	Batavia.	Cape Horn, in
Athens.	St. Helena Isle.	S. America.

9. What is the sun's meridian altitude at the following places, on the following days?

Gottingen,	April 17th, and August 1st?
Canary Isles,	May 15th, and December 25th?
Port Mahon,	February 28th, and July 7th?
Smyrna,	May 1st, and November 11th?

To all places situated north of the tropic of cancer the sun's meridian altitude is always south; to all places situated south of the tropic of capricorn its meridian altitude is always north; and to those places situated between the tropics its meridian altitude is sometimes north and sometimes south.

From the above examples it will be seen, that the difference between the sun's greatest and least meridian altitudes, at any place situated without the tropics, is equal to 46° 56′, or twice 23° 28′, the distance of each tropic from the equator.

PROBLEM XIX.

To find the Sun's Altitude for any Hour, having the latitude and the day of the month given.

1. Elevate the globe for the latitude, bring the sun's place to the meridian, and set the index to 12 at noon.

2. Turn the globe till the index point to the given hour; and having screwed the quadrant of altitude on the zenith, bring it over the sun's place.

3. Then the degree on the quadrant cut by the sun's place will be the altitude required.

EXAMPLES.

1. Required the altitude of the sun at Jerusalem, on October 21st, at ten o'clock, *a.m.* *Ans.* 38°.

2. At Petersburg, June 21st, at 6 *p.m.* *Ans.* 20°.

Required the sun's altitude at the following places:

3. Jamaica, Dec. 1st, at 3 *p.m.*

4. London, May 1st, at 10 *a.m.*

5. Spitzbergen, June 21st, midnight.

6. New Orleans, Dec. 21st, 4 *p.m.*
7. Cape of Good Hope, May 15th, 10 *a.m.*
8. Washington, Sept. 25th, 3 *p.m.*
9. Louisburg, March 27th, 11 *a.m.*
10. Edinburgh, Nov. 30th, 10 *a.m.*
11. Malta, June 9th, 8 *a.m.*
12. Glasgow, April 4th, 3 *p.m.*

For more examples, see Problem XVII., on the celestial globe.

PROBLEM XX.

Having the Sun's Meridian Altitude, to find the Latitude of the place.

Bring the sun's place to the meridian, and move the globe up or down, till the distance between the sun's place and the north or south point of the horizon (as the case requires) be equal to the given altitude; then will the elevation of the pole be the latitude required.

By Calculation.—1. Subtract the altitude from 90° for the zenith distance, which is N. if the zenith be north of the sun; or S., if it be the contrary.

2. If the zenith distance and declination be both north or both south, add them together; but if one be north and the other south, subtract the less from the greater, and the sum or difference will be the latitude of the same name with the greater.

EXAMPLES.

1. The sun's meridian altitude on the 18th of May, was 42° 13′ S.; required the latitude.

In this case, the sun's altitude being S., the zenith will be N. of the sun,—being always of the contrary name to the altitude.

	90°	0′	
	42	13	S.
	47	47	zenith distance N.
Add	19	24	sun's declination N.
Ans.	67	11	N. lat., the zenith distance and declination being of the same name.

2. What is the latitude of the place at which the sun's m. alt., August 5th, is 74° 24′ N.? *Answ.* 1° 36′ N.

Required the latitudes coinciding with the annexed meridian altitude of the sun, on the days given.

3. Sun's meridian altitude	38° S.	January 13th.
4. ———————	48 S.	February 17th.
5. ———————	18 S.	March 11th.
6. ———————	30 S.	April 24th.
7. ———————	64 S.	May 17th.
8. ———————	35 S.	June 4th.
9. ———————	25 N.	July 29th.
10. ———————	48 N.	August 6th.
11. ———————	50 N.	November 19th.

12. Observing the sun's meridian altitude, on June 5th, to be $70\frac{1}{2}$° S.; and at the same instant observing a time-piece regulated for Greenwich, found it to be 10 min. past 11 *a.m.*; required the place of observation.

13. On March 21st the sun's meridian altitude was found by observation to be 52° 30′ S., and the difference of time between the place of observation and London was 1 hr. 32 min. sooner,—required the place.

14. The sun's meridian altitude, May 15th, was observed to be 36° 45′ N., and it was 13 min. past 1 *p.m.* when it was noon at London,—required the place.

15. Required the latitude and longitude of that place where the sun's meridian altitude, on May 21st, was 78° S., and where it was 3 *p.m.* when it was noon at London.

16. A ship, sailing from Jamaica, took the sun's meridian altitude on January 21st, and found it to be 50° S.; and at the same instant observed a time-keeper, regulated for London, to point to 42 min. past 2 *p.m.*; how far was the ship distant from Jamaica?

17. At a certain place, where the clocks are 2 hrs. faster than at London, the sun's meridian altitude was observed to be 30° to the south of the observer, on the 21st of March; required the place.

18. At a place where the clocks are 3 hrs. 32 min. faster than at London, the sun's meridian altitude was observed to be $80\frac{1}{2}°$ S. on June 9th,—required the place.

19. Where the clocks are 5 hrs. slower than at London, the sun's mer. alt. was observed to be 60° to the south of the observer, on April 16th,—required the place.

20. In what latitude is the sun's greatest meridian altitude 79° S.?

21. Where has the sun no zenith distance on Sept. 23rd?

PROBLEM XXI.

To find when the Sun is due East or West, the Latitude of the place and the day of the month being given.

1. Elevate the globe for the latitude of the place, bring the sun's place to the meridian, and set the index to 12.

2. Fix the quadrant of altitude in the zenith, and bring it, if the sun's declination be of the same name with the latitude, to the *eastern* point of the horizon; then turn the globe till the sun's place come to the edge of the quadrant, and the index will show the time when the sun is due east.

3. If the declination and latitude are of different names, bring the quadrant to the *western* point of the horizon, and turn the globe till the point in the ecliptic, opposite to the sun's place, come to the edge of the quadrant, and the index will show the time when the sun is due east.

4. Subtract the hour when the sun is due east, from 12, for the time when it is due west.

When the declination and latitude are of the same name, the sun is due east after rising, but when of different names, the sun is due east before rising.

As it is not so convenient to observe when the sun is due east below the horizon, the opposite point of the ecliptic is brought due west, and the index then shows the time of the sun's being due east.

EXAMPLES.

1. When is the sun due east and west at Newcastle, Nov. 3d? *Ans.* E. $\frac{1}{4}$ past 5, and W. $\frac{1}{4}$ before 7

2. At Leghorn, June 21st? *Ans.* E. $7\frac{3}{4}$, and W. $4\frac{1}{4}$.

3. At London, on the summer and winter solstices?

4. Liverpool, April 23rd and Dec. 15th?

5. At the following places, on March 21st, and Sept. 23rd? viz. Panama, on the Isthmus of Darien; Truxillo, in Peru; and Paramaribo, in Surinam?

6. At Buenos Ayres, Feb. 2nd?

7. At Carlscrona, April 4th?

8. At Brusa, on December 2nd?

9. At Demerara, on November 27th?

QUESTIONS FOR EXAMINATION IN SECTION IV.

What is the ecliptic? Why is it so called? What angle does it make with the equator? What is this angle called? Into how many parts or signs is it divided, and how many degrees does each contain? What are the names of the six northern signs? Write their characters. What are the names of the six southern signs? Write their characters. Name the spring, summer, autumnal, and winter signs. Which are the ascending, and which are the descending signs? What are the tropics, and at what distance are they from the equator? What are their names, and why are they so called? What is it that determines the distance at which they are drawn from the equator? What are the polar circles? At what distance are they from the poles, and at what distance from the equator? What are the equinoctial points? What are the solstitial points? What is meant by the sun's altitude? How often in the year are the days and nights equal to all places upon the earth? What are these days called? In what places of the earth are the days and nights always equal? Which is the longest day to all places in the northern hemisphere? What is this day called? Which is the shortest day to all places in the northern hemisphere? What is this day called? Which is the longest and which is the shortest day to all places in the southern hemisphere? During what time are the days constantly increasing to all places in the northern hemisphere? During what time are the days continually increasing in the southern hemisphere? What time of the year is the sun's declination north? How is the sun's place in the ecliptic found? How is the sun's declination found? On what two days of the year is the sun's declination greatest, north or south? On what days has the sun no declination? How is the globe rectified for the sun's place and day of the month? How are the rising and setting of the sun found by the globe? How is the length of the day and night found? How is the sun's meridian altitude found for any given day at any given place?

How is the sun's altitude for any hour of the day found? Having the sun's meridian altitude, how is the latitude found? How is it found when the sun is due east or west at any given place?

QUESTIONS FOR EXERCISE IN SECTION IV.

1. At what hour does the sun rise at N. Cape, Dec. 21st?
2. Is June 21st longer at Jerusalem or Newcastle, and how much?
3. At which of these places is Dec. 21st the longest?
4. Which is the longest day to Quito?
5. The difference between the longest and shortest day at Paris?
6. What is the sun's m. altitude at Petersburg, June 21st?
7. How high will the sun ascend on Christmas day at Bastia?
8. How high will the sun ascend at Samarcand on Sept. 29th?
9. The sun's altitude June 21st at North Cape at midnight?
10. What is the sun's altitude at Moscow, at 8 *a.m.* May 1st?
11. When does the sun rise due east at Carlisle?
12. What time does the sun rise and set at Petersburg, Naples, and Canton, on January 24th?
13. At what hour does the sun rise and set at Dublin, Gibraltar, Teneriffe, and Vienna, April 15th, July 4th, and Nov. 20th?
14. What is the length of the day and night on April 22nd, at London, Madrid, and Batavia?
15. What is the length of the day and night on June 10th, at St. Helena, Mexico, New York, and Canton?
16. What is the sun's declination, June 14th, and August 31st?
17. What is the sun's m. altitude at London on October 26th?
18. Give the sun's alt. at London, May 21st, at 9 *a.m.*?
19. What is the sun's alt. at Newcastle, May 21st, at 9 *a.m.*?
20. The sun's altitude at Constantinople, June 4th, at 3 *p.m.*?
21. How much longer is June 5th at Archangel than at Madras?
22. What is the sun's greatest altitude in Magellan's Strait?
23. What is the sun's least meridian altitude at Stockholm—at Malta—at Warsaw?

SECTION V.

DEFINITIONS.

1. The surface of the earth is divided into five *zones*.

2. The *torrid zone* is that space of the earth included between the tropics.

It is bounded by the tropic of cancer on the north, and the tropic of capricorn on the south: its breadth is 46° 56′, that being the distance of the tropics from each other.

3. The two *temperate zones* are those parts lying between the tropics and polar circles.

The north temperate zone is bounded on the south by the tropic of cancer, and on the north by the arctic circle; its breadth is 43° 4′, that being the distance between the tropic of cancer and the arctic circle. The south temperate zone is bounded on the north by the tropic of capricorn, and on the south by the antarctic circle: its breadth is the same as that of the north temperate zone.

4. The two *frigid zones* are those spaces included within the polar circles.

These circles are at the same distance from the poles as the tropics from the equator, viz., 23° 28′.

5. If the latitude of any place be less than $23\frac{1}{2}°$, it lies in the torrid zone; if it be more than $23\frac{1}{2}°$ and less than $66\frac{1}{2}°$, it is in one of the temperate zones; and if it be more than $66\frac{1}{2}°$, it is in the frigid zone.

6. The inhabitants of these zones are distinguished by the different direction of their shadows.

Those who live in the torrid zone are called *amphiscii;* that is, having both kinds of meridian shadows: twice in the year they have no shadow at noon, and are then called *ascii.*

Those who live in the temperate zones are called *hetoroscii*; that is, having only one kind of meridian shadow. Those who live in the south temperate zone have their shadows at noon always towards the south; and those in the north temperate zone always towards the north.

Those who live in the frigid zones have, when their days are more than 24 hours long, the sun, and therefore their shadows, moving all around them; hence they are called *periscii.*

7. The sun is said to be *vertical* when it is in the zenith, or directly over head.

OF THE APPEARANCES OF THE SUN IN THE SEVERAL ZONES.

To all places in the torrid and temperate zones, the sun rises and sets daily.

To all places in the frigid zones the sun, in summer, does not set for a certain number of days, nor rise in winter for the same number of days: at other times of the year it rises and sets daily.

To all places in the torrid zone the sun is vertical at noon twice in the year: thus an inhabitant of the equator has the sun vertical when it is in the equinoctial. And at any other period the places to which the sun is vertical, are those whose latitude is equal to the declination of the sun, and of the same name with it; thus, at 10° N. latitude the sun is vertical when its declination is 10° N.

This may be further illustrated by observing, that the equator and equinoctial coinciding (*i. e.*, the equinoctial being nothing more than the equator supposed to be continued to the heavens), when the sun is in the equinoctial, a perpendicular ray, coming from it to the earth, will fall upon the equator: and, during a diurnal revolution of the earth, the equator will be formed or passed over by this ray. When the sun is not in the equinoctial, the perpendicular ray will fall as far to the north or south of the equator as the sun is distant north or south of the equinoctial; and during a diurnal revolution of the earth, that parallel of latitude will be described by this ray, whose distance from the equator is equal to the sun's declination, and of the same name with it.

Whilst the earth, in its annual motion round the sun, is moving from cancer to capricorn, the sun appears to move from capricorn to cancer; hence its declination varies from 231 S. to 23½ N.: and during that time, or in half a year, its rays will have been successively perpendicular to all places in the torrid zone.

Whilst the earth is moving through the other half of its orbit from capricorn to cancer, the sun appears to move from cancer to capricorn, and varies in declination from 23½ N. to 23½ S.; it will be vertical to the same places, but in a retrograde order.

The tropic of cancer is the most northern circle described by the vertical rays of the sun; that of capricorn the most southern.

The sun is vertical only once a year at the tropics; at the tropic of cancer on June 21st, and at the tropic of capricorn on December 21st.

All places out of the torrid zone, being at a greater distance from the equator than the sun's greatest declination, can never have the sun vertical.

From the ecliptic being drawn upon the terrestrial globe, and the pupil knowing that it is the line in which the sun appears to move, he may be inclined to suppose that the sun moves daily round the earth in the oblique manner in which the ecliptic is drawn.

To correct this false notion, it may be observed, that the ecliptic is a circle peculiar to the celestial globe, where it really marks out the sun's apparent path among the stars; but on the terrestrial globe it is of no other use than to find the sun's declination on any day.

The sun's vertical rays form a sort of spiral line from tropic to tropic. This may be explained by supposing a quantity of silk string to be wrapped round the globe, from one tropic to the other. If the silk string be so contrived as to be thicker towards the equator, where the daily difference of declination is greatest; and if the number of times it requires to be wrapped round, before it covers the space between the tropics, be equal to half the number of days in one year, it will exactly represent the spiral line formed by the rays of the sun in six months. In the other six months the same sort of spiral line will be formed in a contrary direction.

PROBLEM XXII.

A place being given in the Torrid Zone, to find those two days of the year in which the Sun is vertical to that place.

By the Globe.—1. Bring the given place to the meridian, and mark its latitude.

2. Turn the globe round, and observe the two points of the ecliptic that pass under this mark; the calendar will show the days corresponding to these points, which will be the answer required.

Or, having found the latitude of the place, bring the *analemma* to the meridian, then directly below the latitude will be found the days required.

Without the Globe.—1. Find the latitude, either from a table of latitudes and longitudes, or from maps.

2. Observe in White's Ephemeris, or in Table I. at the end of this work, on what two days of the year the sun's declination is equal to the latitude, and of the same name with it: these are the days required.

The examples to this problem may be proved by the following method. Find how many days there are from the time when the sun is vertical, to the nearest solstice, and also how many there are from that solstice to the time when it is vertical again: if the number of days be equal, the solution is right.

EXAMPLES.

On what days is the sun vertical to the following places?

1. Otaheite. *Ans.* Jan. 30 and Nov. 11.
2. Rio Janeiro. Jan. 2 Dec. 9.
3. St. Helena.
4. Batavia.
5. Bencoolen.
6. Quito.
7. Borneo.
8. Pelew Islands.
9. Sierra Leone.
10. Tobago.
11. Port Royal.
12. Bombay.
13. Canton.
14. Friendly Isles.
15. Trincomalee.
16. Guadaloupe.
17. Porto Bello.
18. Vera Cruz.
19. Tinian Isle.
20. Manilla.
21. Columbo.
22. Santa Fé de Bogotà.

PROBLEM XXIII.

To find all those places in the Torrid Zone to which the Sun is vertical on a given day.

Find the sun's declination for the given day, and mark the declination, then turn the globe round, and all those places which pass under that mark of the meridian will have the sun vertical on the given day.

EXAMPLES.

1. To what places is the sun vertical Nov. 10th?

Ans. To Otaheite, the Great Cyclades, and New Hebrides, in the South Sea; Cape Grafton, in New South Wales; the Island of Madagascar; Monomotapa and Mataman, in Africa; Punta Gorda, in Brazil; and the southern parts of Amazonia and Peru, in South America.

2. To what places is the sun vertical on Feb. 2nd?

Ans. To the same as in the last example.

To what places is the sun vertical—

3. On April 16 and Aug. 28?
4. At the summer solstice?
5. March 21 and Sept. 23?
6. May 16 and July 29?
7. Winter solstice?
8. May 1?

PROBLEM XXIV.

The day and hour at any place being given, to find where the Sun is then vertical.

Find the sun's declination, and by Prob. XIII. the places where it is noon at the time; then of those places where it is noon, that will have the sun vertical whose latitude is the same as the declination.

EXAMPLES.

1. To what place is the sun vertical, when it is 39 min. past 6 *a.m.* at London, August 18th? *Ans.* Madras.

2. Where is the sun vertical on the 24th of October, when it is 29 min. past 7 *p.m.* at Jerusalem? *Ans.* Lima.

Having the times given at the following places, where is the sun then vertical?

3.	September 23.	6 50 *a.m.*	Bagdad.
4.	August 1,	5 0 *p.m.*	Bristol.
5.	April 30,	1 53 *p.m.*	Amsterdam.
6.	June 21,	Noon	Canton.
7.	September 9,	6 30 *a.m.*	Jerusalem.
8.	March —	0 30 *p.m.*	Canton.
9.	May 4,	8 10 *a.m.*	Vienna.
10.	May 20,	11 43 *p.m.*	Calicut.
11.	January 1,	6 0 *p.m.*	Mexico.
12.	February 12,	9 0 *a.m.*	Dublin.
13.	July 28,	5 16 *p.m.*	Port Royal.
14.	March 11,	6 10 *a.m.*	Malta.
15.	December 9,	3 0 *p.m.*	London.
16.	September 2,	3 0 *a.m.*	London.
17.	November 6,	1 37 *p.m.*	C. of Good Hope.
18.	July 28,	8 15 *a.m.*	Vienna.
19.	December 21,	1 56 *a.m.*	London.

PROBLEM XXV.

Having the hour given at any place, on any given day, to find where the Sun is rising, where it is setting, where it is noon, and where it is midnight.

Find, by Problem XXIV., the place to which the sun is then vertical; elevate the globe for that place, and bring it to the meridian.

Then, to all those places in the western semicircle of the horizon, the sun is rising; to those under the upper semicircle of the meridian it is noon; to all places in the eastern semicircle of the horizon the sun is setting; and to those under the lower semicircle of the meridian it is midnight.

EXAMPLES.

1. At what places is the sun rising on June 4, when it is 4 *p.m.* at London?

Ans. At the north-east part of Siberia; at Kamtchatka; at the most westerly of the Sandwich Isles; and the most easterly of the Society Isles.

Where is it noon at the same time?

Ans. At Baffin's Bay, New Britain, Martinique, Trinidad, and the middle part of South America.

At what places is the sun then setting?

Ans. At Tobolsk, the Caspian Sea, Desert of Arabia, the middle of the Red Sea, Abyssinia, the unknown parts of Africa, and the country of the Hottentots.

At what places is it midnight at that time?

Ans. At Chinese Tartary, the eastern part of China, the Philippine Isles, and the western part of New Holland.

2. On April 27th, 6 hrs. 45 min. *a.m.* at Newcastle, required the places to which the sun is rising and setting; also where it is noon and midnight.

Ans. Rising—Greenland, the Azores, Cape Verd Isles, Ascension Isle. *Setting*—Aleutian Islands, Queen Charlotte's Islands, eastern coast of New Holland. *Noon*—

Middle of Siberia, middle of the western peninsula of India. *Midnight*—Middle of North America, Mexico.

3. To what places is the sun rising and setting July 27, when it is 2 hrs. *a.m.* at Pico (Azores); and where is it noon and midnight at the same time?

4. May 24, 8 *p.m.* at Newcastle, where is the sun rising and setting, and where is it noon and midnight?

5. At what places is the sun rising and setting, and where is it noon and midnight, when it is 10 *p.m.* at Botany Bay on August 15th?

6. April 4th, 6 *a.m.* at Edinburgh, where is it noon, midnight, sun-rise, and sun-set?

7. June 9th, 3 *a.m.* at Glasgow, where is it noon and midnight, and where is the sun rising and setting?

8. Midnight at Singapore Sept. 15, where is the sun vertical, and where is it rising and setting?

PROBLEM XXVI.

A place being given in the North Frigid Zone, to find when the Sun begins to appear, and when to disappear; also the Length of the longest Day and Night.

By the Globe.—1. Elevate the globe for the latitude, and bring the ascending signs to the south point of the horizon: observe what degree of the ecliptic is cut by that point, and find, on the calendar, the day of the month answering to that degree; this will be the time of the sun's beginning to appear above the horizon at the given place, which is the end of the longest night.

2. Bring the descending signs to the south point of the horizon, and the day answering to the degree of the ecliptic cut by it, will be that on which the sun disappears, which is the beginning of the longest night.

3. Bring the ascending signs to the north point of the horizon; and the degree of the ecliptic, noted as above, will show when the sun begins to shine continually; which is the beginning of the longest day.

4. Bring the descending signs to the same point, and in the same manner it will be found when the sun ceases to shine continually, or the end of the longest day.

5. From the end of the longest night to the beginning of the longest day, and conversely, the sun rises and sets daily.

BY THE ANALEMMA.—1. Elevate the globe for the latitude, and bring the analemma to the south point of the horizon, then the two days of the month on the analemma cut by the horizon, will be the beginning and end of the longest night.

2. Bring the analemma to the north point of the horizon, and you will find in the same manner the beginning and end of the longest day.

WITHOUT THE GLOBE.—1. Subtract the latitude from 90°; the remainder is called the *co-latitude.*

2. The sun being in the ascending signs, find, by the table, on what day its declination is equal to the co-latitude, but of a *contrary* name; this will be the day on which the sun first appears above the horizon: find the same when the sun is in one of the descending signs; this will be the day on which it entirely disappears.

3. Find, in the same manner, the two days when the sun's declination is equal to the co-latitude, and of the *same* name with it: the one will be the beginning, and the other the end, of the longest day.

EXAMPLES.

1. Whale Island, discovered by Mackenzie, lies in lat. 69° 14′ N.; required the time when the sun first appears above the horizon, and when it disappears; also the length of the longest day and night there.

Here 69° 14′ being taken from 90°, leaves 20° 46′ for the co-latitude. The two days on which the sun's declination is 20° 46′ S. (of a contrary name to the latitude) are Jan. 17th and Nov. 25th; the former is the day on which the sun first appears above the horizon, the latter that on which it disappears.

The two days on which the sun's declination is 20° 46′ N. (of the same name with the latitude) are May 24th and July 20th; the former is the beginning, and the latter the end, of the longest day.

Hence, at Whale Island, the sun first appears Jan. 17th, and rises and sets daily till May 24th, a space of 127 days: it continues above the horizon from May 24th to July 20th; therefore the longest day there is equal to 57 natural days. From July 20th it rises and sets daily to Nov. 25th, 128 days, and never rises again till Jan. 17th; so its longest night is equal to 53 days.

2. When does the sun begin to appear above the horizon at North Cape, in Lapland, lat. 71° 10′ N.; when does it disappear; and how many days are the inhabitants without seeing the sun?

Ans. The sun appears Jan. 26, and rises and sets daily till May 15; after which time it continues above the horizon till July 29; then it rises and sets daily till Nov. 16, when it disappears till Jan. 26; the length of the longest night is therefore equal to 71 days.

3. When does the sun begin to appear at South Cape, in Spitzbergen, lat. 76° N.; when to disappear; and what is the length of the longest day there?

4. The most northerly land discovered are seven islands called the *Seven Sisters*, that lie to the north of Spitzbergen, in lat. 81° N. Captain Phipps, in his voyage towards the North Pole, was so completely surrounded with ice at this place, that he and all the ship's company were for some time under the dreadful apprehension of being obliged to pass the winter here. How long would they have been without seeing the sun?

5. How long is the longest day at the North Pole?

6. In 1819–20, Captain Parry wintered at Melville Island, in the Polar Sea, lat. 75°; how many days were he and his men deprived of the light of the sun?

7. In 1827, Captain Parry, in his attempt to reach the North Pole, advanced as far as 82° 45′ North; required the length of the longest day there?

PROBLEM XXVII.

To find in what Latitude, in the North Frigid Zone, the Sun begins to shine, without setting, on any given day.

Find the sun's declination on the given day, subtract it from 90°, and the remainder will be the latitude required.

The given day must be between March 21st and June 21st.

In the same manner it may be found in what latitude, in the south frigid zone, the sun begins to shine, without setting, on any given day between Sept. 23rd and Dec. 21st.

EXAMPLES.

1. In what latitude does the sun begin to shine without setting on April 23? *Ans.* 77° 31′ N.

2. May 15? 5. April 2?
3. June 1? 6. Nov. 5?
4. June 21? 7. Dec. 1?

PROBLEM XXVIII.

Having the length of the longest day in any place, to find the Latitude of that place.

By the Globe.—1. Bring the first of cancer to the meridian, and set the index to 12.

2. Turn the globe westward till the index point to the hour of setting, which is equal to half the length of the day.

3. Raise or depress the pole till the sun's place be observed to be exactly in the western horizon; the elevation of the pole will give the latitude of the place.

By this problem it may be found in what latitude any day is of a given length, by bringing the sun's place for the given day to the meridian, and proceeding as above.

The examples in this problem may be proved by Problem XVII.

EXAMPLES.

1. In what latitude is June 21st 16 hours long?
Ans. Lat. 49° N.
2. Where 18 hours long? *Ans.* Lat. $58\frac{1}{2}$° N.
3. Where is Dec. 1st 14 hrs. long? *Ans.* Lat. 32° 46′ S.
4. In what latitudes is January 21st—

5 hours long?	10 hours?	16 hours?
7 hours?	12 hours?	18 hours?

5. In what latitudes is February 20th—
7 hours long? 11 hours? 15 hours?

6. In what latitudes is May 15th, or July 29th—
6 hours long? 9 hours? 14 hours? 18 hours?

PROBLEM XXIX.

To find the Latitudes of those places in the Frigid Zone where the Sun does not set for a given number of days.

1. Take half the number of the days, and count as many degrees from the first of cancer towards the equinoctial point.

2. Bring the point thus arrived at to the brass meridian, and observe the degree cut by it.

3. Subtract this from 90°, and the remainder will be the latitude of the place.

The above method is not perfectly correct, because the sun does not advance one degree in the ecliptic every day, but takes 365¼ days to move through the whole 360 degrees in the ecliptic.

EXAMPLES.

1. In what latitude does the sun shine continually for 50 days. *Ans.* 69°.

2. In what latitude does it shine for 76 days? *Ans.* 71° 30′.

3. In what latitude does the sun shine continually for 1 month; for 2, 3, 4, 5, and for 6 months?

QUESTIONS FOR EXAMINATION IN SECTION V.

Into how many zones is the earth divided? What are the boundaries of the torrid zone? What is its breadth? How are the two temperate zones situated? What is the breadth of each? What lines are the boundaries of the frigid zones? In which of the zones does the sun rise and set daily? In which does it not set for a certain number of days in summer, or rise for a certain number of days in the winter? What is meant by the sun's being vertical? In which of the zones is the sun vertical twice a year? At what hour of the day is the sun vertical to any place? How often in the year is the sun vertical to places in the north temperate zone? How often is the sun vertical at the tropics? To what tropic is the sun vertical on June 21st? At what tropic is the sun vertical on December 21st? Why is the sun never vertical to places that are not in the torrid zone? How is it found on what two days of the year the sun is vertical to any place in the torrid zone? How is this found without the globe? How may the examples be proved? How are the places found to which the sun is vertical on any given day? Having the day and hour given, how is it found where the sun is then vertical? A lace being given in the north frigid zone, how is it found when the sun begins to appear above the horizon, and when it begins to disappear; also, the length of the longest day and night? On any given day between the vernal equinox and summer solstice, how is it found in what latitude in the north frigid zone the sun begins to shine without setting?

QUESTIONS FOR EXERCISE IN SECTION V.

1. To what places will the sun be vertical on April 9th?
2. On March 12th?
3. On August 15th?
4. When will the sun pass vertically over Surinam?
5. When will the sun pass vertically over the islands of Ascension, Mauritius, and Guam?
6. On what two days in the year will a person at St. Christopher's have no shadow at noon?
7. To what place will the sun be vertical on January 31st, when it is 9 in the morning at Newcastle?
8. On June 14, when it is ½-past eight in the morning at Newcastle, where is the sun vertical?

To what places will the sun be vertical—

9. On July 12th, when it is 9 in the evening at Jerusalem?
10. On the 26th of June, when it is 7 *a.m.* at London.
11. On July 10th, when it is 2 in the morning at Quebec?
12. On Christmas-day, when it is midnight at Petersburg?
13. On November 10th, when it is 6 in the evening at Ormuz?
14. Is the sun ever vertical at Jerusalem?
15. Is the sun ever more than 24 hours above the horizon at Archangel?
16. Suppose a person to pass the winter in 77° N. latitude, how long would he be without seeing the sun?
17. In what latitude does the sun begin to shine, without setting, on May 1st?

SECTION VI.

DEFINITIONS.

1. *Twilight* is that medium between light and darkness which happens before sunrise, and after sunset.

2. The *crepusculum* is a circle parallel to the horizon, and 18° below it, where the twilight begins and ends.

OF TWILIGHT.—As soon as the sun comes within 18° of the horizon, its rays strike the higher parts of the atmosphere and, being refracted and reflected to every part, occasion that agreeably gradual transition from darkness to light, called *twilight.*

In the same manner in the evening, after the sun sets, its rays strike upon the higher parts of the atmosphere, until it is more than 18° below the horizon : this prevents us from being suddenly deprived of the light of the sun.

The benefits of twilight are obvious. A change so great, as from the darkness of midnight to the splendour of noon-day, would probably be injurious to the sight; and it would be unpleasant to all, and in many cases very dangerous to travellers, to be involved in darkness without timely notice of its approach.

In countries near the equator, twilight is of much shorter duration than it is in countries of high latitudes; for at the equator the sun rises and sets perpendicularly, and consequently the twilight there cannot be greater than 1 hour 12 minutes,—but to places at a great distance from the equator it rises and sets very obliquely; and hence it requires a longer time to go 18° below the horizon.

At the latitude of 49° N., twilight continues the whole night on June 21st; and at places still further north, it continues the whole night, for a certain number of days before and after the summer solstice. At London there is no total darkness from May 28th till July 20th.

Twilight continues, at the north pole, from September 23rd, when the sun sets, to November 12th,—a space of 51 days. Twilight first appears again there about the 30th of January, and continues till sunrise on March 21st. Thus, though the inhabitants (if any) at the north pole never see the sun for 6 months, yet, out of that time, they have twilight for 14 weeks. The time that they receive no light from the sun is only 12 weeks; and during that time the moon is 6 weeks above the horizon.

PROBLEM XXX.

To find at what place it is Twilight at any given time.

Find where the sun is then vertical, and elevate the globe for that place. Observe what places are less than 18° below the horizon; to those below the western semicircle it is twilight in the morning, and to those below the eastern semicircle it is twilight in the evening.

Otherwise.—Elevate the globe for the antipodes of the place to which the sun is then vertical, and observe what places are within less than 18° above the horizon.

EXAMPLES.

1. On March 10th, when it is 11 *p.m.* at New Orleans, where is it twilight?

Ans. Morning.—Britain, France, middle of Africa.

Even. Twilight.—Society and Sandwich Isles, Alashka.

2. When it is 6 hrs. 45 min. *a.m.* at Newcastle on April 27th, where is it twilight? *Ans. Morning*—Labrador, Newfoundland. *Evening*—Alashka, New Hebrides, New Caledonia, part of New Zealand.

3. Where is it twilight, when it is 3 o'clock *p.m.* at London, on June 4th?

4. On September 25th, when it is 10 *p.m.* at Trinidad?

5. Dec. 16th, when it is noon at Easter Island?

6. On April 4th, when it is 6 *a.m.* at Edinburgh?

7. On June 9th, when it is 3 *a.m.* at Glasgow?

8. On March 24th, when it is 4 *p.m.* at Benares?

PROBLEM XXXI.

To find the Duration of Twilight on a given day.

1. Elevate the globe for the latitude of the place, bring the sun's place to the meridian, and set the index to 12.

2. Turn the globe till the sun's place be 18° below the horizon, and the index will show the beginning of twilight; or that point in the ecliptic, opposite to the sun's place, may be brought 18° above the western horizon.

3. Subtract the commencement of twilight from the time of the sun's rising (see Problem XVII.), and the remainder will be the duration of twilight.

EXAMPLES.

How long does twilight continue at London on—

1. March 2nd?	*Ans.* 1 hr. 50 min.
2. June 21st?	*Ans.* No night.
3. September 25th?	*Ans.* 2 hrs. 0 min.
4. December 26th?	*Ans.* 2 10

How long does twilight continue on March 21st at—

5. Cape of Good Hope?
6. Quito?
7. Jerusalem?
8. Vienna?
9. Petersburg?

How long will it continue on June 21st at—

10. Cape Horn?
11. Gilolo Isle?
12. Formosa Isle?
13. Pekin?
14. Petersburg?
15. Cairo?

PROBLEM XXXII.

To find at what places an Eclipse of the Moon is visible.

Find, by Problem XXIV., the place to which the sun is vertical at the given time. Elevate the globe for the antipodes of that place, and bring the antipodes to the meridian; then, to all the places which are above the horizon, the eclipse will be visible.

At an eclipse of the moon, the sun and moon are in opposite points of the ecliptic; and the place to which the moon is then vertical is the antipodes of that to which the sun is vertical.

EXAMPLES.

1. On May 10th, 1808, there was a total eclipse of the moon when it was 8 o'clock in the morning at Greenwich; where was it visible? *Ans.* N. and S. America, the islands in the Pacific Ocean, east coast of New Holland.

2. On April 30th, 1809, there was an eclipse of the moon when it was 1 *a.m.* at London; where was it visible?

3. In 1811, March 10th, there was an eclipse of the moon, at 6½ *a.m.* at London; where was it visible?

4. Aug. 22nd, 1812, there was an eclipse of the moon when it was 3 *p.m.* at London; where was it visible?

QUESTIONS FOR EXAMINATION IN SECTION VI.

What is it that produces twilight? In what countries is twilight of the shortest duration? In what latitude does twilight continue the whole night on June 21st? How long does twilight continue the whole night at London, and places of the same latitude as London? How is it found where it is twilight at any given time? How is the duration of twilight found at any place on any given day? How is it found where an eclipse of the moon is visible?

PART II.

CONTAINING PROBLEMS ON THE CELESTIAL GLOBE.

DEFINITIONS.

1. THE *celestial globe* is an artificial representation of the heavens, having the fixed stars delineated upon it, in their natural order and situation.

The celestial globe is not so exact a representation of the heavens as the terrestrial globe is of the earth ; because the stars are drawn upon a convex surface, and they appear in the heavens in an inverted order on a concave surface : but suppose the globe were made of glass, then, to an eye placed in the centre, the stars drawn upon it would appear on a concave surface, just as they do in the heavens.

2. The *solar system* consists of the sun and all those bodies which revolve round it. These are the planets, with their satellites, and the comets.

3. The *fixed stars* are those bodies which shine by their own light, and are not subject to motion.

The term fixed stars is not strictly correct. Many of the stars are known to have a proper motion through space; and several even of the double stars, besides revolving round each other, are transferred, without parting company, by a progressive motion common to both, towards some determinate region. It becomes an interesting question—Does our sun move in an immense orbit of its own, carrying the whole solar system with it?

4. A *constellation* is a group of stars.

5. *Planets* are opaque bodies which only shine by reflecting the light of the sun.

The name is derived from the Greek πλανητης (a wanderer). A planet does not twinkle as the fixed stars do.

6. *Secondary planets*, or *satellites*, are the moons which

revolve round the primary planets, as those bodies revolve round the sun.

7. *Comets* consist for the most part of a large and splendid, but ill-defined, nebulous mass of light, called the head; from which there usually proceeds, in a direction opposite to the sun, a stream of light called the tail.

8. The *celestial poles* are the extremities of the earth's axis produced to the heavens: they are those two points round which the stars appear to revolve.

9. The *equinoctial* is the equator supposed to be continued to the heavens.

10. *Parallels of declination* are small circles drawn parallel to the equinoctial; or, they are the parallels of latitude supposed to be continued to the heavens.

11. *Celestial meridians* are lines drawn from pole to pole, directly across the equinoctial; they are also called *circles of declination;* or, they are the terrestrial meridians supposed to be continued to the heavens.

12. The *declination* of the sun, moon, or stars, is their distance north or south from the equinoctial.

13. *Right ascension* is that degree of the equinoctial which comes to the meridian with the sun, moon, or stars, reckoning eastward from the first point of Aries; or it is that degree which comes to the horizon with the sun, moon, or stars, in a right sphere.

14. *Oblique ascension* is that degree which comes to the horizon with the sun, or a star, in an oblique sphere.

15. *Ascensional difference* is the difference between the right and oblique ascension. Expressed in time, it gives the sun's rising before or after 6 o'clock.

16. *Right descension*, *oblique descension*, and *descensional difference*, have the same reference to the setting of the sun, or of a star, as the above terms have to rising.

17. The *latitude* of any celestial body is its distance north or south from the ecliptic.

18. *Parallels of celestial latitude* are small circles parallel to the ecliptic.

19. The *longitude* of any celestial body is its distance from the first point of Aries, reckoned eastward in signs, degrees, and minutes, upon the ecliptic.

The latitude and longitude of celestial bodies have the same reference to the ecliptic as the lat. and long. of places upon the earth have to the equator; the longitude is reckoned all round to 360°.

20. The *rising* of any celestial object is when its centre appears in the eastern part of the horizon; *culminating* when it comes to the meridian, and its *setting* when its centre disappears in the western part of the horizon.

21. *Azimuth*, or *vertical circles*, pass through the zenith and nadir, and are perpendicular to the horizon.

22. The *prime vertical* is that vertical circle which passes through the east and west points of the horizon.

If the quadrant of altitude be fixed upon the zenith, and brought to any part of the horizon, it will represent the quadrant of a vertical circle; if brought to the east or west point of the horizon, it will represent the quadrant of the prime vertical.

23. *Azimuth* is the distance of a vertical circle passing through any celestial object, from the north or south point of the horizon, and is either easterly or westerly.

24. *Amplitude* is the distance of any celestial object from the east or west point of the horizon, at the time of rising or setting, and is either north or south.

The azimuth and amplitude are both found upon the wooden horizon; the amplitude being numbered from the east and west points towards the north and south, and the azimuth from the north and south points towards the east and west. If the azimuth be not marked upon the horizon, it may be found from the amplitude, being its complement, or what it wants of 90°.

25. The *zodiac* is a zone which surrounds the heavens, extending 8° on each side of the ecliptic: it contains 12 constellations, each bearing the name of some object,—from which the signs of the ecliptic have their names.

26. The *altitude* of any celestial object is the arc of a vertical circle, intercepted between the centre of the object and the horizon.

27. The *zenith distance* is an arc of a vertical circle contained between the centre of a celestial object and the zenith; or it is what the altitude wants of 90°.

28. The *meridian* altitude, or zenith distance, is the alt. or zenith dist. when the object is in the meridian.

29. *Orbit* is the path which a body describes in its revolution round the sun.

30. A body is in *conjunction* with the sun when it has the same longitude, and in *opposition* when the difference of longitude is 180°. The *occultation* of a star or planet is its eclipse, occasioned by the interposition of the moon or other planet between the earth and it.

31. The *geocentric* place of a planet is its place in the heavens as seen from the earth; the *heliocentric* place is its place as seen from the sun.

32. *Disc* of the sun or moon is its round face, which, from the great distance of the object, appears flat.

33. A *digit* is the twelfth part of the diameter of the sun and moon.

Geometrical Definitions.

1. A *great circle* divides a globe into two equal, *a small circle* into two unequal, parts.

2. A *right* or *direct sphere* is that which has the poles in the horizon, and the equinoctial and parallels of declination perpendicular to it.

3. An oblique sphere is that which has one of the poles elevated above the horizon less than 90°, and the other depressed below it; the equinoctial and parallels of declination form, with the horizon, oblique angles.

4. A parallel sphere is that which has the equator in the horizon, and the poles in the zenith and nadir.

SECTION I.

OF THE STARS.

A clear winter evening affords one of the most brilliant prospects in nature. The canopy of the heavens is covered with an innumerable multitude of stars, some shining with greater, and others with less, splendour.

To the eye they appear to be all placed at the same distance from the earth; and their different apparent magnitudes and brightness we are apt to attribute to the size of the bodies themselves, rather than to the different distances at which they are placed. From the irregular manner in which they seem scattered about, as well as from their apparently infinite numbers, any attempt to arrange them in classes, or to count their numbers, would at first view appear impossible. Yet we find that this was done in the very infancy of astronomy. The shepherds of Chaldea are supposed to have been the first who directed their attention to this subject: the nature of their employment invited them to the work, and the continued serenity of their sky enabled them to pursue it without interruption. In the time of Job some of the constellations were well known; hence the following apostrophe, "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion? Canst thou bring forth Mazzaroth in his season? Or canst thou guide Arcturus with his sons?" Stars continue visible through telescopes during the day as well as the night; from the bottoms of deep narrow pits bright stars may be discerned by the naked eye.

Astronomers, to assist the imagination and the memory in conceiving and retaining the number and position of the stars, divided them into certain groups, called *constellations*, which, by a stretch of fancy, they supposed to resemble the figure of a man, or other object.

The number of the ancient constellations was 48, but the present number upon the globe is 70, though, by some, it amounts to 91; of which 34 belong to the northern hemisphere, 12 to the zodiac, and the remaining 45 to the southern hemisphere: those stars which do not come into any of the constellations are called *unformed stars*.

Stars are further divided into classes according to their apparent size. The largest are said to be of the first magnitude, the next in size of the second magnitude, and so on. The individual stars in each constellation are marked with the letters of the Greek alphabet; the first letter, α, (alpha,) being put for the largest star in the constellation—the second letter, β, (beta,) for the next largest—γ, (gamma,) for the next—δ, (delta,) ε, (epsīlon,,) ζ, (zeta,) η, (ēta,) for the next—and so on; and when there are more stars in a constellation than letters in the Greek alphabet, the rest are marked by italic letters. This serves to point out the stars, as well as if particular names were given to each. But, besides this method of distinguishing them, some of the most remarkable have proper names assigned them.

The lowest magnitude visible to the naked eye is the sixth, but astronomers carry the classification of the stars as far as the sixteenth magnitude. All the stars of the same magnitude do not possess equal brilliancy: thus some stars, said to be of the first magnitude, are scarcely superior to the brightest of the second magnitude, or the feeblest of the second to the brightest of the third, and so on.

The following is a catalogue of the stars in each constellation, with the names of the most remarkable stars.

The figures placed against each constellation denote the number of stars composing it, and the figure attached to each principal star marks its magnitude.

1. CONSTELLATIONS NORTH OF THE ZODIAC.

1.	Ursa Minor	The Little Bear	24	Pole Star	2
2.	Ursa Major	The Great Bear	87	Dubhe	1
3.	Perseus	Perseus	59	Al'genib	2
	Caput Medusæ	Medusa's Head		Algol	2
4.	Auriga	The Waggoner	66	Capella	1
5.	Boötes	The Herdsman	54	Arcturus	1
6.	Draco	The Dragon	80	Ras'taben	2
7.	Cepheus		35	Aldera'min	3
8.	Canes Venatici	The Hounds	25		
9.	Cor Caroli	Charles's Heart	3		
10.	Triangulum	The Triangle	11		
11.	Triangulum Minus	The Little Triangle	5		
12.	Musca	The Bee, or Fly	6		
13.	Lynx	The Lynx	44		
14.	Leo Minor	The Little Lion	53		3
15.	Coma Berenices	Berenice's Hair	43		
16.	Camelopardalus	The Camelopard	58		
17.	Mons Mænalus	Mount Mænalus	11		
18.	Corona Borealis	The Northern Crown	21	Gemma	2
19.	Serpens	The Serpent	64		2
20.	Scutum Sobieski	Sobieski's Shield	8		
21.	Hercules	Hercules	113	Ras Al'gothi	3
22.	Ophiuchus	Serpent Holder	74	Ras Alha'gue	2
23.	Taurus Poniatowski	Poniatowski's Bull	7		

24. Lyra	The Harp	22	Vega	1
25. Vulpecula et Anser	The Fox and Goose	37		
26. Sagitta	The Arrow	18		
27. Aquila et Antionoüs	The Eagle	71	Altair, or Atair	1
28. Delphinus	The Dolphin	18		
29. Cygnus	The Swan	73	Deneb (the tail)	1
30. Equu'leus	The Colt	10		
31. Lacerta	The Lizard	16		
32. Pegasus	The Flying Horse	89	Markab	2
33. Andromeda		66	Alpheratz	2
34. Cassiopeia	The Lady in the Chair	55	Schedir	3

2. CONSTELLATIONS IN THE ZODIAC.

1. Aries	The Ram	66		2
2. Taurus	The Bull	141	Aldebaran	1
3. Gemini	The Twins	85	Castor and Pollux 1	2
4. Cancer	The Crab	83	Acubens	4
5. Leo	The Lion	95	Regulus	1
6. Virgo	The Virgin	110	Spica Virginis	1
7. Libra	The Scales	51	Zubenel Genu'bi	2
8. Scorpio	The Scorpion	44	Antares	1
9. Sagittarius	The Archer	69		3
10. Capricornus	The Goat	51		
11. Aquarius	The Waterbearer	138		
12. Pisces	The Fishes	113		

3. CONSTELLATIONS SOUTH OF THE ZODIAC.

1. Phœnix	The Phœnix	13		
2. Officina Sculptoria		12		
3. Erid'anus	The River Po	84	Achernar	1
4. Hydrus	The Water Snake	10		
5. Cetus	The Whale	97	Menkar	2
6. Fornax Chemica	The Furnace	14		
7. Horologium	The Clock	12		
8. Reticulus	The Net	10		
9. Xiphias	The Sword Fish	7		
10. Cela Praxitelis	The Gravers	16		
11. Lepus	The Hare	19		
12. Columba Noachi	Noah's Dove	10		2
13. Orion		78	Betelguese	1
14. Argo Navis	The Ship Argo	64	Canopus	1
15. Canis Major	The Great Dog	31	Sirius	1
16. Equuleus Pictorius	The Painter's Easel	8		
17. Monoceros	The Unicorn	31		

18. Canis Minor	The Little Dog	14	Pro'cyon	1
19. Chameleon	The Chameleon	10		
20. Pyxis Nautica	Mariner's Compass	4		
21. Piscis Volans	The Flying Fish	8		
22. Hydra	The Hydra	60	Cor Hydræ	2
23. Sextans	The Sextant	41		
24. Robur Carolinum	The Royal Oak	12		
25. Machina Pneumat.	The Air Pump	3		
26. Crater	The Cup	31	Alkes	3
27. Corvus	The Crow	9	Algorab	3
28. Crux	The Cross	6		1
29. Musca Australis	The Southern Fly	4		
30. Apus Indica	The Bird of Paradise	11		
31. Circinus	The Compass	4		
32. Centaurus	The Centaur	35		
33. Lupus	The Wolf	24		
34. Quadra Euclidis	Euclid's Quadrant	12		
35. Triangulum Aust.	The Triangle	5		2 & 3
36. Ara	The Altar	9		
37. Telescopium	The Telescope	9		
38. Corona Australis	The Southern Crown	12		
39. Pavo	The Peacock	14		2
40. Indus	The Indian	12		
41. Microscopium	The Microscope	10		
42. Octans Hadleianus	Hadley's Quadrant	43		
43. Grus	The Crane	13		2
44. Toucan	The American Goose	9		
45. Piscis Australis	The Southern Fish	24	Fomalhaut	1

OF THE NUMBER OF THE STARS.

The number of stars that can be seen at any one time, by the naked eye, does not exceed a thousand; though, from their twinkling and the indistinct manner in which they are viewed, they appear to be innumerable.

But if we take into the account the stars that are visible through good telescopes, their number may be said to be almost, if not altogether, infinite. They are not equally distributed in the sky, but are chiefly crowded together in the region of the Milky Way.

The Milky Way is a broad track or path encircling the heavens; it is an assemblage of stars too remote to be seen singly, but so closely disposed as to give a luminous appearance to that part of the heavens. In the Milky Way Dr. Herschel has, in a quarter of an hour, seen 116,000 stars pass through the field of view of his telescope. "In short," to use the words of Sir John Herschel, "the Milky Way, when examined through powerful glasses, is found to consist entirely of stars scattered by millions, like glittering dust, upon the black ground of the general heavens."

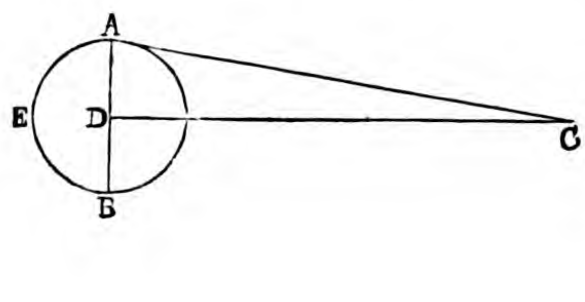
Astronomers have, however, not yet fathomed the sky; as more powerful telescopes are applied, stars unseen before burst upon the view.

OF THE DISTANCE OF THE STARS.

For a long time the only thing known respecting the distance of the stars was, that the nearest of them could not be less than nineteen billions of miles distant from us; how much more was not known. From the observations of Bessel, a Prussian astronomer, it is now rendered probable that the distance is three times that amount, or upwards of fifty-seven billions of miles.

The swiftest motion we are acquainted with is that of light, which moves at the rate of twelve millions of miles in a minute. Though flying with this inconceivable velocity, it will require ten years to traverse the space which separates us from the nearest fixed star. If the opinion of astronomers be correct, that stars of the second magnitude are twice the distance of those of the first, the third at twice the distance of the second, and so on, how great the distance of those which are just perceptible! The light that strikes upon our eyes from the Milky Way on a winter's night must have left the luminaries which afford it upwards of a thousand years ago. A cannon-ball, with its rush of twenty miles a minute, would require five and a half millions of years to travel from the nearest fixed star to us.

The method of ascertaining the distance of the stars depends upon the determination of their annual parallax. The process may be thus explained:



A person standing at A, on the margin of a circular lake, A, E, B, will see a tree at C in a different direction from a person situated at the centre, D.

The difference of direction being ascertained, or, in other words, the angles C A D and C D B being measured, and the length of A D being taken, the distance of the tree at C, or the length of the line C D can readily be found by a trigonometrical process. The angle A C D is denominated the *parallax* of the object at C, with respect to the observers at A and D. It is evident that the farther the object at C is removed from the spectators, the less this parallax will become.

Let us apply this illustration to astronomical purposes, and suppose the circle A E B to represent the earth, and the point C a fixed star. It might be expected that rays of light from the star at C would strike a spectator at A, and another, supposed to be at the centre D, in different directions; or, in other words, that the delicate instruments and practised eyes of astronomers would be able to detect some difference between the angles C A D and C D B. But they have not. The line A D, therefore, or the radius of the earth, 4000 m., is nothing in comparison with D C, the distance of the star at C from the centre of the earth.

Next let the circle A E B represent the earth's orbit. The angle A C D is in this case called the *annual* parallax. Now, although the point A is distant from D ninety-five millions of miles, astronomers for a long time could not detect any parallax. They measured the angles subtended by a particular star at all seasons of the year; or, in other words, from all points of the earth's orbit, without observing any difference. At length Professor Bessel has found the parallax of the star 61 Cygni, to be about one-third of a second. Confidence is placed in his observations, but as the angle is so very minute, the confirmation of his result is looked for with interest.

Owing to the extreme distance of the stars, their discs or bodies cannot be rendered visible by the most powerful telescopes.

Many of the stars must be much superior in brightness to our sun. It has been computed that Sirius, the brightest of the stars, emits fourteen times as much light as the sun.

It is probable that the stars are at as great a distance from each other as the nearest star is from the earth.

OF THE APPARENT MOTION OF THE STARS.

The motion of the earth upon its own axis, from west to east, causes the apparent motion of the stars in a contrary direction, from east to west: they all move round in circles parallel to the equinoctial.

Hence, when the equinoctial is perpendicular to the horizon, they rise and set perpendicularly; when the equinoctial cuts the horizon obliquely, they all rise and set obliquely; when it coincides with the horizon, the stars neither rise nor set, but move round in circles parallel to the horizon.

At the equator the pole star is always upon the horizon, and all the other stars rise and set perpendicularly; each star being twelve hours above and as many below the horizon, as may be seen by elevating the globe for a right sphere.

In the North Temperate Zone the stars will rise and set obliquely; and those stars whose distance from the pole is not greater than the latitude of the place, turn round the pole without setting. This will be seen by elevating the globe for the latitude of London. But it will be better observed by having recourse to the heavens themselves, and watching the motion of the stars for a few hours on a winter's evening.

Those stars that have, at any time, the same right ascension with the sun, come to the meridian with it; and the other stars come to the meridian before or after the sun, according as they are W. or E. of it. The sun appears to advance eastward among the stars, at the rate of nearly 1° or 4 m. of time per day; this causes the stars to come to the meridian, on any day, 4 minutes sooner than on the day preceding.

Those stars that are on the meridian at midnight will, the next night, be on it 4 m. before 12; in two nights 8 m., and so on. From this cause the heavens, in the course of six months, present an entirely new assemblage of stars (with the exception of those that never go below the horizon) to the eye. A revolution of one year brings the sun exactly into the same situation, with respect to the stars, as it was on the same day of a former year; on the same day of any year the same stars will always come to the meridian at the same time.

A sidereal day, by which astronomers generally reckon, is 4 m. shorter than the solar one; and a sidereal year (that is, the time in which the earth completes a revolution in its orbit, as indicated by its return to the same point in the heavens) is 365 d. 6 h. 9 m. 9.6 s. long, according to solar time, but it is 366 d. 6 h. 9 m. 9.6 s., reckoned in sidereal time. Civil time is regulated by the equinoctial year, which is the interval between two returns of the sun to the same equinox. Its duration is 365 d. 5 h. 48 m. 49.7 s.

OF NEW, TEMPORARY, VARIABLE, AND DOUBLE STARS.

Several stars which are marked in the early catalogues, and some which have been observed by modern astronomers, have disappeared from the sky. On the other hand, there are some stars now in the heavens which have only recently become visible; these are termed *new* stars.

A kindred phenomenon is that of stars becoming suddenly visible, shining for a brief period with considerable splendour, and then disappearing altogether. These are *temporary* stars.

The earliest star of this kind on record is that which suddenly appeared in the year 125 B.C. It was observed by Hipparchus, who was in consequence induced to draw up a catalogue of the stars, the earliest on record. Another blazed forth in A.D. 389, remained three weeks as bright as Venus, and then disappeared altogether. There are records of similar appearances in the years 945, 1264, and 1572. The star of 1572 was observed by Tycho Brahe. His attention was drawn to it by observing one evening (Nov. 11) on his return from his observatory to his dwelling-house, a group of country people gazing at a star which he was sure did not exist half an hour before. It was then as brilliant as Sirius, and continued to increase till it surpassed Jupiter when brightest, and was even visible at mid-day. It began to diminish in December of the same year; and in March, 1574, it had entirely disappeared. The stars of 945, 1264, and 1572 appeared in the same part of the heavens, between Cepheus and Cassiopeia. This circumstance, combined with the fact of their having appeared at nearly equal intervals, has suggested the idea that the appearances are owing to the revolution of the same star in an extremely eccentric orbit. This conjecture will be confirmed or overthrown in about thirty or forty years, when, if correct, the star will re-appear.

There is a class of stars denominated *variable*, whose light undergoes a periodical increase and diminution.

One of the most remarkable of these is Algol in Medusa's head. It is usually visible as a star of the 2nd mag., and as such continues visible for 2 d. 14 hrs., when it suddenly begins to diminish in splendour, and in about 3½ hrs. is reduced to the 4th mag. Its feeblest lustre lasts little more than 15 m., when it begins to increase, and in 3½ hrs. more is restored to its usual brightness. Its full period is 2 d. 20 hrs. 48 m. Another of these stars is ο Ceti, called also Mira, or the wonderful star.

It goes through its phases in 331 d. 10 hrs. When brightest, it is of the 2nd mag., and remains so for about a fortnight. It then decreases during three months, when it passes out of sight, continues invisible for five months, and then re-appears. There are altogether about twenty stars ascertained to be variable, and upwards of fifty suspected to belong to the class.

Many stars are multiple, that is, they appear to be single when seen by the naked eye, but are found to consist of two or more, when viewed through a telescope of sufficient power.

The number of these *double stars*, and the smallness of the interval between the stars so conjoined, forbid the idea of an accidental contiguity. This is entirely put out of the question by the discovery of the fact that many of these double stars revolve round a common centre. Fifty or sixty instances have been noticed of the two stars revolving about each other in regular orbits, and constituting what are termed *binary stars*, to distinguish them from double stars generally so called. Some of the most remarkable of these are—Castor, whose constituents complete a revolution in 252 yrs.; η Coronæ in 43 yrs; ξ Ursæ in 58 yrs.; 61 Cygni in 452 yrs.; ν Virginis in 629 yrs.

Besides binary stars, systems consisting of three, four, and even five individuals, have been found to exist.

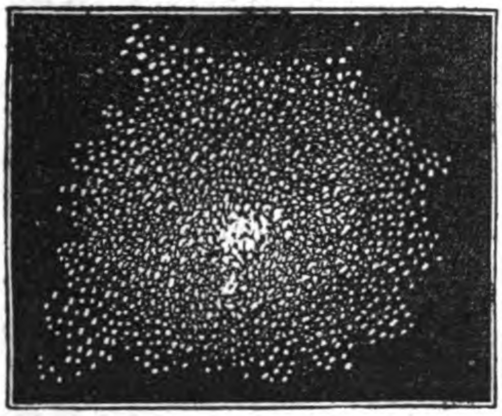
Many of the double stars exhibit the curious and beautiful phenomena of contrasted colours. In such instances the larger star is usually of a ruddy or orange hue, while the smaller one appears blue or green. Persons possessed of ordinary telescopes will get an illustration of this by observing the star Albireo in the beak of the Swan.

The whole number of stars whose multiple character has been ascertained, cannot be less than 6000.

OF NEBULÆ AND CLUSTERS OF STARS.

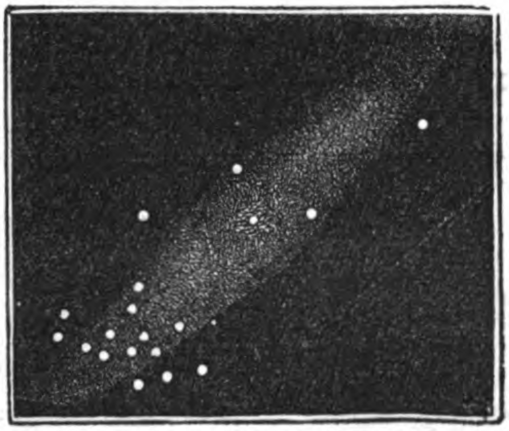
The most astonishing as well as most mysterious objects in the heavens are *nebulæ*, which are misty patches of light, and are scattered in considerable numbers through space. When viewed through powerful telescopes, some of them are found to consist of clusters of stars; these are termed resolvable nebulæ; in other cases the diffused luminosity continues unbroken; these nebulæ are said not to be resolvable.

On a clear winter's night a faint light is observed to envelop the six or seven stars which form the Pleiades; a common telescope will show that it is occasioned by a cluster of stars too minute to be individually recognised by the naked eye. A cluster in the sword handle of Perseus affords a similar and very beautiful exhibition; and the luminous spot in Cancer, called Præsepe, or the bee-hive, may with equal facility be resolved. In the constellation Hercules, midway between the stars η and ζ, is a nebula which in favourable circumstances may be seen by the naked eye. Viewed through an ordinary telescope, it appears exactly like a small round comet without a tail; but when very high powers are



applied to it, an appearance like that figured in the cut is presented. "It would be a vain task (says Sir John Herschel) to count the stars in one of these *globular clusters*. They are not to be reckoned by hundreds. On a rough calculation, it would appear that many of them must contain at least ten or twenty thousand stars, compacted and wedged together in an area not more than a tenth part of that covered by the moon." And yet, in all probability, the individuals of such a group are suns like our own, and their mutual distances equal to those which separate our sun from the nearest fixed star! The works of God baffle our comprehension—how mysteriously great and glorious is the Creator! "Canst thou by searching find out God? canst thou find out the Almighty unto perfection?"

Many, however, of the nebulæ (and such only are properly so called) have not been resolved. A remarkable instance of this kind is in the constellation Andromeda, near the star ν. It is visible, under favourable circumstances, to the naked eye, and when seen through a telescope has the appearance of a candle shining through a horn (see cut). "It has in it a few small stars; but they are obviously casual, and the nebula itself offers not the slightest appearance to give ground for a suspicion of its consisting of stars."



A telescope of very moderate powers directed to the middle star of the three forming the sword of Orion will reveal a very beautiful nebula. It has, however, recently been resolved by very powerful telescopes; and the opinion gains ground that all the nebulæ are clusters. Between the stars β and ν Lyræ (see fig. of Lyra) is a nebula that has the appearance of a ring, which is easily seen.

The number of nebulæ already catalogued is between two and three thousand.

It is considered by many that our sun partakes of the nebulous character. The peculiar appearance called the zodiacal light has led to this conjecture. It is easily seen after almost any clear sunset in tropical climates, but in this country it can only be distinguished in the evening about the months of April and May, or at the opposite season before sunrise. It consists of a long train of faint light of a conical form surrounding the sun, and following generally the course of the ecliptic. It extends beyond the orbit of Venus.

PROBLEM I.

To find the Right Ascension and Declination of any Star.

Bring the star to the brass meridian; the degree of the meridian over it is the declination, and the degree of the equinoctial under the meridian the right ascension.

Declination on the celestial globe is the same thing as latitude on the terrestrial, and right ascension the same thing as longitude.

The right ascension may otherwise be found by elevating the globe for a right sphere (viz., bringing the poles to coincide with the horizon), and bringing the star to the eastern horizon; the point of the equinoctial that comes to the horizon at the same time will be the right ascension: it may be expressed either in degrees or hours.

The use of the declination is principally to find the latitude of any place by the altitude of the stars.

EXAMPLES.

1. What are the right ascension and declination of Sirius? *Ans.* Rt. as. 99° 0′, or 6 hrs. 36 m. Dec. 16° 27′ S.

2. Required the rt. as. and dec. of the pole star. *Ans.* Rt. as. 13° 0′, or 0 h. 52 m. Dec. 88° 14′ N.

Required the right ascension and declination of—

3. Andromeda's Girdle, Mirach, β. 4. Ram's Following Horn, α. 5. Whale's Jaw, Menkar, α. 6. Medusa's Head, Algol, β. 7. Perseus' Side, Algenib, α. 8. Brightest of the Seven Stars. 9. Bull's Eye, Aldebaran, α. 10. Auriga's Shoulder, Capella, α. 11. Orion's Foot, Rigel, β. 12. Bull's N. Horn, β. 13. Orion's Left Shoulder, Bella-

trix, γ. 14. Orion's Girdle, ε. 15. Orion's Right Shoulder, Betelguese, α. 16. First Twin, Castor, α. 17. Little Dog, Procyon, α. 18. Second Twin, Pollux, β. 19. Boötes, Arcturus, α. 20. Lyra, α.

PROBLEM II.

Having the Right Ascension and Declination of a Star, to find it on the Globe.

Bring the right ascension, marked on the equinoctial, to the brass meridian; then, under the given declination marked on the meridian, will be the star required.

EXAMPLES.—Required the stars whose right ascension and declination are as follow:

	RIGHT ASCENSION.				DECLINATION.		
	In degrees.		*In time.*				
1.	139°	15′	9h.	17m.	7°	48′	S.
			Ans. Alphard, Hydra's Heart.				
2.	149	15	9	57	12	56	N.
			Ans. Regulus, Lion's Heart.				
3.	162	15	10	49	57	27	N.
4.	162	45	10	51	62	50	N.
5.	174	30	11	38	15	41	N.
6.	191	15	12	45	57	3	N.
7.	198	30	13	14	10	7	S.
8.	209	30	13	58	65	20	N.
9.	211	30	14	6	20	13	N.
10.	219	45	14	39	15	12	S.
11.	226	30	15	6	8	38	S.
12.	231	30	15	26	27	24	N.
13.	244	15	16	17	25	58	S.
14.	256	15	17	5	14	38	N.
15.	261	15	17	25	12	43	N.
16.	268	0	17	52	51	31	N.
17.	277	30	18	30	38	36	N.
18.	295	15	19	41	8	21	N.
19.	341	30	22	46	30	40	S.
20.	343	30	22	54	14	8	N.

PROBLEM III.

To find the Latitude and Longitude of a given Star.

1. Bring the pole of the ecliptic, which is in the same hemisphere with the given star, to the brass meridian, and fix over it the quadrant of altitude.

2. Holding the globe steadily, move the quadrant till it come over the given star; then the degree of the quadrant cut by the star is its latitude, and the degree on the ecliptic cut by the quadrant is its longitude.

That part of the heavens north of the ecliptic is called the *northern* hemisphere, and that south of the ecliptic the *southern* hemisphere; so that a star may be north of the equinoctial, and yet have S. latitude, or south of the equinoctial, and have N. latitude.

The longitude of celestial bodies is not reckoned in *degrees* and *minutes*, as the right ascension is, but in *signs*, degrees, and minutes, in the same manner as the sun's place, which is only another name for the sun's longitude.

The quadrant of altitude is fixed upon the pole of the ecliptic, because in that position it will be perpendicular to every point of the ecliptic, and therefore represent circles of longitude.

EXAMPLES.

Required the lat. and long. of the following stars:

1. Taurus, β. *Ans.* 5° 22′ N. L. ♊ 19° 47′ L.
2. Pollux. *Ans.* 6° 40′ N. L. ♋ 20° 28′ L.

3. Regulus.	10. Capella.	16. Dubhe.
4. Scorpio, β.	11. Fomalhaut.	17. Algol.
5. Markab.	12. Procyon.	18. Aldebaran.
6. Atair.	13. Centaur, α.	19. Spica Virginis.
7. Arided.	14. Enar Achernar.	20. Antares.
8. Schedir.		21. Rigel.
9. Draco, α.	15. Arcturus.	22. Canopus.

PROBLEM IV.

The Day of the Month being given, to find at what Hour any Star comes to the Meridian.

By the Globe.—1. Bring the sun's place to the meridian, and set the index to 12 o'clock.

2. Turn the globe round till the given star come to the meridian, and the index will show the hour.

If the star be to the E. of the sun, it will come to the meridian after the sun, and hence the hour will be *p.m.*; but if the star be to the W. of the sun, the hour will be *a.m.*

WITHOUT THE GLOBE.—Find the sun's right ascension for the day, by the table in White's Ephemeris, or by Table II. at the end of this work; and find the rt. as. of the star from Table III. or from any catalogue of stars.

Subtract the sun's right ascension from that of the star, (both being expressed in time,) and the remainder will be the time of the star's coming to the meridian.

If the right ascension of the sun be greater than that of the star, add to it 24 before you subtract; and the remainder, if less than 12, is the time of the star's coming to the meridian in the *afternoon*; if the remainder be greater than 12, take 12 away, and the last remainder is the time of the star's coming to the meridian in the *morning*.

EXAMPLES.—At what hour do the following stars come to the meridian on Feb. 9th?

1. Lyra.	*Ans.* 9 h. 1 m. *a.m.*
2. Aldebaran.	*Ans.* 6 55 *p.m.*
3. Arcturus.	7. Castor.
4. Capella.	8. Fomalhaut.
5. Sirius.	9. Markab.
6. Regulus.	10. Atair.

The first Example performed without the Globe.

The sun's right ascension, on Feb. 9th, is 21 hrs. 29 min.; the right ascension of Lyra is 18 hrs. 30 min.; to the last add 24, and from the sum 42 hrs. 30 min., subtract 21 hrs. 29 min.; the remainder is 21 hrs. 1 min. From this remainder take away 12, and there are left 9 hrs. 1 min.; which is the time of the star's coming to the meridian in the morning.

Required the time at which the following stars come to the meridian on the respective days.

11. Regulus,	Oct. 24.	14. Cassiopeia, β,	Nov. 8.
12. Draco, α,	Sept. 20.	15. Ras Algethi,	Aug. 22.
13. Bellatrix,	Jan. 7.	16. Menkar,	May 5.

At what hour does Alphard (Hydra's Heart) on—

17. January 29. 20. September 23.
18. May 15. 21. November 5.
19. August 12. 22. December 21.

At what hour do the following stars.

23. Mirach, April 6. 26. Seven Stars, Aug. 29.
24. Almaach, June 21. 27. Procyon, Oct. 14.
25. Algol, July 12. 28. Great Bear, α, Dec. 26.

PROBLEM V.

To find on what Day of the Year any Star passes the Meridian at any given Hour.

By the Globe.—1. Bring the given star to the meridian, and set the index to the given hour.

2. Turn the globe till the index point to 12 at noon; the day of the month, corresponding to the degree of the ecliptic under the meridian, will be the day required.

Without the Globe.—1. If the star come to the meridian in the morning, add the time that it wants to noon to the right ascension of the star, and the sum will be the right ascension of the sun on the required day.

2. If the star come to the meridian in the evening, subtract the time from noon from the star's right ascension, and the remainder will be the sun's right ascension.

3. The day of the month, answering to this right ascension, may be found from Table II.

If, in adding, the sum is more than 24h. or 360°, subtract from it 24h. or 360°, and the remainder will be the sun's right ascension.

If, when you subtract, the rt. as. of the star is less than the time from noon, add to it 24h., or 360°, before subtracting.

Examples.—1. On what day does Algenib, in Perseus, come to the meridian at midnight?

Here 3h. 10m., the right ascension of Algenib, added to 12h., the time from noon, gives 15h. 10m., the sun's right ascension; the day in the Table answering this R. A. is Nov. 12.

2. On what day does Spica Virginis come to the meridian at half-past nine in the evening? *Ans.* May 18th.

On what days do the following stars come to the meridian at midnight?

3. Algol.
4. Betelguese.
5. Acubens, Cancer.
6. Alioth, Great Bear, ε.

On what days do the following stars come to the meridian at nine o'clock in the evening?

7. Ras Alhague.
8. Rastaben.
9. Leo, β.
10. Pegasus, β.

Required the days on which the following stars come to the meridian at five o'clock in the morning.

11. Sirius.
12. Aries, α.
13. Taurus, β.
14. Great Bear, δ.
15. Serpent, α.
16. Andromeda, α.

On what days do the following stars come to the meridian at ten o'clock in the evening?

17. Orion, ε.
18. Acubens.
19. Alderamin.

On what days does Arcturus come to the meridian, at—

20. Noon?
21. 3 *p.m.*?
22. 9 *p.m.*?
23. Midnight?
24. 3 *a.m.*?
25. 6 *a.m.*?

PROBLEM VI.

The Latitude, Hour of the Night, and Day of the Month, being given, to find the Altitude and Azimuth of any Star.

Elevate the globe for the given latitude, bring the sun's place to the meridian, and set the index to 12; and turn the globe till the index point to the given hour.

Fix the quadrant of altitude on the zenith, and bring it over the star; then the degree upon the quadrant cut by the star will be its altitude, and the distance between the foot of the quadrant and the north or south point of the horizon will be the azimuth.

EXAMPLES.—1. Required the altitude and azimuth of Cor Leonis, at London, on May 11th, at 11 o'clock *p.m.*

Ans. Alt. 26° 50′. Az. S. 76° 30′ W.

2. Required the altitude and azimuth of Capella, at Rome, on December 2nd, at five in the morning.

Ans. Alt. 42°. Az. N. 60° W.

What are the altitude and azimuth of the following stars, at Newcastle, October 6th, at the following hours?

3. Arided, midnight.
4. Capella, 8 *p.m.*
5. Castor, 10 *p.m.*
6. Algenib (α, Perseus), 8 *p.m.*
7. Menkar, 11 *p.m.*
8. Atair, 9 *p.m.*
9. Vega, 9 *p.m.*
10. Arcturus, 7 *p.m.*

Required the altitude and azimuth of the following stars, at London, December 21st, at 4 in the morning.

11. Spica Virginis.
12. Sirius.
13. Deneb (Leo, β).
14. Cor Hydræ.
15. Procyon.
16. Pleiades (Taurus, η).
17. Arided (Cygnus, α).

Give the altitude and azimuth of the following stars, at C. Good Hope, June 21st, at midnight.

18. Spica Virginis.
19. Antares (Scorpio, α).
20. Arcturus.
21. Ras Alhague.
22. Fomalhaut (S. Fish, α).
23. Achernar (Eridanus, α).

What are the altitude and azimuth of the following stars, at Jerusalem, August 9th, at 4 o'clock *a.m.*?

24. Menkar (Cetus, α).
25. Algol.
26. Dubhe (Ursa Major, α).
27. Phœnix, α).
28. Fomalhaut (S. Fish, α).

Required the altitude and azimuth of the following stars at Quito, on March 22nd, at 10 *p.m.*

29. Cor Hydræ.
30. Canopus (Argo, α).
31. Sirius.
32. Centaurus, α.
33. Cor Caroli.

PROBLEM VII.

The Azimuth of any Star and Day of the Month being given, to find the Hour of the Night and the Altitude of the Star, in a given Latitude.

1. Rectify the globe as in the last problem, fix the quadrant of altitude upon the zenith, and bring it to the given azimuth.

2. Turn the globe round till the star come to the quad-

rant; then the index will show the hour, and the altitude of the star will be found upon the quadrant.

N.B. Some of the examples admit of two answers.

EXAMPLES.

1. The azimuth of Regulus, the Lion's Heart, at London, May 11, was S. 76° W.; required the altitude and hour of the night. *Ans.* Hour, 11 *p.m.* Alt. 27°.

2. The azimuth of Capella, at Rome, on Dec. 2nd, was N. 60° W.; required the altitude and hour of the night. *Ans.* Hour, 5 *a.m.* Alt. 42°.

Having the azimuth of the following stars, required their altitude, and the hour for London, on Sept. 1st.

3. Ras Alhague, S. 47° W.
4. Dubhe, N. 23 W.
5. Delphinus, α, S. 20° E.
6. Cygnus, , S. 55 E.

Having the azimuth of the following stars for Newcastle, Oct. 6th, required the hour and the altitude.

7. Seven Stars, S. 88½° E.
8. Arcturus, N. 81 W.
9. Aries, α, S. 65 E.
10. Capella, N, 40. E.
11. Auriga, β, N. 52° E.
12. Betelguese, S. 80 E.
13. Cancer, α, S. 70 E.
14. Procyon, S. 29 E.

PROBLEM VIII.

The Altitude of a Star, the Day, and the Latitude being given, to find the Azimuth and Time of the Night.

1. Rectify the globe as in the former problems.

2. Having screwed the quadrant upon the zenith, turn the globe and move the quadrant till the star cut the quadrant at the given altitude; the index will show the hour, and the quadrant the azimuth on the horizon.

The stars having the same altitude twice a day, it is necessary to know whether the given star is E. or W. of the meridian, or whether the hour required is in the evening or morning.

EXAMPLES.—1. The altitude of Rigel, in Orion, was observed at Boston (America) to be 15° in the evening of

December 8th; what were the hour and azimuth? *Ans.* 8 hrs. 1 min.; azimuth, S.E. by E. 7° E.

2. At Jerusalem, on the morning of August 9, the altitude of Alderamin (Cepheus, α,) was 41°; required the hour and the azimuth. *Ans.* Az. N. 34° W.; hour 4.

Having the altitudes of the following stars at London, on the days given, required the time and azimuth.

3. Sept. 1, Even.	Ursa Major, η,	38°
4. Dec. 21, Morn.	Deneb, Leo, β,	50
5. May 11, Even.	Regulus,	27
6. Sept. 1, Even.	Scheat Alp. β, Pegasus,	47
7. May 11, Even.	Castor,	18
8. Dec. 21, Morn.	Sirius,	8

Having the altitudes of the following stars at Grand Cairo, required the hour and azimuth.

9. June 4, Even.	Alphard,	$14\frac{1}{2}$°
10. ———————	Spica,	43
11. Aug. 12, Morn.	Menkar,	57
12. ———————	Sirius,	$14\frac{1}{2}$

PROBLEM IX.

Having the Azimuth of a Star, the Latitude, and Hour, to find the Star's Altitude and Day of the Month.

1. Elevate the globe for the latitude, fix the quadrant on the zenith, and bring it to the given azimuth.

2. Bring the star to the edge of the quadrant, and set the index to the given hour; the altitude of the star will then be found upon the quadrant.

3. Turn the globe till the index point to noon; and the day of the month answering to the degree of the ecliptic cut by the brass meridian, is the day required.

EXAMPLES.

1. At London, 11 o'clock *p.m.*, the azimuth of Spica Virginis was observed to be S. 17° W.; required its altitude and the day of the month. *Ans.* May 11th; alt. 27°.

2. At London, 9 *p.m.*, the azimuth of α, N. Crown, was S. 89° W.; what were the alt. and day of the month? *Ans.* Sept. 1st; alt. 38°.

3. At Newcastle, 10 *p.m.*, the azimuth of Almaach (Andromeda, γ) was S. 84° E.; required the alt. and day.

4. At Jerusalem, 4 *a.m.*, the azimuth of Markab was S. 71° W.; what were the day and altitude?

5. At Jerusalem, at 4 *a.m.*, the azimuth of Alderamin was N. 34° W.; required the day and altitude.

6. At the Cape of Good Hope, at midnight, the azimuth of the star Fomalhaut was S. 73° E.; required the day of the month and the altitude of the star.

7. At Rome, 5 *a.m.*, the azimuth of Capella was N. 60° W.; required the day and the altitude of the star.

PROBLEM X.

To find the Hour of the Night, by observing when any two Stars have the same Azimuth.

1. Rectify the globe as in the preceding problems.

2. Move the globe and the quadrant, till the quadrant come over both stars; the index will show the hour.

It may be found when two stars have the same azimuth, by holding up a small line, with a plummet, between the eye and the stars; or, by observing when any two stars are in a line with the end of a house or wall, which is known to be perpendicular.

Examples.—1. May 11th, at London, Vega and Atair were observed to have the same azimuth; what was the hour? *Ans.* 2 hrs. 15 min. *a.m.*

2. March 29th, Atair and Vega had the same azimuth at Stockholm; required the hour. *Ans.* 4 o'clock *a.m.*

Required the hour at London when the following stars have the same azimuth on the annexed days.

3. January 3,	Algol and Aldebaran.
4. February 6,	Cor Caroli and Arcturus.
5. May 12,	α, Cygnus, and α, Pegasus.
6. November 15,	Castor and Cor Hydræ.

7. Procyon and Sirius were observed to have the same azimuth at Rome, December 2nd; what was the hour?

PROBLEM XI.

To find the Rising, Setting, and Culminating of any Star,—its Continuance above the Horizon,—its oblique Ascension and Descension,—and its eastern and western Amplitude for any given Day and Place.

1. Rectify the globe as in the preceding problems.

2. Bring the given star to the eastern horizon, and the index will show the hour of rising; the degree of the equinoctial that rises with the star is its oblique ascension; and the distance of the star from the east point of the horizon is its eastern or rising amplitude.

3. When the star is brought to the meridian, the index will show the time of culminating.

4. Bring the star to the western horizon, and its setting, oblique descension, and western amplitude, will be found in the same manner as its rising, eastern amplitude, and oblique ascension.

5. The number of hours from rising to setting will be the time of its continuance above the horizon.

EXAMPLE.—Required the time when the following stars rise, come to the meridian, and set; how long they continue above the horizon; likewise their oblique ascension and descension, and their eastern and western amplitude, at the respective places and days.

1. Sirius, at London, on March 14th.

Ans. Rises at 2h. 24m. *p.m.*; Culminates, 6h. 57m. *p.m.*; Sets, 11h. 30m. *p.m.*; Above the horizon, 9h. 6m.; Oblique ascension, 120° 47′; Oblique descension, 77° 17′; Amplitude, 27° S.

2. Fomalhaut, at the Cape of Good Hope, on Dec. 10th.

Ans. Rises, 10h. *a.m.*; Culminates, 5h. 30m. *p.m.*; Sets, 1h. *a.m.*; Above the horizon, 15h.; Oblique ascension, 317°; Oblique descension, 5°; Amplitude, 38° S.

3. Achernar in Eridanus, at Otaheite, on June 4th.

4. Arcturus, at Newcastle, on March 11th.

5. Rigel, at Jerusalem, on September 23rd.

6. Menkar, α, Cetus, at Rome, on October 12th.

7. At what time does Atair rise, culminate, and set at Jamaica on June 9th?

PROBLEM XII.

To represent the Face of the Heavens for any given Day and Hour, in any given Latitude.

Bring the sun's place to the meridian, put the index to 12, and turn the globe to the given hour; the stars in the heavens will appear in the same situations as they are upon the globe, but in an inverted order.

EXAMPLES.

1. Required the situation of the stars for the latitude of Newcastle, on October 6th, at 8 *p.m.*

The answer to this example constitutes—

A SURVEY OF THE HEAVENS.

The first star which strikes the eye of the observer in the north-east part of the heavens is Capella, in the constellation *Auriga*, or the Waggoner: it is a beautiful star of the 1st magnitude, of the altitude of 23°, or nearly the fourth part of the distance from the horizon to the zenith. There are in this constellation two stars of the 2nd magnitude, which form with Capella a triangle; the star which forms the short side of the triangle is in the right shoulder of Auriga, and is marked β; it lies at the distance of about 8° from Capella, farther to the north; its altitude is 18°: the star forming the longer side of the triangle is in the right foot; it is also usually represented as forming the tips of the Bull's northern horn; its distance from Capella is more than 25°; its altitude not more than 5°, and azimuth N. E. The general grouping of the

AURIGA.

stars of this constellation forms a six-sided figure, as represented in the annexed figure.

The star Capella is easily distinguished by the acute-angled triangle formed by three stars of the 4th magnitude, a little to the south of Capella, that bear the name of the *Kids*.

GEMINI.

If a line be drawn through the two stars that form the upper side of the triangle, and continued to the horizon, it will point out Castor, α, in Gemini, just rising; azimuth, E. N. E.: it is between the 1st and 2nd magnitude. The other stars in this constellation have not yet risen; but when they are above the horizon they form a tolerably correct parallelogram.

PERSEUS.

A line drawn between Castor and Capella, and continued higher in the heavens, will point out *Perseus*. It may also be easily found by directing the eye to the seven stars, and noticing the curved line which the principal stars in the constellation make from that point. Algenib, in the breast of Perseus, is a star of the 2nd magnitude. In the sword handle of Perseus is a beautiful cluster of stars, which a telescope of moderate power will display.

A little to the south of Perseus is the head of *Medusa*, which Perseus is holding in his hand. The brightest star in it is Algol, which is a variable star; its altitude is 33°; azimuth, E. N. E.; it is only 10° distant from Algenib.

Directly below the head of Medusa, about 14° above the horizon, are the *Pleiades,* or Seven Stars: they are situated in the shoulder of *Taurus,* and are so easily known, that no description is necessary. Aldebaran, a star of the 1st magnitude, which forms the eye of Taurus, is just rising; azimuth E. N. E. A vertical circle, drawn through Algol, will point to it. There are two stars of the 3rd magnitude, and several smaller, very near Aldebaran, which form with it a triangle, or the letter V. The whole cluster is called the *Hyades.*

TAURUS.


CASSIOPEIA.

A line, drawn from Aldebaran through Algol, and continued to the zenith, will direct to *Cassiopeia,* or the *Lady in the chair.* This contains five stars of the 3rd magnitude, besides several of the 4th: it is in form something like the letter W, or, as some think, an inverted chair. It is situated above Perseus, within 30° of the zenith. The altitude of the brightest star, α, called Schedir, is 60°; azimuth, E.N.E.

Below Cassiopeia, and west of Perseus, is *Andromeda,* which contains three stars of the 2nd magnitude. A line from Algenib, parallel to the horizon, toward the south, will pass very near these three stars; and as they are all of the same magnitude, and placed nearly at the same distance of 15° from each other, they may easily be known. The name of the star nearest Perseus, and which is in the foot of Andromeda, marked γ, is Almaach: its altitude is 49°, azimuth, E. N. E. The name of β, in the

ANDROMEDA.

ARIES.

girdle, is Mirach: its altitude 44°; azimuth, E. The altitude of α, in the head of Andromeda, is 46°; azimuth, E. S. E. The remarkable nebula, of which a figure is given (p. 269), is shown in the annexed engraving, near the star marked ν.

About 18° below Mirach are two stars in *Aries*, not more than 5° distant from each other, forming with Mirach an isosceles triangle: the eastern star, α, is of the 2nd magnitude; the other, β, of the 3rd, attended by a smaller star, marked γ, of the 4th magnitude. A line drawn from Mirach, perpendicular to the horizon, will pass between the two, and, besides, will point to a star of the 2nd magnitude, directly E., not 3° above the horizon.

This star is the first of *Cetus*, marked α, and is of the 2nd magnitude; it is named Menkar: a line, drawn from Capella through the Pleiades, will also point to it. Cetus is a large constellation, and contains eight stars of the 3rd magnitude; they all lie to the west of Menkar; β, a star in the tail, is more than 40° distant from it. The azimuth of β is S. E. by E.; altitude nearly the same as that of Menkar.

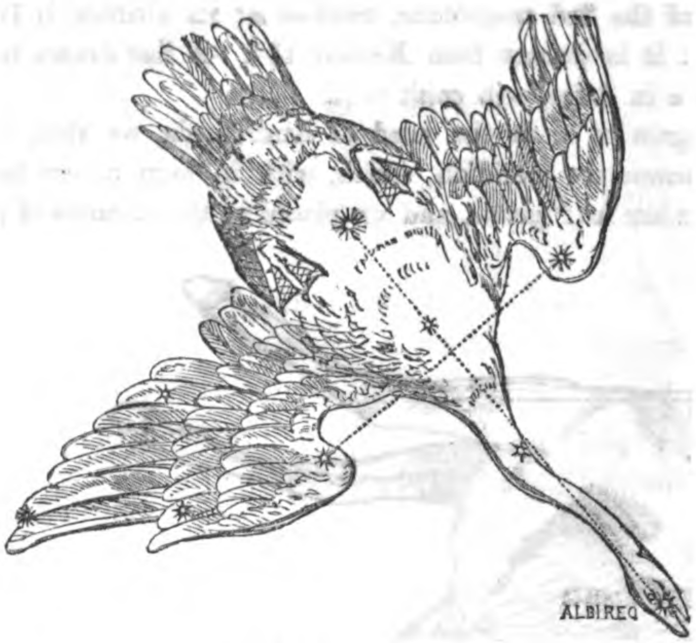
The constellation *Pisces* is situated next to Aries; a number of small stars under the left arm of Andromeda forms the most northerly fish, and an ellipse of stars below the wing of Pegasus (as shown in the figure of that constellation) constitutes the other. This constellation contains one star of the 3rd magnitude, marked α; its altitude is 10°; azimuth, E. by S.: it is distant from Menkar 15°. A line drawn from Almaach, through α in Aries, will point to it.

If we return again to α, in the head of Andromeda, we shall find three other stars nearer the meridian, which, with it, form a very large square: these stars are in *Pegasus*, and are placed at the distance of 15°

PEGASUS. PISCES. AQUARIUS.

from each other; they are all of the 2nd magnitude. The two stars forming the western side of the square are called, the upper one Scheat, which is marked β, and which is in the thigh of Pegasus; the under one, Markab, which is marked α, and which is in the wing: the lowest star in the eastern side of the square is in the tip of the wing, and is marked γ. The altitude of Scheat is 55°; azimuth, S. E. ½ E. Altitude of Markab, 43°; azimuth, S. E. by S. ½ E.

A line drawn through γ and β (the diagonal in the square of Pegasus), and continued to the meridian, will point out *Cygnus*, a remarkable constellation, in the form of a large cross, in which there is a star of the 2nd magnitude, named Deneb, or Arided; it is marked α, and is almost directly upon the meridian, at the altitude of 80°. Cygnus contains six



CYGNUS.

LYRA.

stars of the 3rd magnitude, one of them Albi'reo, or β, in the beak, is a beautiful double star.

CEPHEUS.

The constellation *Cepheus* contains no remarkable stars; it is situated between Cygnus and the north pole. It is easily found by observing that his left foot is close upon the pole star and directing the eye in search of three stars of the 4th magnitude which are in his head. Three others of the 3rd magnitude, one in his right shoulder, one in his side, and another in his left knee, form an arc of a circle, of which a star of the 4th magnitude in his left shoulder is the centre.

Below Pegasus, and nearer the meridian, is *Aquarius*, containing four stars of the 3rd magnitude. A line, drawn from α in Andromeda, through

Markab, will point to α in Aquarius. Its altitude is 32°; azimuth, S. S. E. The young student in search of Aquarius will do well to search for the four stars which form the water-pot, and which are arranged as represented in the drawing.

A bright star of the 1st magnitude, named Fomalhaut, in *Piscis Australis*, is then upon the horizon; azimuth, S. S. E.

Delphinus is a small constellation, situated about 30° below Cygnus, upon the meridian: it contains five stars of the 3rd magnitude; four of them are placed close together, and form the figure of a rhombus, or lozenge. A line, drawn through the two under stars of the square, will point to it: its altitude is about 50°.

DELPHINUS. AQUILA.

A little to the west of Delphinus, but not quite so high, is *Aquila*, containing one very bright star, of the 1st magnitude, named Atair: it may very easily be known from having a star on each side of it, of the 3rd magnitude, forming a straight line: the length of the line is only about 5°: altitude of Atair, 40°; azimuth, S. S. W.

Considerably above Atair, and a little to the west of Cygnus, is *Lyra*, containing a star of the 1st magnitude, one of the most brilliant in the firmament. It is called Lyra, or Vega, and is 35° to the north-west of Atair: altitude, 60°; azimuth, W. S. W. Lyra, Atair, and Arided, form a large triangle.

We come now to notice three constellations which occupy a considerable space in the western side of the heavens: these are *Hercules*, immediately below Lyra; *Serpentarius*, between Hercules and the horizon, extending a little more towards the south; and *Boötes*, reaching from the horizon W. N. W. to the altitude of 45°.

Hercules is rather a difficult constellation for the beginner to make out. It is best to seek first for a star in his right foot, which, with three others in the head of the Dragon, form a lozenge-shaped figure not easily mistaken. When this star is once detected, the arrangement of the other stars, as indicated in the annexed drawing, may be made out. It contains eight stars of the 3rd magnitude: the star in the head, α, named Ras Al'gethi, is within 5° of α in the head of Serpentarius. This last is a star of the 2nd magnitude, and is named Ras Alhague; its altitude is 30°; azimuth, S. W. by W. ½ W. A line drawn from Lyra, perpendicular to the horizon, will pass between these two stars. The other

HERCULES.

stars in Hercules extend towards the zenith, and those in Serpentarius towards the horizon. The remarkable cluster of stars figured in p. 269 is situated midway between ζ and η Hercules, as shown in the cut. Of this magnificent cluster Professor Nichol remarks, it is impossible to give a fitting representation. Perhaps no one ever saw it for the first time, through a large telescope, without uttering a shout of wonder.

The constellation *Boötes* may easily be known from the brilliancy of Arcturus, a star of the 1st magnitude, and supposed to be the nearest

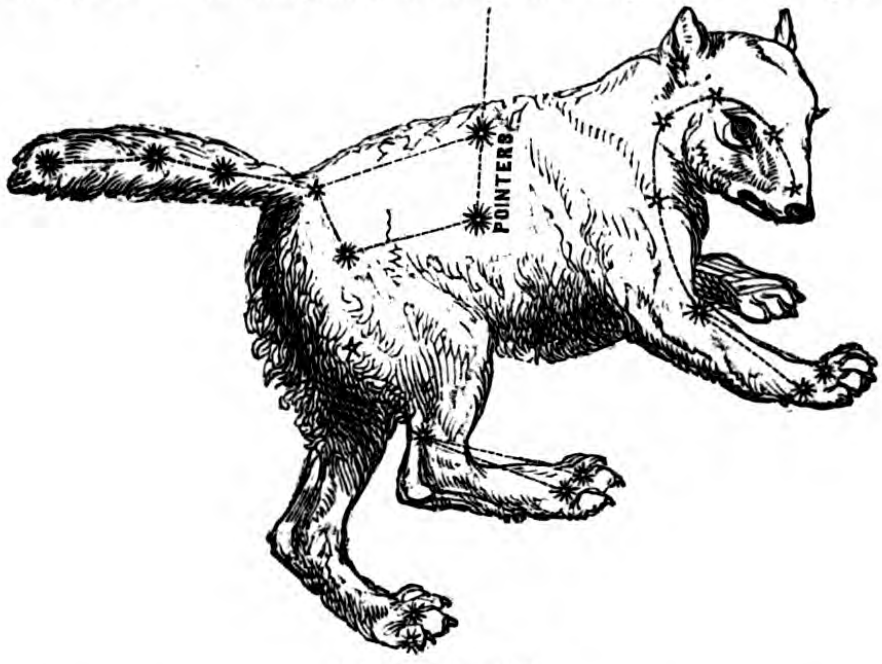
NORTHERN CROWN. BOÖTES. COR CAROLI.

to our system of any in the northern hemisphere; it is within 10° of the horizon; azimuth, W. N. W. Boötes also contains seven stars of the 3rd magnitude, mostly situated higher in the heavens than Arcturus. The star immediately above Arcturus is called Mezen Mirach, and is marked ε; it is a beautiful double star of different colours. The star in the left shoulder, δ, named Seginus, forms, with Mirach and Arcturus, a straight line.

Between Serpentarius and Boötes is *Serpens*, containing one star of the 2nd, and eight of the 3rd magnitude: α in Serpens is nearly at the same distance from the horizon as Arcturus; azimuth, W.

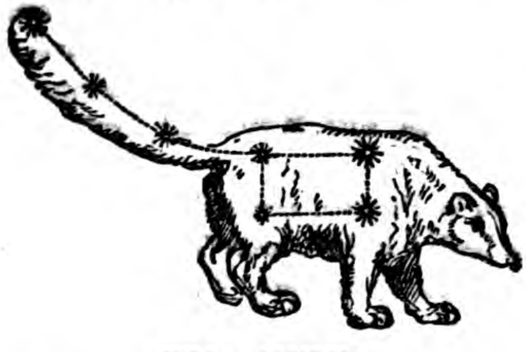
Above Serpens, and a little to the east of Boötes, is the *Northern Crown*, containing one star of the 2nd magnitude, named Gemma, and several of the 3rd, which have the appearance of a semicircle. A line drawn from Lyra to Arcturus will pass through this constellation.

We come now to *Ursa Major*, a constellation containing one star of the first, three of the 2nd, and three of the 3rd magnitude. It may easily



URSA MAJOR.

be distinguished by these seven stars, which, from their resemblance to a waggon, are called Charles's Wain. The four stars in the form of a long square are the four wheels of the waggon; the three stars in the tail of the Bear are the three horses, which appear fixed to one of the wheels. The two hind wheels (α, named Dubhe, and β) are called the *pointers*, from their always pointing nearly to the north pole: hence the pole star may be known. The other prominent stars in the Bear will be made out with tolerable ease by a reference to the engraving. The altitude of Dubhe is 30°; azimuth, N. by W. ½ W.; the distance between the two pointers is 5°; the distance between the pole star and Dubhe, the upper pointer, is 30°*.



URSA MINOR.

Ursa Minor, besides the pole star, of the 2nd magnitude, situated in the tail, contains three of the 3rd, and three of the 4th magnitude. These form a figure having some resemblance to Charles's Wain, and may easily be traced.

Draco, containing four stars of the 2nd, and seven of the 3rd magnitude, spreads itself in the heavens near Ursa Minor; the four stars in the head are in the form of a rhombus, or lozenge; the tail is between the pole star and Charles's Wain.

Besides these constellations there are a number of others, which, as they contain no remarkable stars, have not been described: an enumeration of these will suffice.

The *Lynx*, between Ursa Major and Auriga; *Camelopardalus*, between Ursa Major and Cassiopeia; *Musca*, and the *Greater* and *Less Triangles*, between Aries and Perseus; *Equuleus*, close to the head of Pegasus; *Sagittarius*, setting in the S.W.; *Antinoüs*, and *Sobieski's Shield*, below Aquila; the *Fox* and the *Goose*, between Aquila and Cygnus; the *Greyhounds*, *Charles's Heart*, and *Berenice's Hair*, between Boötes and Ursa Major; and *Leo Minor*, below Ursa Major.

The time of any star's passing the meridian on any day is four minutes earlier than it was on the preceding day; by making that allowance, the above view of the heavens will answer for September 6th, about 10 o'clock; September 21st, about 9 o'clock; or October 21st, about 7 o'clock in the evening.

2. Point out the situation of the stars, for the latitude of Newcastle, on January 1st, at 8 o'clock in the evening.

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* The young zoologist may object to the length of the tail of this constellation, as well as of Ursa Minor. The following colloquy, from a writer of the 16th century, will amuse if it do not instruct him :—

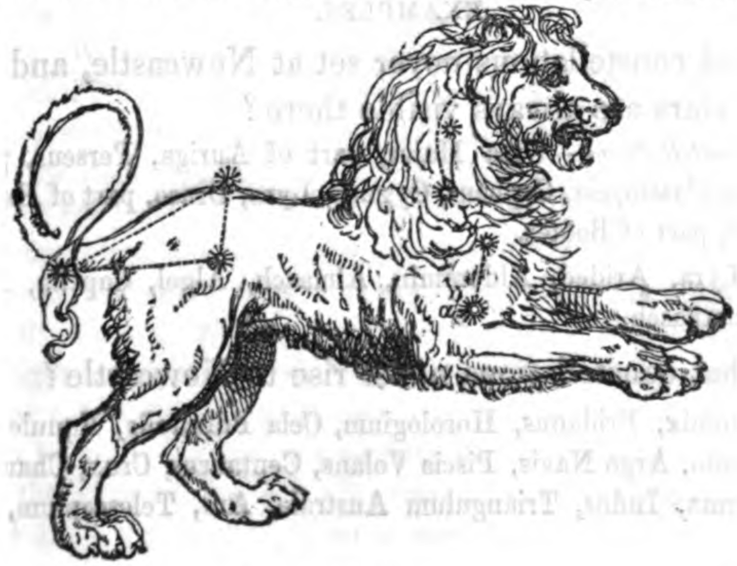
" *Scholar*. I marvel why, seeing she (Ursa Major) hath the forme of a beare, her taile should be so long.—*Master*. Imagine that Jupiter, fearing to come too nigh unto her teeth, layde on her tayle, and thereby drewe her up into the heaven, so that shee of herselfe being very weightie, and the distance from the earth to the heavens very great, there was great likelihood that her taile must stretch."

The heavens are peculiarly splendid at this season. In addition to many of those constellations already described, Orion and the Great and Little Dog bespangle the sky. Orion is easily known by the three stars in his belt and the three in his sword. The brightest nebula in the heavens is situated on the middle star of the sword. The stars Betelguese, *α*, and Bellatrix, *γ*, point in a manner nearly direct to the bright star Prŏcy̆on in the Little Dog, and the three in his belt point to Sirius in the Great Dog, the most brilliant of all the stars. The constellation of the Hare is beneath the feet of Orion.

ORION.

3. Required the situation of the stars at Newcastle, on March 21st, at 9 in the evening.

The constellation *Leo Major* is seen to advantage at this time. The



LEO MAJOR.

head and fore quarters are indicated by a group of stars in the form of a reaping hook, the brightest of them is Regulus, α; a right-angled triangle marks his hind quarters; the bright star in the tail is Denebola.

4. What are the principal constellations which will be above the horizon of Edinburgh, on May 1st, at 10 o'clock in the evening?

PROBLEM XIII.

To find what Stars never rise, or never set, to any place.

By the Globe.—1. Elevate for the latitude.

2. Hold a pencil at the north point of the horizon, and by turning the globe round, draw a circle; then all the stars between it and the elevated pole never set.

3. Hold a pencil at the south point of the horizon, and draw a circle as before; then all the stars between that place and the depressed pole never rise.

4. If the place has S. latitude, to find those stars that never set, hold the pencil at the south point of the horizon; and for those that never rise, at the N. point.

Without the Globe.—1. Subtract the latitude of the place from 90°, and the remainder is the co-latitude.

2. If the declination of the star is greater than this, and of the same name, it will never set; if it be greater, and of a contrary name, it will never rise.

EXAMPLES.

1. What constellations never set at Newcastle, and what principal stars are always visible there?

Ans. Constellations—Ursa Major, part of Auriga, Perseus, part of Andromeda, Cassiopeia, Cepheus, Cygnus, Lyra, Draco, part of Hercules, Ursa Minor, part of Boötes.

Stars—Lyra, Arided, Alderamin, Almaach, Algol, Capella, Dubhe, Alioth, Benetnasch.

2. What constellations never rise to Newcastle?

Ans. Phœnix, Eridanus, Horologium, Cela Praxitelis, Equuleus Pictorius, Dorado, Argo Navis, Piscis Volans, Centaurus, Crux, Chameleon, Lupus, Norma, Indus, Triangulum Australe, Ara, Telescopium, Pavo, Grus.

3. Are there any stars which never set at Jamaica?

Ans. Ursa Minor, part of Cepheus, part of Camelopardalus.

4. Are there any stars that never rise at Otaheite?

Ans. The same that never set at Jamaica.

5. How far N. must I go never to lose sight of Arcturus?

6. How far south of the equator must those people live who never see any part of the Great Bear?

7. In what latitude must I be never to see Lyra?

8. Where must I be never to see Sirius?

9. Whither must I go never to lose sight of Sirius?

QUESTIONS FOR EXAMINATION IN SECTION I.

What is the celestial globe? What is the solar system? What are the fixed stars? What is a constellation? What are the primary planets? What are satellites? What are comets?

What are the celestial poles? What is the equinoctial? What are parallels of declination? What are celestial meridians?

What are the declination and right ascension of a heavenly body? What is oblique ascension and ascensional difference? What are right and oblique descension, and descensional difference?

What are the latitude and longitude of a celestial body? What are parallels of celestial latitude, and circles of celestial longitude?

What is meant by the culminating of any celestial object? What is the azimuth of a heavenly body? What is amplitude?

What is the zodiac? How many degrees is it broad? Into how many signs, or constellations, is it divided?

What is meant by altitude and zenith distance? What is the orbit of a planet? When is a body in conjunction with the sun, and when is it in opposition? What is meant by occultation?

What is meant by the geocentric and heliocentric place of a planet?

How are stars classified? What is the lowest magnitude visible to the naked eye?

How many can be seen at any one time?

What is the milky way? What is the supposed distance of the nearest fixed star? What is the velocity of light? How long would a ray of light be in passing from the nearest star to the earth? At what rate does a ball fired from the mouth of a cannon move, and how long would it be in passing from the earth to the nearest star?

Are the stars all placed in the same concave hemisphere, at the same distance from the earth? What is meant by a temporary star? Who observed the earliest on record? When did the last remarkable one appear? When may it possibly reappear? What is remarkable about the star Algol? Name another variable star. What is a double star? Name one. What is the distinction between binary and double stars? What are nebulæ? Name one of the most remarkable of the resolvable nebulæ. What does the zodiacal light consist of? Where is it seen in the evening?

What is it that occasions the apparent motion of the stars from east to west? How do the stars rise and set at the equator? Which star appears always stationary?

How are the r. as. and dec. of any star found? From what point on the globe is the right ascension reckoned? How is a star found from having its r. as. and dec. given? How are the lat. and long. of a star found? The day of the month being given, how is it found at what hour any star comes to the meridian? How is it found on what day of the year any star passes the meridian at any given hour? How are the altitude and azimuth of any star found? From having the azimuth of any star and day of the month given, how are the altitude of the star and the hour of the night in a given latitude found? From having the alt. of a star, the day of the month, and lat. given, how are the az. and time of the night found? Having the az. lat. and hour given, how are the alt. of the star and day of the month found?

How is the hour of the night found by observing when any two stars have the same azimuth? How are the rising, setting, and culminating of any star found? How are the oblique ascension and descension found? How are the eastern and western amplitude?

How may the globe be made to represent the face of the heavens, for any given day and hour, in a given latitude? How is it found what stars never rise, and what stars never set, to any place?

Point out upon the globe all the stars of the first magnitude.

Which constellations in the heavens appear the most brilliant?

QUESTIONS FOR EXERCISE IN SECTION I.

1. Required the right ascension and declination of Alphard, Benetnasch, Antares, Canopus, Acubens, and their latitude and longitude?

2. At what hours do Algol, Dubhe, Arcturus, Pollux, Bellatrix, Sirius, Capella, appear on the meridian of London, March 24th?

3. At what hours do they appear on September 25th?

4. When does Regulus come to the meridian on Jan. 1st, March 10th, June 14th, Sept. 25th, Oct. 25th? and Nov. 5th?

5. What is the right ascension of β, in Auriga?

6. What is the right ascension of β, in the Northern Scale?

7. On what days will the following stars be upon the meridian at

midnight:—Capella, Aldebaran, Bellatrix, Arcturus, Fomalhaut, Pleiades, Vega, and Atair?

8. On what days do they come to the meridian at 4 *a. m.*?

9. On January 1st, when it is 8½ *p. m.* at London, what are the altitude and azimuth of the following stars:—Algol, Pleiades, Menkar, Aldebaran, Sirius, Procyon, Taurus, β; Capella, Leo, γ; Cassiopeia, α Cygnus, α; Vega, and Draco, α?

10. What are the alt. and az. of Cygnus, α, Corvus, α; Regulus, Cancer, α; Procyon, Dubhe, Perseus, α; and Capella, at London, May 1st, at 10 *p. m.*?

11. On October 6th, the azimuth of Menkar, at Newcastle, was S. 52° E.; required the hour and the altitude.

12. At London, on December 21st, the azimuth of Cor Hydræ was S. 14° W.; required the hour and the altitude.

13. At the Cape of Good Hope, on June 21st, the azimuth of Spica Virginis was N. 89° W.; required the hour and the altitude.

14. On August 9th, the altitude of Phœnix, α, at Jerusalem, was 14°; required the hour and the azimuth.

15. At Quito, on March 22nd, the altitude of Canopus (Argo, α) was 21°; what was the hour?

16. What was the hour at London, on September 1st, when the altitude of Arided was 80°?

17. The azimuth of the brightest of the Pleiades, at Newcastle, was S. 88½° E. when it was 10 in the evening; what was the day of the month, and what was the altitude of the star?

18. At Boston, U. S., the azimuth of Rigel was S. E. by E., 7° E., at 8 hrs. 1 min. *p. m.*; required the day of the month.

19. What time does Dubhe set at Newcastle on February 28th?

20. When it was 5 in the morning at Rome, the azimuth of Capella was N. 60° W.; what was the day of the month?

21. Give the rising, setting, and culminating of Castor; Sirius; Corona Borealis, α; Arcturus; and Procyon; at London, Jan. 31st.

22. How long is Sirius above the horizon at Petersburg?

23. At what time does Achernar rise at York on September 2nd?

24. What is the time of rising, setting, and culminating of Algenib, Menkar, Vega, and Cor Hydræ, at St. Helena, Oct. 6th?

25. What stars of the first and second magnitudes are above the horizon at London, on January 1st, at 9 o'clock in the evening?

26. Required the situation of the stars at York, on May 1st, when it is midnight?

27. What constellations never set, and what never rise, at Rome?

28. What stars never rise, and what never set, at the north pole?

29. Are there any stars which never appear above the horizon at the equator

30. Where must I be never to see Menkar?

31. Where must I be never to lose sight of Aldebaran?

SECTION II.

OF THE SUN.

The sun is the centre of the solar system, all the planets moving round it at different distances, and in different periods.

The ancients conceived that the earth was at rest, and that the sun, moon, planets, and stars all moved round it. Such is the equable motion of the earth that we have great difficulty in supposing that it is not only revolving on its axis, but is rolling rapidly in its path round the sun. But how much more probable is it that this little globe revolves once in the twenty-four hours upon its axis, than that the sun and fixed stars, all vastly greater than the earth, and at an enormous and very different distances from it, complete a revolution round it in that period. The ancients noticed that the sun was continually shifting his place among the fixed stars, and that whilst he made only 365 revolutions round the earth, the stars had made 366. To account for these facts, they supposed that whilst the sun is carried round the earth by the general motion of the starry sphere, he has a sphere of his own which travels in the contrary direction, and makes one revolution round the earth in a year. They are as satisfactorily and much more simply accounted for upon the supposition that the earth has an annual course round the sun. In order to account for the apparently capricious motions of the planets, the ancients devised a complex system of independent spheres, the mechanism of which it was difficult to comprehend. Upon the Copernican theory, which supposes the sun to be the centre of the solar system, and the earth to have a double motion, all is plain and easy. Tycho Brahe, an able and very useful astronomer, unable to resist the truth of the theory of Copernicus, and yet unable to throw off entirely the prejudices of centuries, invented another system. He admitted that the sun was the centre round which all the planets, except the earth, revolved, but that the sun, with all his followers, revolved round the earth as the centre of the whole. This theory obtained few followers. The sun, though very nearly, is not exactly the centre of the solar system, the real centre being a point which is the common centre of gravity of the sun and the other bodies which compose the system. Owing, however, to the immense quantity of matter contained in the sun, this point is almost identical with the sun's centre.

The figure of the sun is nearly globular, and its diameter is equal to 111 times that of the earth, being about 883,000 miles: hence its surface is 12,300 times, and its bulk, or solid content, 1,380,000 times that of the earth. The sun is composed of lighter materials than the earth, an equal bulk of the sun's substance possessing less than a quarter of the density of that of the earth; notwithstanding this, its gigantic dimensions give it a force of gravity twenty-seven times greater than the earth. It is the attraction of the sun that retains the planets in their orbits, and to it they are indebted for light, heat, and motion. The sun is not absolutely at rest; it probably has a motion of its own through space; and it is found, by the spots on its surface, to turn round on its axis from west to east in about twenty-five days. The mean distance of the sun from the earth is 95,000,000 miles.

The sun agrees with the fixed stars in the property of emitting light continually; and it is not improbable that they have many other properties in common. The sun is, therefore, considered as a fixed star comparatively near us, and the stars as suns at immense distances.

From being the source of light and heat, the sun was long supposed to be a body of fire; but Sir W. Herschel supposed that the body of the sun is an opaque habitable planet, surrounded by a double atmosphere, the outer being luminous, diffusing light and heat through the whole system; the inner, a cloudy stratum protecting the body of the sun from the heat of the luminous one. The luminous atmosphere, being at times intercepted and broken, gives us a view of the dark one beneath (the penumbra), and of the body of the sun.

The spots on the sun are interesting telescopic objects, and large ones may be seen by instruments of moderate power, the eye of the observer being protected by coloured glasses. The spots consist of a perfectly dark central part, surrounded with a kind of border, less completely dark, called a *penumbra*. Their general appearance is represented in the cut illustrating solar eclipses. They are irregular in shape and very various in size. Sometimes they exceed 45,000 m. in diameter. When watched from day to day they appear to be subject to violent agitation; they enlarge and contract, break up into two or more, change their forms, disappear altogether, or new ones appear. They hardly ever last longer than six weeks. The neighbourhood of great spots, and the places where spots frequently afterwards break out, are generally observed to be covered with strongly marked curved or branching streaks more luminous than the rest, called *faculæ*. These are, perhaps, the ridges of immense waves in the luminous regions of the sun's atmosphere, indicative of violent agitation in their neighbourhood.

The annual revolution of the earth produces the apparent motion of the sun among the stars in the ecliptic, by which he describes his annual path. This produces a daily change in right ascension and declination. The sun's amplitude and azimuth vary, both with the day of the month and the latitude of the place.

The amplitude is always of the same name with the declination: the greatest amplitude north is when the sun is in the north tropic; and south, when he is in the south tropic. Places that have the greatest latitude (not greater than 66½°) have the greatest variation of amplitude; places at the equator have the least variation.

PROBLEM XIV.

To find the Sun's Right Ascension and Declination.

Bring the sun's place to the brass meridian; the degree over it shows the declination, and the degree of the equinoctial under the meridian shows the right ascension.

EXAMPLES.—Required the sun's right ascension and declination for the following days.

	RIGHT ASCENSION. In degrees.	In time.	DECLINATION.	
1. Jan. 1.	282° 22′	18 h. 17 m.	21° 59′ S.	*Ans.*
2. Feb. 10.	324 22	21 37	14 10 S.	

. March 22. 4. May 12. 5. June 22.
6. August 10. 7. September 22. 8. December 21.

PROBLEM XV.

To find the Sun's Oblique Ascension, Ascensional Difference, Eastern Amplitude, and Time of Rising, on any given day, at any given place.

1. Elevate the globe for the latitude, bring the sun's place to the meridian, and set the index to 12.

2. Bring the sun's place to the eastern side of the horizon, and the degree of the equinoctial now at the horizon is the sun's oblique ascension.

3. The right ascension being found by the last problem, the difference between it and the oblique ascension will be the ascensional difference.

4. The number of degrees on the horizon, intercepted between the east point and the sun's place, is the eastern or rising amplitude.

5. The hour shown by the index, when the sun is at the horizon, is the time of its rising.

From the ascensional difference, the time of the sun's rising may be found without the globe thus:—If the sun's declination and the latitude of the place be of the same name, the ascensional difference, reduced to time, and subtracted from six o'clock, will give the time of the sun's rising. If the declination and latitude be of different names, the ascensional difference must be added to six.

EXAMPLES.

1. Required the sun's oblique ascension, ascensional difference, eastern amplitude, and time of rising, at London, May 1st. *Ans.* Ob. as., 19°; As. diff., 19° 48′; E. amp. 25° N.; Rising, 4 h. 40 m.

2. The same for Gibraltar, Nov. 25th. *Ans.* Ob. as., 257° 7′; As. diff., 15° 41′; E. amp., 26° 9′ S.; Rising, 7 h. 4 m.

3. For Halifax (America), Dec. 25th. *Ans.* Ob. as. 300°; As. diff. 25° 38′; E. amp., 34° S.; Rising, 7 h. 45 m.

4. Required the same for Hanover, June 4th.

5. Required the same for Newcastle, July 29th.

6. Required the same for Petersburg, June 21st.

PROBLEM XVI.

To find the Sun's Oblique Descension, Descensional Difference, Western Amplitude, and Time of Setting, on any given day, at any given place.

Proceed as in the last problem, only bring the sun's place to the western horizon.

The sun's setting may be found from the descensional difference.

If the declination and latitude be of the same name, the descensional difference, added to six o'clock, will give the time of the sun's setting; if they be of different names, the descensional difference, subtracted from six o'clock, will give the time of the sun's setting.

The sun's ascensional and descensional difference, as found by the globe, being equal to each other, either of them may be used in finding the rising and setting of the sun.

EXAMPLES.—Required the sun's oblique descension, descensional difference, western amplitude, and time of setting at the following times and places:—

1. C. Good Hope, July 19th. *Ans.* Ob. des. 103° 44′. Des. diff. 15° 8′. W. amp., 25° 32′. Setting, 5 h.

2. Quebec, May 15. *Ans.* Ob. des., 74°. Des. diff., 21° 39′. W. amp., 28° N. Setting, 7 hrs. 23 m.

3. Alexandria, Jan. 21st. 4. Konigsberg, Aug. 12th. 5. Liverpool, May 14th. 6. Washington, Dec. 21st. 7. Archangel, June 21st. 8. Edinburgh, Jan. 1st. 9 Malta, June 9th.

PROBLEM XVII·

The Latitude, Hour of the Day, and Day of the Month being given, to find the Sun's Altitude and Azimuth.

This problem is the same as Problem VI., page 275, only the quadrant of altitude must be brought over the sun's place, instead of being brought over the star.

EXAMPLES.—Required the sun's altitude and azimuth at the following places and times:—

		h. m.	Altitude.	Azimuth.
1. Lisbon, May 18,		7 30 *a.m.*	30°	N. 88° E.
2. Madrid, April 15,		10 0 *a.m.*	50	S. 47 E.
3. Jerusalem,	Feb. 22,		8 45 *a.m.*	
4. Bombay,	March 20,		9 30 *a.m.*	
5. Canton,	March 10,		8 0 *a.m.*	
6. Ditto,	———		4 0 *p.m.*	
7. Tongataboo,	Sept. 23,		4 0 *p.m.*	
8. Oonalashka,	June 21,		7 0 *p.m.*	
9. London,	May 1,		10 0 *a.m.*	
10. Rome,	March 10,		9 10 *a.m.*	

PROBLEM XVIII.

The Day of the Month and the Sun's Azimuth being given, to find the Sun's Altitude and the Hour of the Day.

See Problem VII., page 276.

To all places in the torrid zone, when the sun's declination is greater than the latitude, and of the same name with it, the sun has the same azimuth twice in the forenoon, and twice in the afternoon; and the examples in that case admit of two answers.

EXAMPLES.—1. At Gibraltar, on November 25th, the sun's azimuth was observed to be 50° from the south towards the east; what was the time? *Ans.* $8\frac{1}{2}$ *a.m.*

2. At Madras, the sun's azimuth was observed to be N. 70° E. in the morning of June 15th; required the time. *Ans.* 24 min. past 7, or 52 min. past 8.

Having the sun's azimuth at the following places and days, required the hour and the sun's altitude.

3. Tobolsk,	July 1,	S.	62°	W.
4. Astracan,	Sept. 1,	S.	43	W.
5. Cairo,	Dec. 1,	S.	56	W.
6. Paris.	Nov. 5,	S.	30	W.
7. London,	May 1,	S.	$44\frac{1}{2}$	E.
8. Petersburg,	July 27,	S.	70	E.
9. Lima,	May 2,	N.	55	W.
10. London,	June 21,	S.	67	E.

PROBLEM XIX.

The Sun's Altitude, Day of Month, and Latitude of the place being given, to find the Sun's Azimuth and Hour of the Day.

See Problem VIII., page 277.

The sun having the same altitude twice in the day, it must be known whether the time be in the morning or in the evening.

Examples.—1. At Newcastle, May 15th, *p.m.*, the sun's alt. was 25°; required the hour and the sun's azimuth.
Ans. 5 *p.m.*; azimuth, N. 88° W.

2. At Botany Bay, on April 23rd, the sun's altitude in the morning was observed to be 25°; required the hour and the azimuth. *Ans.* ¼ before 9; azimuth, N. 55° E.

Having the sun's altitude on the undermentioned days, required the hour and the sun's azimuth at—

			Altitude.	
3.	Madras,	June 21,	Morning	19°
4.	Cape Horn,	Dec. 22,	Evening	50
5.	Petersburg,	July 15,	Morning	26
6.	Batavia,	March 1,	Evening	46
7.	London,	August 21,	Morning	36
8.	Stockholm,	July 7,	Morning	12
9.	Constantinople,	Dec. 7,	Morning	12
10.	North Cape,	June 21,		4° 38′

PROBLEM XX.

The Latitude, the Sun's Altitude and Azimuth being given, find the Day of the Month, and the Hour of the Day.

1. Elevate the globe for the latitude, fix the quadrant upon the zenith, and bring it to the given azimuth.

2. Turn the globe about, and that degree of the ecliptic which cuts the quadrant at the given altitude will be the sun's place,—from which find the day of the month.

3. Keeping the quadrant in the same position, turn the

globe till the sun's place come to the meridian, and set the index to 12: then bring the sun's place again to the quadrant, and the index will show the hour.

Unless it be known whether the sun be in the ascending or descending signs, the examples admit of a double answer.

EXAMPLES.

1. The sun was observed, in the summer season, to be 33° high, when its azimuth was S. 70° E. at Petersburg; required the day and hour. *Ans.* July 27, 8 h. 14 m. *a.m.*

2. The sun at Lima, being 45° high, when its azimuth was N. 50° W.; required the day and hour. *Ans.* May 2, or Aug. 10, at 2 h. 33 m. *p.m.*

3. At London, the altitude being 17° high, when the azimuth was S. 17° E.; name the day and the hour.

4. At the Pelew Islands, the sun being in the descending signs, its altitude was found to be 37°, when its azimuth was S. 54° W.; required the day and hour.

5. At Owhyhee, the sun's altitude was 27°, when its azimuth was S. 74° W.; required the day and the hour.

6. At London, the sun's altitude was 46° 31′, when its azimuth was S. 44½° E.; required the time.

QUESTIONS FOR EXAMINATION IN SECTION II.

What is the diameter of the sun? What is its bulk compared with the earth? What is the power of gravitation at its surface? What is it that retains the planets in their orbits? Is the sun absolutely at rest? What is its distance from the earth? What is Sir William Herschel's opinion with respect to the sun? Describe the general appearance of the spots on its surface. What is the penumbra supposed to be?

What produces the apparent motion of the sun among the stars?

How are the sun's right ascension and declination found for any day?

How are the sun's oblique ascension, ascensional difference, eastern amplitude, and time of rising found, on any given day?

How are the sun's oblique descension, descensional difference, western amplitude, and time of setting found? How may the time of the sun's rising be found from the ascensional difference?

From having the latitude, hour of the day, and day of the month given, how are the sun's altitude and azimuth found?

How are the sun's altitude and the hour of the day found in a given latitude, from having the day of the month and the azimuth ?

Having the sun's altitude, day of the month, and latitude of the place given, how are the sun's azimuth and hour of the day found ?

From having the latitude, the sun's altitude, and azimuth given, how are the day of the month and hour of the day found ?

QUESTIONS FOR EXERCISE IN SECTION II.

1. Required the sun's right ascension and declination for the last day in each of the calendar months.

2. What are the sun's oblique ascension, ascensional difference, eastern amplitude, and time of rising, at the following times and places :—York, February 5th ; Berlin, January 29th ; Juan Fernandez, March 1st ; Quito, June 21st ; Samarcand, December 21st ; Pegu, May 15th ; Alexandria, August 10th ; Bender, July 11th ; Cape Horn, December 25th ; Pelew Islands, November 5th ?

3. Give the sun's oblique ascension, descen. difference, western amplitude, and time of setting, for the same places and times.

4. What are the sun's altitude and azimuth at the following places and times :—Copenhagen, March 5th, 10 *a.m.* ? Marquesas, July 7th, 3 *p.m.* ? Pekin, August 12th, 7 *a.m.* ; Batavia, January 1st, 11 *a.m.* ? Cape of Good Hope, December 21st, 6 *p.m.* ? Guadaloupe, June 4th, 8½ *a.m.* ?

5. April 15th, in the afternoon, the sun's altitude at Madrid was 50° ; required the hour and the azimuth.

6. At London, on May 1st, the sun's azimuth was S. 44½° E. ; required the hour and the sun's altitude.

7. At Canton, on March 10th, the sun's azimuth was S. 74° E. ; what were the hour and altitude ?

8. At Jerusalem, on February 22nd, the sun's azimuth was S. 55° E. ; required the hour and altitude.

9. At Rome, on March 10th, the sun's azimuth was S.E. 6° 24′ E. ; required the hour and altitude.

10. In lat. 51½°, the sun's altitude was 46½°, on June 21st ; required the hour and the azimuth.

11. At Oonalashka, on June 21st, in the evening, the sun's altitude was 10° ; required the hour and the azimuth.

12. At London, what are the sun's altitude, and the hour, when it is due east or west on the longest day ?

13. At London, on June 21st, how far from the north does the sun rise and set ?

14. At Paris, on November the 5th, in the evening, the sun's altitude was 20° ; required the hour and azimuth.

15. In the morning of June 21st, the sun's altitude at London was 46° 20′; what was the hour?

16. The sun being in the ascending signs, its altitude at Newcastle was observed to be 22°, when its azimuth was N. 87° W.; required the day of the month and the hour of the day.

17. At Stockholm, in the summer season, the sun's altitude was 12°, when its azimuth was N. 63° E.; required the day of the month and the hour of the day.

18. At Edinburgh, June 21st, how far from N. does the sun rise?

19. How many degrees are there between that point of the horizon in which the sun rises at Newcastle on June 21st, and that point in which it rises on December 21st?

20. In what part of the horizon does the sun rise at Quito, on June 21st and December 21st.

SECTION III.

OF PLANETS AND COMETS.

The planets are heavenly bodies which do not, like the fixed stars, shine by their own light, but by the reflection of the light of the sun. The ancients reckoned but five planets—Mercury, Venus, Mars, Jupiter and Saturn; modern investigation has added several to the list, and probably more are yet to be discovered.

In the order of their distance from the sun they are—Mercury, Venus, the Earth, Mars, the nine Asteroids, Jupiter, Saturn, Uranus, and Neptune. Mercury and Venus, which are nearer the sun than the earth is, are called *inferior* planets, and the others, which are more distant, are called *superior* planets.

The inferior planets, in consequence of their comparative contiguity to the sun, are never seen in opposition to it; that is, they are never seen in the east when the sun is in the west, nor in the west when the sun is in the east; nor are they ever seen on the meridian at midnight. But the superior planets, whose orbits are much farther removed from the sun than that of the earth, are often seen in opposition to the sun.

All the planets, with the exception of the Asteroids, confine their movements to that zone of the heavens called the zodiac.

The obvious conclusion from this is, that the planes of the orbits of the planets are inclined to each other at very small angles, and that they correspond very nearly with the plane of the ecliptic.

The planets all move round the sun in the order of the signs; that is, from the west towards the east; but their apparent motion, as seen from the earth, is very irregular (hence they are termed planets, or *wandering stars*): sometimes it is from west to east, called *direct;* and sometimes from east to west, called *retrograde;* at other periods they appear for a while stationary. But this apparent irregularity is occasioned by their being viewed from a body which is itself in motion.

Suppose a person placed at the centre of a large circular area, and that several bodies are moving round that centre, all the same way, but at different distances from it, and with different velocities; these bodies, to the person placed at the centre, will all appear to be moving in the same direction; but if the person were placed at a distance from the centre and carried round in one of those bodies, he would no longer see the rest moving in the same orderly manner as before. Such is the case with the planets seen from the sun, the centre of the system; they all pursue their regular courses from west to east:—but viewed from the earth, one of the moving bodies, their apparent motion is very different from the real.

The motion of the inferior planets may be very familiarly illustrated by carrying a small ball, or globe, round a circular wire, having placed a candle at a distance on one side, and a screen on the other, to receive the shadow of the ball. Whilst the ball is carried round the circle, without ever changing its course, the shadow against the screen moves backward and forward, something like the vibrations of a pendulum. Such is the case with Mercury and Venus; they keep moving backward and forward in that part of the heavens in which the sun is; Mercury never going farther from the sun than 29°, and Venus than 47°.

To account for the retrograde motion of the superior planets, it may be observed, that when two bodies are moving the same way, with different velocities, that body which moves more slowly, seems to recede from the other with a motion equal to the difference of their velocities: thus, whilst the earth and one of the superior planets, suppose Jupiter, are both moving eastward (the planet being in opposition), the earth moving faster than Jupiter, the latter is left behind, and, though his real motion is eastward, he appears to be moving from east to west.

The planets can only be seen when some part of their surface on which the sun shines is turned towards the observer. Hence the inferior planets present all the phases of the moon.

When Mercury or Venus is between the earth and the sun it is said to be in its inferior conjunction. In this situation the whole of the enlightened portion of the planet is turned away from the earth, and it is invisible to us; but as it proceeds on its course a thin crescent of light is presented to our view, which gradually passes into the half-mooned and gibbous form. When arrived at its superior conjunction; that is, when the sun is interposed between the earth and it, the whole of its enlightened side is turned towards us, but in this situation its brilliancy is lost in the blaze of the sun's rays.

Mars is sometimes slightly gibbous (*i.e.*, something less than a circle, like the moon between the first and second quarter); but, with this exception, all the superior planets shine with a full disc. The reason of this is that they are so much farther removed from the sun than the earth is, that in whatever part of its orbit the earth may be, we see them nearly as we would view them from the sun itself.

The planets do not move in a circle, as the ancients and even as Copernicus supposed, but in an ellipse or oval, and they do not proceed in their course with a uniform velocity, but always move fastest when nearest the great source of attraction, the sun.

The laws of planetary motion, as originally discovered by Kepler, and usually called Kepler's three laws, are the following:—

1st. A line drawn from the centre of a planet to the centre of the sun describes equal areas round him in equal times.

2nd. The orbits of the planets are ellipses, having the sun in one of their foci.

3rd. The squares of the periodic times are proportional to the cubes of their mean distances from the sun.

The secondary planets or satellites obey the same laws as the primary. They all move from west to east except the satellites of Uranus, whose motions are supposed to be from east to west; and they all, so far as is known, occupy the same time in making a rotation upon their axis as in completing a revolution in their orbit; they consequently always present the same phase to their primary.

Mercury. ☿

This planet is nearer to the sun than any which has yet been discovered: it is seldom visible, being generally lost in the sun's rays: its diameter is about 3200 miles, and distance from the sun 37 millions of miles. It rotates on its axis in 24 hrs. 5 m. It turns round the sun in 88 days, moving at the rate of about 110,000 miles per hour, or 30 miles per second; it receives its name from the extreme rapidity of its flight.

Mercury being so much nearer the sun than the earth is, the heat of the sun there will be seven times greater than our summer heat. This being greater than the heat of boiling water, all the water on our globe would be evaporated, and everything on its surface burnt to atoms, were it similarly situated. Hence any beings inhabiting it must be very different from us. The density of Mercury is very great, being rather greater than that of quicksilver. A cannon ball, passing at the rate of 20 miles in a minute, would take 3½ years in going from the sun to Mercury.

Venus. ♀

This planet receives its name from its extreme beauty; it may easily be known, from its being the most brilliant of all the planets, and from its rising before the sun in the morning, when it is a *morning star*, or setting after the sun in the evening, when it is an *evening star*. Venus and Mercury, when viewed through a telescope, have all the phases of the moon.

The diameter of Venus is nearly equal to that of the earth, being 7800 miles: the length of its day is also nearly the same as that of ours, being 23 hours, 21 minutes, the time that it takes to turn on its axis. This is known by the spots on its surface. Its distance from the sun is 69 millions of miles; and it finishes its journey round the sun in 224 days, 16 hours, moving at the rate of 80,000 miles per hour, or, 23 m. per second. The light and heat of the sun at Venus are double that which is enjoyed by the inhabitants of this globe. A cannon ball would require more than 6 years in passing from the sun to Venus. The density of Venus is a little greater than that of the earth, and like the earth it possesses an atmosphere. Venus, as well as Mercury, is sometimes seen to pass over the sun's disc: this is called a transit, and it furnishes astronomers with the means of determining the distances of all the planets. Captain Cook's first voyage to the South Sea was undertaken for the purpose of observing, at Otaheite, the last transit of Venus, in 1769. The next transit will be in 1874.

The reason that a transit of Venus does not take place at every revolution is, that its orbit does not coincide with that of the earth. A transit can only take place when the sun, earth, and Venus are in the same straight line, and this can never be excepting when the earth and Venus happen to be both in the line of intersection of the planes of their orbits; that is, when Venus is in her *nodes*.

The same observations are applicable to the transits of Mercury, which take place at intervals of 6, 7, 13, 46, and 263 years.

It is obvious that no transits of the superior planets can occur, but the earth being an inferior planet to Mars, Jupiter, &c., will perform occasional transits to them.

The Earth. ⊕

The next planet in the order of distance from the sun is that which we inhabit. The equatorial diameter of the earth is 7925, its polar 7899 miles, and the number of square miles upon its surface 197 millions. It turns upon its axis in 23 hrs. 56 m. as indicated by its return to the same star.

The period is called a sidereal day. The mean solar day consists of 24 hrs., the additional 4 m. being required, as already explained, to bring any point on the earth's surface to the same position in regard to the sun. The length of the solar day is not uniform; this arises from the inequality in the rate of the earth's motion round the sun, and the inclination of the earth's axis to the plane of its orbit. (See Prob. XXX.)

Its mean distance from the sun is 95 millions of miles, It performs a revolution in its orbit in 365 d. 6 h. 9 m. 10 sec., moving at the rate of 68,000 miles per hour, which is more than 1,100 miles per minute, or 18½ m. per sec.

The equinoctial, or tropical year, which is the interval between two successive returns of the sun to the same equinox, consists of 365 d. 5 hrs. 48 m. 49 sec. The difference between the equinoctial and the sidereal, or true year, is owing to a regression of the equinoctial points, which is caused by the attraction of the sun and moon upon the projecting matter at the equator. The *precession of the equinoxes*, as this motion is called, causes a slow change in the apparent position of the pole star. In about 12,000 years, Vega, the principal star in Lyra, will be very near the pole, and will consequently be the pole star. The pole of the heavens will make a complete revolution in about 26,000 years.

The earth is in its *perihelion*, or that part of its orbit nearest the sun, on Dec. 31st, and in its *aphelion*, or farthest from the sun, on July 1st. The sun is about 3 millions of miles nearer to us in the depth of winter than in the middle of summer.

It seems strange that we should have the coldest season when we are nearest to the source of heat, but it must be remembered that during winter the sun continues only a short time above the horizon, and his rays fall very obliquely upon the earth.

The earth is surrounded with a thin fluid called air, the whole body of which forms the atmosphere.

The lower parts of the atmosphere are denser than the higher; and the density diminishes the greater the altitude; this it does so rapidly that at an elevation of 18,000 ft., which is nearly that of Cotopaxi, we have ascended through one-half the body of air incumbent on the earth's surface. It is owing to the atmosphere that the rays of light coming from the sun are dispersed in all directions, and thus the whole heavens become illuminated. Without an atmosphere, we should derive no benefit from the light of the sun, except when our sight was directed to him; all the other parts of the heavens would appear dark, and the stars would be visible at noon-day. It is also the atmosphere that produces twilight, as already explained. By refracting the rays of light, it causes the sun to appear in the morning before he is above the horizon, and in the evening after he is set.

A cannon ball would take 9 years in passing from the sun to the earth.

The Moon. ☽

The moon is the constant companion of the earth in its annual revolution round the sun, and next to that body, it is to us the most remarkable in our system; it supplies us with light during the absence of the sun, and furnishes us with a measure of time. The mean distance of the moon from the earth is 240,000 miles; its diameter is 2160, being to that of the earth as 3 to 11. It turns round the earth in 27 days, 7 hours, 43 minutes, and is carried round the sun with the earth in 1 year. Between one new moon and another are 29 days, 12 hours, 44 minutes; this is the foundation of the division of time into months. It turns round its axis in the same time, and hence it always presents the same face to us.

As the moon shines by borrowed light, and the enlightened part is not always turned towards the earth, it is only in one position that the moon appears round; this is, when it is in opposition to the sun, the whole of the enlightened side being then turned towards the earth: this appearance is called *full moon.* When it is in conjunction with the sun, the enlightened side is turned from us, and the moon is consequently invisible: this is called *new moon.* A few days after conjunction, it is seen in the shape of a crescent, and it gradually enlarges till the whole of the enlightened side appears. After full moon, it again loses its circular form, and the enlightened part decreases as before it increased.

As the moon affords light to the earth, so the earth, in return, affords light to the moon; but the surface of the earth being 13 times greater than that of the moon, it affords 13 times more light to the moon. The length of the day and night to the moon being nearly 30 of our days, the sun will be 15 days above the horizon, and the night will be of the same duration.

When the moon is only a few days old, the unenlightened part of it is, in favourable circumstances, partially visible. This phenomenon is caused by the light reflected from the earth—the moon's *earthlight*—which is then great, as the enlightened side of the earth is turned towards the moon.

Numerous mountains and caverns render the surface of the moon very uneven.

The fact is proved by the following considerations:—1. When the moon is horned, or gibbous, the boundary line of light and darkness is notched and broken, which is exactly the aspect that elevations and depressions would produce. 2. Close by the illuminated portion, yet within the dark part, there are small shining points which gradually join the luminous space and new ones appear. These are evidently the tops of mountains whose summits catch the illumination of the sun's rays before the plains below, just as Mount Blanc is enlightened while the valley of Chamouni, at its foot, is in darkness. 3. Further evidence is afforded by the facts that the mountains project shadows in a direction from the sun, that the caverns are dark on the side nearest the sun, and illuminated on the opposite side, and that the shadows shorten as the sun's rays become more direct, and lengthen as his beams fall more obliquely.

The form of the lunar mountains is various. There are many isolated peaks of a sugar-loaf form; one of these, Pico, is 7000 ft. high. There are several mountain chains, but the most striking peculiarity in lunar mountains are ring fences, or circular ramparts, inclosing plains and hollows of various diameters, the most extensive having isolated peaks jutting from their bosom.

The moon is supposed to have neither atmosphere nor seas.

Beautiful as is the appearance of the moon as seen from the earth, the earth must be a still more striking object as seen from the moon.

If we could place ourselves in the middle of the lunar disc, we should enjoy a very singular spectacle; we should see our earth placed in the zenith, like a motionless lamp, or only turning on its axis; and we should probably be able to distinguish the continents, islands, &c., as they would reflect more light than the oceans.

Supposing the moon inhabited, the inhabitants of that hemisphere next the earth will always see the earth in the same place in the heavens, while the sun will appear to perform his revolution in a month. The inhabitants of the opposite hemisphere, on the contrary, will never see the earth; unless, prompted by curiosity, they make a journey to behold the extraordinary phenomenon.

Mars. ♂

Next to the earth is Mars. It may be known in the heavens by its dusky red appearance, which induced the ancients to give it the name of the God of War. Its diameter is little more than half that of the earth, being about 4100 miles; but the length of its day is nearly the same as ours, for it turns on its axis in 24 hours 39 minutes. Its distance from the sun is about 145 millions of miles; the length of its year is equal to 687 days, and therefore it travels at the rate of 55,000 miles per hour. Mars has an atmosphere of considerable density. When viewed through a telescope, several spots are seen on its surface, some of which are permanent, others are not. Owing to its distance from the sun, the light and heat at Mars are only half of that which we enjoy. No moon has yet been discovered belonging to it. A cannon ball would take 13 years in passing from this planet to the sun.

Mars seems to shine with very different degrees of splendour. This is owing to the circumstance that in the course of its revolution it is situated at very different distances from the earth. When Mars is in opposition to the sun, it is only 50 millions of miles distant from us, but when it is in conjunction with the sun, it is 240 millions of miles distant from the earth. When nearest the earth, it presents a surface twenty-five times larger than when at its greatest distance.

Mars has a greater resemblance to the earth than any other planet in the system. Land and water diversify its surface. Owing to the inclination of its axis, it will have a change of seasons. White spots have been observed at its poles; these have been conjectured to be snow, as they disappear when they have been long exposed to the sun, and are greatest when just emerging from the long night of the polar winter of that planet.

THE ASTEROIDS.

None of the nine minor planets is sufficiently large to be visible to the naked eye. They are distinguished from the older planets by several peculiarities. They are all nearly at the same distance from the sun, and complete a revolution round him in nearly the same time. They wander beyond the zodiac in consequence of their orbits being more inclined to the ecliptic than those of the other planets; their orbits are also more eccentric, and they cross one another.

Flora (⚘), discovered in 1847, completes a revolution round the sun in 1193 days.

Iris ( ), discovered in the same year, makes a revolution round the sun in 1345 days.

Vesta (⚶) is about 225 millions of miles from the sun, and completes its revolution round it in 1326 days. In size it resembles a star of the 5th magnitude.

Hebe ( ), discovered about the year 1847, completes its orbit in 1375 days.

Astrœa ( ), discovered in 1845, revolves round the sun in 1510 days.

Juno (⚵) is situated at about 253 millions of miles from the sun, and completes its revolution in 1593 days.

Ceres (⚳), discovered in 1801, is very nearly 263 millions of miles from the sun, and performs its revolution in 1681 days. Ceres was the first of the asteroids that was discovered, and was first noticed by M. Piazzi, astronomer at Palermo, in Sicily, 1st. Jan. 1801.

Pallas (⚴) is a little more than 263 millions of miles from the sun, and turns round the sun in 1686 days.

Metis ( ) was discovered in 1848.

Before the discovery of the asteroids, the existence of a planet between Mars and Jupiter had been conjectured. It was observed that the interval between the orbit of each planet and that of the next goes on doubling as we proceed from the centre of the system; but that the interval between Mars and Jupiter greatly exceeded the usual proportion. The attention of astronomers having been called to the circumstance, they were rewarded by the discovery of these small planets in the situation where they anticipated one large one to be. Some have supposed that the asteroids are the fragments of a larger orb which has been shattered by some internal convulsion.

Jupiter. ♃

We come now to Jupiter, the largest of all the planets, and which the Greeks dignified with the name of their chief deity. It is easily known by its peculiar magnitude and brilliancy. Its diameter is about 87,000 miles; and hence it is 1300 times larger than the earth. It turns on its own axis in 9 hours 55 minutes; and revolves round the sun in 11 years 315 days, moving at the rate of about 30,000 miles per hour.

Being more than five times farther from the sun than the earth, viz., 494 millions of miles, the light and heat enjoyed by the inhabitants of Jupiter must be only the twenty-seventh part of that afforded by the sun to the earth. But this defect is partly supplied by 4 satellites, or moons, which constantly attend this planet, some of which will always be above the horizon. The density of Jupiter is little more than that of water. A cannon ball would take 47 years in passing from the sun to Jupiter.

The rotation of this planet on its axis is so rapid that the equatorial diameter exceeds the polar by 6000 m. As the axis is very nearly perpendicular to the plane of its orbit, there will be no variety of seasons at Jupiter, and the days and nights will be constantly of equal length.

Jupiter, when viewed through a telescope, exhibits a series of dark zones or belts. They are variable, but are generally parallel to the equator of the planet. The dark belts are supposed to be the body of the planet, and the bright parts compact and undisturbed strata of clouds and vapour.

All the satellites of Jupiter, except the second, are rather larger than our moon; they were discovered by Galileo in January 1610. As they move in an orbit nearly parallel to the equator of the planet, they are always seen in a straight line coincident with the equator.

Eclipses of Jupiter's satellites happen very frequently. Sometimes they are seen passing before the planet, and casting shadows on his disc; and sometimes disappearing behind the body, or being hid in its shadow at a distance from it.

The eclipses of Jupiter's satellites were formerly much used in computing the longitude of places on earth. The time of an eclipse at Greenwich being given in the Nautical Almanac, and the time of the occurrence of the same eclipse at the place where longitude is required being ascertained by observation, the difference of time and hence of longitude can be deduced. This method is now little used, in consequence of the superior accuracy of that by lunar observations.

It was by the observation of the eclipses of Jupiter's satellites that the velocity with which light travels was ascertained. It was found that an eclipse occurred 8 m. sooner than the average time when the earth was nearest to Jupiter, and 8 m. later than the usual time when it was farthest from Jupiter. Hence it was inferred that light requires 16 m. to pass from the nearest to the farthest point of the earth's orbit, a distance of 190 millions of miles. Light, therefore, moves at the rate of 192,000 miles per second.

Saturn. ♄

Till within 70 years Saturn was considered the most remote planet in our system. It shines with a pale, dead light. Its diameter is about 79,000 miles; so that, in point of size, it is the second in the system. It exceeds the earth in bulk nearly 1000 times. It turns on its axis in 10 hours 29 minutes. Its distance from the sun is 900 millions of miles; and it performs its journey round that luminary in a little less than 30 years, and consequently travels at the rate of 22,000 miles per hour.

Being between 9 and 10 times farther from the sun than the earth, it enjoys 90 times less light and heat; but the daylight there is not so small as we should suppose, for it has been calculated to be many hundred times greater than the light which we enjoy from our full moon.

The Great Creator of the universe seems to have indemnified the inhabitants of Saturn for their great distance from the sun, by giving them 7 moons, and also by surrounding the planet with two broad rings, which are probably of considerable importance in reflecting the light of the sun to the planet. These rings present a singular appearance when viewed through a telescope. The density of Saturn is about that of light wood. A cannon ball would take 85 years in passing from the sun to Saturn.

The breadth of the exterior ring of Saturn is 10,500 miles, and that of the interior 17,000. The interior ring is 19,000 m. distant from the body of the planet. The thickness of the rings is supposed to be about 100 miles. The rings rotate in a plane of their own in nearly the same time that the planet performs a revolution on its axis. The rings are clearly opaque bodies, for they throw a shadow on the body of the planet on the side nearest the sun, and receive the shadow of the planet on the opposite side.

Uranus. ♅

This planet was discovered, March 13th, 1781, by Sir W. Herschel. It is the third of the planets in point of magnitude; it has a diameter of 35,000 miles, and its volume is about 80 times that of the earth. Its distance from the sun is 1800 millions of miles. It requires 84 years to perform its journey round that luminary, though it travels at the rate of nearly 16,000 miles per hour. The light and heat of the sun, at Uranus, is 368 times less than at the earth. Probably six satellites, and certainly two, attend this planet. A cannon ball would require 171 years in passing from it to the sun.

Before the discovery of this planet, astronomers conceived that a planet existed beyond the orbit of Saturn, for some inequalities in the motion of Jupiter and Saturn could not otherwise be accounted for. Herschel called this planet Georgium Sidus, in honour of George III., but foreign astronomers gave it the name of its great discoverer. Latterly the name Uranus—the most ancient of the heathen deities, and the father of Saturn—has been adopted, as being more in unison with the appellations of the other planets.

In two respects the satellites of Uranus offer remarkable peculiarities; they move in orbits nearly at right angles to the plane of the orbit of their primary, and in a direction from east to west.

Neptune. ♆

Another planet, more remote from the sun than Uranus was discovered in 1846. It has been denominated Neptune. One moon, at least, attends it; and, like Saturn, it is surrounded by a ring. The period of its revolution is supposed to be 167 years.

The more easily to remember the relative distances of the planets, the following numbers, which are proportional to their mean distances from the sun, will be useful:

Merc.,	Venus,	Earth,	Mars,	Asteroids,	Jupiter,	Sat.,	Ura.
4	7	10	16	28	52	100	196

The mean distance of the earth being 95,000,000 miles, that of any other planet may be obtained by proportion.

The following illustration will convey to minds unaccustomed to contemplate millions of miles, a general impression of the relative magnitude and distance of the parts of our system.

Choose any well-levelled field. On it place a globe, two feet in diameter; this will represent the Sun; Mercury will be represented by a grain of mustard seed on the circumference of a circle, 164 feet diameter for its orbit; Venus, a pea, on a circle 310 feet in diameter; the Earth also a pea, on a circle of 430 feet; Mars, a rather large pin's head, on a circle of 654 feet; Juno, Ceres, Vesta, and Pallas, grains of sand, in orbits of from 1000 to 1200 feet; Jupiter, a moderate-sized orange, in a circle nearly half a mile across; Saturn, a small orange, on a circle of four-fifths of a mile; and Herschel, a full-sized cherry, or small plum, upon the circumference of a circle more than a mile and a half in diameter.

These views ought to humble man. How insignificant is this earth, the theatre of so many passions, and so much contention! How much blood is sometimes shed for the possession of a mere point!

COMETS.

Comets appear in very various aspects. The *head* consists of a nebulous mass of light containing a bright spot in its centre, called the *nucleus*. The more diffuse light surrounding the nucleus is called the *coma*, or hair, from which the word comet is derived. The *tail* consists of a stream of light proceeding from the head, generally directed towards the side most remote from the sun. It is often slightly curved, bending towards the region which the comet has left, and is usually most fully developed just after the comet has passed the perihelion. A tail is by no means an invariable appendage of a comet.

Comets are not, like planets, confined to the zodiacal belt: they move in all parts of the heavens, and they proceed in all directions, some pursuing a retrograde and others a direct course.

Comets revolve in extremely eccentric orbits, so that at one time they are very near the sun, and at another very remote from it.

Those comets which have elliptic orbits make regular revolutions round the sun in fixed periods, but there are some which seem to move in a curve that does not return into itself. These comets having come within the reach of the sun's attraction, move round him, again launch forth into boundless space, again to perform a temporary revolution round the sun or some other system.

Comets appear to consist of matter entirely gaseous.

The proof of this is pretty decisive. They have been found to make no sensible derangement (by attraction) in the motions of Jupiter's satellites, near which they have passed, while they themselves have been considerably diverted from their course. Stars of the 16th magnitude have been seen through the nucleus of some of them. Also they present no phases, which shows that light passes freely through them.

The most remarkable comets that have appeared in modern times are those of 1680 and 1811.

The comet of 1680 was seen by the illustrious Newton. He calculated that its tail was 123 millions of miles long, and that when nearest to the sun it was exposed to a heat 2,000 times greater than that of red-hot iron. This comet is supposed to have been the same as that which appeared about the time of Cæsar's death (B.C. 44).

The comet of 1811 continued visible to the naked eye for more than three months. Its brilliant tail, at its greatest elongation, had an extent of 108 millions of miles by a breadth of 15 millions.

The precise nature of the orbits and the period of time occupied in traversing them, have been ascertained in the case of three comets, which have been named after the astronomers who investigated their courses and predicted their return—Halley's, Biela's, and Encke's.

Halley's comet appeared in the year 1682, and it has twice visited this part of the system since Halley's time, namely, in 1759 and 1835. It has a period of 75 or 76 years.

Biela's comet describes its orbit in 6¾ yrs. Encke's comet has a period of 3⅓ yrs. Both Encke's and Biela's comets are destitute of tail and nucleus.

A very interesting fact has been noticed in the case of Encke's comet. The time in which it completes a revolution round the sun is undergoing a progressive diminution, owing to the diminution of the size of its orbit. It is hence inferred that the comet meets in its passage through the system with a resisting medium, and that it will eventually be precipitated upon the sun's surface.

PROBLEM XXI.

To mark the Places of the Planets on the Globe, from having their longitude and latitude.

1. Look on the right-hand page of White's Ephemeris for the day of the month.

2. Find out the column marked at the top with the character of the planet whose place you are seeking; then, in that column, opposite to the day of the month, is the longitude of the planet for that day at noon.

3. The latitude is given, at the top of the page, for 5 days in every month, and seldom exceeds 2 or 3 degrees.

4. Find the longitude and latitude upon the globe, and put on a small patch with the character of the planet;—and thus may all the planets be marked upon the globe for any day of the year.

Page 32 of White's Ephemeris is appropriated to the Planet Uranus: its variations in longitude and latitude are so small, that they are given for only the first day in each month.

EXAMPLES.

1. What is the situation of the inferior planets for May 13, 1828?

Mercury,	♉	10° 54′	1° 17′ S.
Venus,	♋	7 53	3 3 N.

2. What is the situation of the superior planets on the same day?

Mars,	♑	13° 1′	1° 45′ S.
Jupiter,	♍	7 49	1 22 N.
Saturn,	♋	16 21	0 2 S.
Uranus,	♒	2 18	0 34 S.

3. Required the situation of all the planets for the first day of every month during the present year.

PROBLEM XXII.

To find the Right Ascension and Declination of the Planets —their Rising, Culminating, Setting, Amplitude, Azimuth, Altitude, &c., for a given day and place.

The situation of the planets being marked upon the globe for the given day, their right ascension, declination, &c., may be found the same way as for the fixed stars.

EXAMPLES.—1. Required the right ascension and declination of all the planets on November 13th, 1828.

	RIGHT ASCENSION.		DECLINATION.	
Mercury,	228°	0′	18°	0′ S.
Venus,	188	0	10	39 S.
Mars,	321	0	16	0 S.
Jupiter,	231	0	18	0 S.
Saturn,	129	0	19	0 N.
Uranus,	301	0	21	0 S.

2. At what time did Saturn rise at London, on November 1st, 1828?

Ans. 15 min. past 10 *p.m.*

3. When did Jupiter, Mars, and Venus set at London, on February 2nd, 1837?

4. Required the situation of the Planets for November 19th, 1838.

5. Which of the Planets were visible at Newcastle, November 25th, 1837, and whether in the evening or morning?

PROBLEM XXIII.

To find when Jupiter and Venus are Morning, and when they are Evening Stars.

1. Find their situation, as before directed.

2. If it be to the east of the sun's place, they will be evening stars; if to the west, they will be morning stars.

EXAMPLES.—1. Were Jupiter and Venus morning or evening stars on Dec. 7th, 1828?

Ans. They were W. of the sun, and were morning stars.

2. During what time will Jupiter be a morning star this year, and what time will it be an evening star?

3. Required the same for Venus.

SECTION IV.

PROBLEMS RELATING TO THE MOON.

The motion of the moon is very irregular. This irregularity is occasioned by its being attracted both by the sun and by the earth. It does not move in the ecliptic, but its orbit forms with the ecliptic an angle of $5\frac{1}{4}°$. The points where its orbit cuts the ecliptic are called its *nodes*, and are constantly changing.

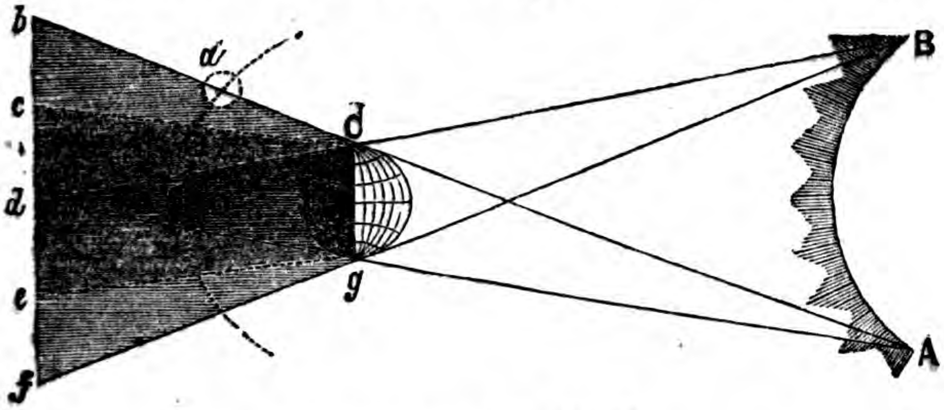
The course which the moon appears to pursue in the heavens is always varying. Passing in a month through all the signs of the zodiac, its meridian altitude will vary in that time 47°. The full moon that happens in Cancer is the most beneficial to us in the northern hemisphere, for its altitude is then the greatest, and it continues longest above the horizon; but when the full moon happens in Cancer, the sun is in Capricorn, and our days being then at the shortest, we are the most in want of auxiliary light. The full moon that is of the least use to us is in Capricorn, for its altitude is then the least, and its stay the shortest above the horizon; but the sun being then in Cancer, our days are long, and the light of the moon is not needed.

This is a wonderful display of the divine wisdom and goodness in apportioning the quantity of light suitable to the various necessities of the inhabitants of the earth, according to their different situations.

The full moon being always opposite to the sun, can never be seen by the inhabitants of the poles whilst the sun is above the horizon; but all the time the sun is below the horizon the full moons never set.

ECLIPSES.

An *eclipse of the moon* is caused by its entering into the earth's shadow. It can only happen at the time of *full*



ECLIPSE OF THE MOON.

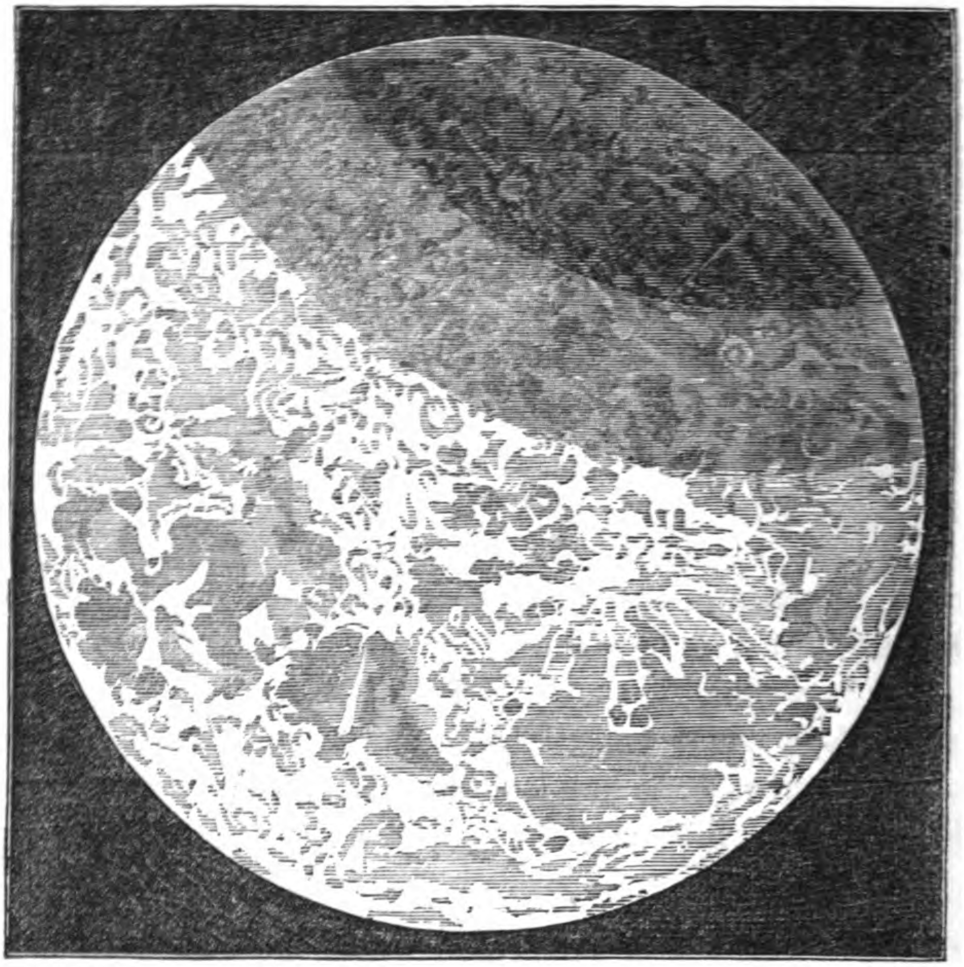
moon, or when in opposition to the sun, as the shadow of the earth must lie opposite to the sun.

The preceding figure will illustrate this.

Let A B represent the sun, and C *g* the earth. The moon, when at *a*, is just entering the earth's shadow, and the eclipse is then said to commence; at D, the moon is wholly enveloped in the shadow, and is totally eclipsed.

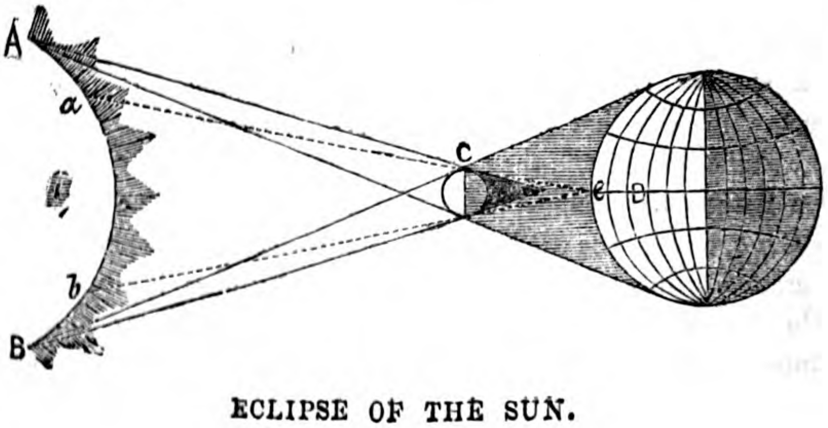
When most obscure, the moon's disc is not entirely hid from us, for some of the solar light generally reaches it through the refracting influence of our own atmosphere.

An observer who consults an almanac often expects an eclipse of the moon to begin long before he notices the earth's shadow to strike it. An inspection of the figure will explain the reason of this. Before the moon reaches the line *b* C it receives rays from the whole of the sun's surface, but after crossing that line, the portion of the sun's disc from which it receives light is gradually diminished by the intervention of the earth; a shadow thus gently steals over the moon. It is only after crossing the line C *d* that all the sun's rays are cut off, and that it enters the *dark* shadow, and it is then only that an observer unprovided with a telescope detects the commencement of the eclipse. The conical dark shadow C *d g*, cast by the earth, is termed the *umbra*. The partial shadow, which gradually increases in intensity as the umbra is approached. is called the *penumbra* (almost shade). During the progress of an eclipse the penumbra always precedes and follows the umbra. The appearance of the penumbra, as seen through a telescope, is well depicted in the annexed wood-cut, allowance being made for a little necessary exaggeration in the depths of its shade.



MOON PARTIALLY ECLIPSED, EXHIBITING THE PENUMBRA.

An *eclipse of the sun* is caused by the interposition of the moon between the earth and sun, and therefore it must happen when the moon is in conjunction with the sun, or at the *new* moon.



ECLIPSE OF THE SUN.

When the sun A B, the moon C, and the earth D, are in the relative position represented in this figure, an eclipse of the sun takes place.

The eclipse may be *total*, when the whole of the sun's disc is obscure; *partial*, when only a part of his surface is obscured; and *annular*, when the moon cuts off a circle in the middle, leaving a luminous ring (Latin *annulus*) around the part obscured.

The wood-cut represents the circumstances in which an annular eclipse takes place. The moon's umbra falls short of the earth, and an observer at *e*, directing his eye along the upper edge of the moon, will see the portion of the sun A *a*, unobscured; directing it past the lower edge, he will see the portion B *b*, and so of the whole circumference.

Frequently on the occurrence of an eclipse of the sun, the moon happens to be nearer to the earth than in the case supposed, and the umbra strikes the earth. The sun will then be totally eclipsed to an observer at *e*, and partially eclipsed to observers on each side of the conical umbra in a degree proportioned to their distance from it.

Lunar eclipses are visible in all parts of the earth which have the moon above their horizon, and are everywhere of the same magnitude and duration; but a solar eclipse is never seen throughout the whole hemisphere of the earth where the sun is visible; as the moon's disc is too small to hide the whole or any part of the sun from the whole disc or hemisphere of the earth. Nor does an eclipse of the sun appear the same in all parts of the earth where it is visible, but when in one place it is total, in another it is partial.

If the moon moved in the ecliptic, there would be an eclipse of the moon every full moon, and an eclipse of the sun every new moon; but the moon being in one part of its orbit $5\frac{1}{4}°$ to the north of the ecliptic, and in another part $5\frac{1}{4}°$ to the south, there can be no eclipse except the moon, at full or change, be near its nodes. When the moon is less than 18° from either of the nodes at the time of change, there will be an eclipse of the sun; when it is less than 12° from either node at the time of full, there will be an eclipse of the moon.

These are called the *ecliptic limits;* and as they are nearly in the proportion of 3 to 2, there will be more solar than lunar eclipses in the same ratio. But more lunar than solar eclipses are seen at any place; because a lunar eclipse is visible to a whole hemisphere, whereas a solar eclipse is visible only to a part. The greatest number of eclipses that can happen any year is seven, and of these five will be of the sun, and two of the moon; the least number that can happen is two, and these must be both solar: the mean number is about four. The season of eclipses will return at an interval of about nine or ten days less than half a year; so that if there be eclipses about the middle of January, the next will be about the first week of July.

OF THE HARVEST MOON.

The moon rises about three-quarters of an hour later on any day than on the day preceding; but in places of considerable latitude, there is a remarkable difference about the time of harvest, when, at the season of full moon, it rises for several nights together, only about seventeen minutes later on one day than on the day preceding. By thus succeeding the sun before twilight is ended, the moon prolongs the light, to the great benefit of those who are engaged in gathering the fruits of the earth; and hence the full moon at this season is called the *harvest moon.* The full moon nearest the vernal equinox rises with the greatest difference of time, viz., an hour and a quarter later each day than on the former.—Problem XXIX. explains, by the globe, the phenomenon of the harvest moon; and Problem XXX. the equation of time.

PROBLEM XXIV.

To assign the Orbit of the Moon its proper situation in the Heavens for any given time.

1. Find the moon's ascending node in White's Ephemeris: the descending node will be 180° distant from that. At the distance of 90° from these nodes, reckoning each way, count $5\frac{1}{4}$° to the north of the ecliptic on one side, and $5\frac{1}{4}$° to the south on the other side.

2. Fasten a silk line round the globe, to cut the ecliptic at the nodes, and to pass over these two points, made at the distance of $5\frac{1}{4}°$ on each side of the ecliptic; and this will represent the moon's orbit for the given day.

EXAMPLES.

1. Represent the moon's orbit for Oct. 25th, 1828.

The moon's ascending node is 15° 56′ in Libra, and the descending node will be 15° 56′ in Aries:—make the silk line cut the ecliptic in these two points; and at the distance of 90° from these points, let it be $5\frac{1}{4}°$ to the north of the ecliptic on one side, and $5\frac{1}{4}°$ to the south on the other side, and it will represent the orbit for that day.

2. Point out the moon's orbit for the present month.

PROBLEM XXV.

To find the Moon's Diurnal Motion in the Ecliptic for any given day.

Find the moon's longitude for the given day, on the right-hand page of White's Ephemeris; subtract from this its longitude on the preceding day; or subtract this from the longitude of the succeeding day; and the difference will be the quantity of diurnal motion sought.

EXAMPLE.

Required the moon's diurnal motion Oct. 25th, 1828.

October 25th, moon's longitude	♊	32°	52′
October 24th,	♉	19	32
	Ans.	13	20

From the moon's diurnal motion may be found its longitude for any hour, by the rule of three; thus—

As 24 hours is to the quantity of daily motion, so is the number of hours to the quantity of motion in that time: for example—

Required the moon's longitude for Oct. 25th, 1828, at 9 *p.m.*

As 24 : 13° 23′ : : 9 : 5°, the motion in 9 hours.

The moon's longitude at noon will be ♊ 2° 52′; to this add 5° 0′ and its longitude, at 9 o clock, *p.m.* will be ♊ 7° 52′.

PROBLEM XXVI.

To mark upon the Globe the Moon's Place in the Heavens for any given day and hour.

Find its longitude for the given hour by the last problem, and its latitude for the given day at noon from White's Ephemeris; put a small patch, with the moon's astronomical character marked upon it, on this place, and it will represent the moon.

The moon's declination, right ascension, altitude, azimuth, &c., may be found in the same way as the declination, &c. of the sun or stars, but not with equal accuracy, on account of the moon's motion.

Examples.—1. Required the moon's place for November 28th, 1828, at 8 hrs. *p.m.*

November 28th, moon's longitude at noon		♌	24°	41'
November 27th,	ditto	♌	12	49
	Diurnal motion		11	52

As 24 hrs.: 11° 52′ : : 8 hrs. : 3° 57′.

The moon's longitude at 8 will be ♌ 28° 38′, and its latitude at noon, given in the Ephemeris, 3° 57′ S.

2. Required the moon's declination for the present day at midnight, and its altitude and azimuth at Newcastle, if it be above the horizon there at that time.

PROBLEM XXVII.

To find the Time of the Moon's Rising, Southing, and Setting, for any latitude and given day of the year.

From the Ephemeris, find the moon's latitude and longitude for the given day, and put on a patch to represent its place; then its rising, southing, and setting may be found the same way as the rising, &c., of the stars.

EXAMPLES.

1. Find the moon's rising and southing on December 25th, 1828, at London.

Ans. South 2 hrs. 56 min. *a.m.* Rises 8 hrs. 34 min. *p.m.*

2. Required the moon's rising, southing, and setting at Newcastle, on December 28th, this year.

PROBLEM XXVIII.

To find the Time of the Year when the Sun or Moon will be liable to be eclipsed.

1. Compare the sun's longitude, at the time of new moon, with the place of the moon's nodes: and if it be within 18°, there may be an eclipse of the sun.

2. Compare the same at the time of full moon; and if it be within 12°, there may be an eclipse of the moon.

EXAMPLES.—1. Was the sun eclipsed in April, 1828?

Ans. New moon happened on the 14th; the place of the moon's node on that day was ♈ 26° 15′, the sun's longitude was ♈ 24° 29′; hence the moon was within 2° of its node, and an eclipse took place.

2. Was the moon eclipsed in December, 1838?

Ans. Full moon happened on the 30th: the moon's nodes on that day were ♒ 29° 21′, and ♌ 29° 21′; the sun's longitude ♍ 8° 25′: hence the moon was 99° 4′ from its nearest node, and consequently no eclipse took place.

3. Find, by the globe, what eclipses of the sun or moon will happen this year.

PROBLEM XXIX.

To explain the Phenomena of Harvest Moon.

Elevate the globe for any northern latitude, suppose for *Newcastle.*

In September, when the sun is in the beginning of Libra, the moon, at full, must be in or near the beginning of Aries: and as the mean motion of the moon is 13° in a day, put a patch on the first point of Aries, and another

13° beyond it on the ecliptic: this last will point out the moon's place the first night after full. Its place on the second, third, &c., night may be found by putting more patches at the distance of 13° from each other.

Bring the first patch to the horizon, and observe the hour, turn the globe till the second patch come to the horizon, and the index will show that it rises only seventeen minutes later than the former. Thus seventeen minutes is the difference of the moon's rising on two successive nights. The other patches will come to the horizon in little more than that time, after each other; which shows that the difference of the moon's rising several nights successively is little more than seventeen minutes each night. The difference of the moon's rising for a week will not be two hours.

The small angle which that part of the moon's orbit makes with the horizon is the reason of its rising at that season, for several evenings, with so small a difference of time.

That part of the moon's orbit near Libra makes the greatest angle with the horizon; and the full moon that happens in Libra rises with the greatest difference of time. This may be seen by placing patehes on the globe, from the first of Libra, to represent the moon's place for several successive nights, when it will be seen that the difference of rising in two evenings will be 1 hour 17 minutes.

That point of the ecliptic which rises at the least angle with the horizon, sets at the greatest; and therefore when there is the least difference in the time of rising, there will be found to be the greatest in the time of setting.

EXAMPLES.

Required the difference in the times of the harvest moon's rising for seven days successively, at

1. Petersburg, 3. London,
2. Edinburgh, 4. Gibraltar.

PROBLEM XXX.

To explain by the Globe the Equation of Time.

Mean, or ***equal*** time, is measured by a clock that is supposed to go without variation, and to measure exactly twenty-four hours from noon to noon. *Apparent* time is that time as measured by a good sun-dial.

The sun's motion being in the ecliptic, and not in the equator, and equal portions of the ecliptic passing over the meridian in unequal times, causes a difference between *equal* and *apparent* time: the adjustment of this difference is called the *equation of time.*

To show this upon the globe, make pencil marks all round the equator and ecliptic, at equal distances (suppose 15°) from each other, beginning with Aries.

Then, on turning the globe, you will perceive that all the marks on the first quadrant of the ecliptic, that is, from Aries to Cancer, come sooner to the brass meridian than their corresponding marks on the equator. Now time, as measured by the dial, is represented by marks on the ecliptic; that measured by a good clock, by those on the equator: hence, whilst the sun is in the first quarter of the ecliptic, the dial is faster than the clock.

On turning the globe, it will be found that the marks on the second quarter of the ecliptic, that is, from Cancer to Libra, come to the meridian later than those on the equator, and consequently the sun is slower than the clock. So it will be seen that, in the third quarter, from Libra to Capricorn, the sun is faster, and in the fourth quarter, from Capricorn to Aries, slower, than the clock.

The earth's motion in its orbit not being uniform, is another cause of difference between mean and apparent time. The equation of time is given for every day in White's Ephemeris, and in most almanacs. The days when the clock and sun agree, are April 15th, June 15th, Sept. 1st, and Dec. 24th. The days of greatest difference are Feb. 11th, May 15th, July 26th, and Nov. 3rd.

QUESTIONS FOR EXAMINATION IN SECTIONS III. AND IV.

What is the literal signification of the word *planet?* How many planets are there, and in what order do they move round the sun? How many are called *inferior planets,* and why are they so called? Which of them are called *superior planets,* and why are they so called? Which of them are called **Asteroids?**

Are Mercury and Venus ever seen in the west in the morning, or in the east in the evening? Which of the planets may be seen on the meridian at midnight?

How do the planets appear to move as seen from the earth? What is the greatest distance, in degrees, that Mercury and Venus ever appear from the sun?

What is Mercury's mean distance from the sun? What is its diameter? How long does it take to turn round the sun? How long to turn on its own axis? What are the distances, diameters, and periods, of the other large planets? How much greater is the heat of the sun at Mercury than upon our earth?

How may the planet Venus be known in the heavens? What appearance has it when viewed through a telescope? At what rate does it move per hour? How much more light and heat do its inhabitants enjoy than we do? At what rate does the earth move per hour?

What is the name of that fluid which surrounds the earth? What are some of the benefits which we derive from it?

What is the diameter of the moon, its distance from the earth, and the time of its revolution round the earth? What is the time between one new moon and another? Explain the phases of the moon. How much more light does the earth afford to the moon, than the moon does to the earth?

How may Mars be known in the heavens?

How much less light does the sun afford to Jupiter than to us? How is this defect supplied?

What appearance has Saturn in the heavens? How many moons has Saturn? In what respect does this planet differ from the others?

Which is the most remote planet yet discovered belonging to our system? How much light does the sun give to Uranus? How many moons belong to it? What peculiarities have they?

What are the names of the minor planets? When was Ceres discovered? Wherein do they differ from the other planets?

What are the parts of a comet? What is the usual form of the orbit of a comet? Name the most remarkable comets of modern times? What interesting fact has Encke's comet revealed?

What is it that causes an eclipse of the moon? Of the sun?

Supposing the north pole to be inhabited, how long would the inhabitants uninterruptedly enjoy the light of the moon in winter?

Within how many degrees of the nodes must the moon be, at the time of change, to produce an eclipse of the sun? Within how many degrees, at full moon, to produce an eclipse of the moon?

What is the greatest and least number of eclipses that can happen in any year, and how many of these must be of the sun?

How may the moon's orbit be represented on the globe? How may the moon's diurnal motion in the ecliptic be found?

How may the moon's longitude for any hour be found? How may the moon's place be found for any day and hour?

How may the moon's rising and setting be found? How may the moon's age be found? How is the moon's southing found?

How can it be found when the sun or moon is liable to be eclipsed? Explain the phenomena of the harvest moon. How can the equation of time be explained by the globe?

A TABLE

OF

THE LATITUDES AND LONGITUDES,

OF THE

PLACES MENTIONED IN THE PROBLEMS.

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Acapulco	Mexico	16° 50′ N	99° 46′ W
Adrianople	Turkey	41 45 N	26 38 E
Akerman	Turkey	46 12 N	30 12 E
Alashka (S. Pt.)	North America	55 0 N	160 0 W
Aleppo	Syria	36 11 N	37 10 E
Alexandria	Egypt	31 13 N	29 55 E
Algiers	Barbary	36 48 N	3 4 E
Alicant	Spain	38 21 N	0 28 W
Amsterdam	Holland	52 22 N	4 54 E
Ancona	Italy	43 36 N	13 32 E
Aracan	Trans-Gangetic India	20 44 N	93 26 E
Archangel	Russia	64 34 N	40 43 E
Ascension (Is.)	Atlantic Ocean	7 56 S	14 13 W
Astracan	Russia	46 30 N	48 0 E
Athabasca (R.)	North America	57 0 N	111 20 W
Athens	Greece	37 58 N	23 43 E
Ava	Birmah	21 51 N	95 58 E
Azof	Russia	47 0 N	39 0 E
Azore (Is.)	Atlantic Ocean	38 0 N	26 0 W
Bagdad	Turkey in Asia	33 25 N	44 35 E
Barbadoes	West Indies	13 5 N	59 43 W
Barcelona	Spain	41 25 N	2 9 E
Bastia	Corsica	42 41 N	9 26 E
Batavia	Java	6 9 S	106 52 E
Benares	India	25 20 N	83 2 E
Bencoolen	Sumatra	3 48 S	102 0 E
Bender	Russia	46 45 N	29 40 E
Bergen	Norway	60 24 N	5 20 E
Berlin	Prussia	52 31 N	13 12 E
Bermudas	Atlantic Ocean	32 22 N	64 30 W

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Berne	Switzerland	46° 56′ N	7° 31′ E
Behring's Island	Pacific Ocean	55 0 N	166 0 E
Bilboa	Spain	43 14 N	2 44 W
Birmingham	England	52 29 N	1 52 W
Bombay	India	18 54 N	72 56 E
Borneo	Pacific Ocean	4 55 N	114 55 E
Boston	United States	42 24 N	71 3 W
Botany Bay	New Holland	34 0 S	151 14 E
Bordeaux	France	44 50 N	0 35 W
Bremen	Germany	53 5 N	8 48 E
Brest	France	48 23 N	4 29 W
Bristol	England	51 27 N	2 35 W
Buenos Ayres	South America	34 36 S	60 0 W
Brusa	Asia Minor	40 10 N	29 5 E
Cadiz	Spain	36 32 N	6 17 W
Caen	France	49 10 N	0 26 W
Cairo	Egypt	30 0 N	31 19 E
Calais	France	50 56 N	1 47 E
Calcutta	India	22 34 N	88 28 E
Calicut	Malabar, India	11 15 N	75 52 E
California	North America	27 0 N	113 0 W
Canary (Is.)	Atlantic Ocean	28 15 N	15 50 W
Candia	Candia Is. Mediter.	35 18 N	25 18 E
Canton	China	23 8 N	113 2 E
C. Blanco	Africa	21 20 N	17 20 W
C. Bojador	Africa	26 12 N	14 26 W
C. Charles	Labrador	52 20 N	55 45 W
C. Charles	United States	37 14 N	75 52 W
C. Chudleigh	Labrador	60 30 N	64 30 W
C. Coast Castle	Guinea	5 15 N	2 30 W
C. Comorin	India	8 5 N	77 44 E
C. Farewell	Greenland	59 45 N	47 50 W
C. Finisterre	Spain	42 54 N	9 16 W
C. Good Hope	Africa	34 30 S	18 23 E
C. Horn	South America	55 25 S	60 30 W
C. Matapan	Greece	36 23 N	22 29 E
C. South	New Zealand	47 0 S	167 20 E
C. St. Mary	Madagascar	25 35 S	45 20 E
C. St. Roque	Brazil	5 0 S	36 0 W
C. Vela	South America	12 5 N	72 9 W
C. Verd	North Atlantic	16 0 N	24 0 W

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
C. Wrath	Scotland	58° 36′ N	4° 57′ W
Carlisle	England	54 52 N	2 55 W
Carlscrona	Sweden	56 10 N	15 32 E
Casan	Siberia	55 44 N	49 8 E
Cashgar	Chinese Tartary	40 55 N	72 50 E
Cayenne	French Guayana	4 50 N	52 15 W
Charleston	United States	32 50 N	80 0 W
Cherson	Russia	46 52 N	32 48 E
Christiania	Norway	59 55 N	10 48 E
Christiansand	Norway	58 8 N	8 3 E
Christmas (Is.)	Pacific	1 57 N	157 35 W
Churchill (Fort)	Hudson's Bay	58 48 N	93 12 W
Colombo	Ceylon	7 2 N	79 55 E
Constantinople	Turkey	41 1 N	28 55 E
Cook's Strait	New Zealand	41 0 S	175 0 E
Copenhagen	Denmark	55 41 N	12 35 E
Coppermine R. mouth.	North America	69 0 N	115 30 W
Corinth	Greece	37 58 N	22 54 E
Cork	Ireland	51 55 N	8 32 W
Corsica	Mediterranean	42 12 N	9 0 E
Corunna	Spain	43 23 N	8 18 W
Damascus	Syria	33 27 N	36 25 E
Dantzic	Prussia	55 20 N	18 38 E
Darien (Isth.)	America	9 0 N	77 30 W
Delhi	India	28 40 N	77 5 E
Demerara	South America	6 0 N	58 15 W
Disco (Is.)	Davis's Strait	69 50 N	54 30 W
Dover	England	51 7 N	1 19 E
Dresden	Saxony	51 2 N	13 43 E
Dublin	Ireland	53 23 N	6 20 W
Dunkirk	France	51 2 N	2 22 E
East Cape	Siberia	67 0 N	170 0 E
Easter Island	Pacific Ocean	27 9 S	109 25 W
Edinburgh	Scotland	55 57 N	3 11 W
Elsinore	Denmark	56 2 N	12 38 E
Endeavour (R.)	New Holland	15 25 S	145 17 E
Falkland (Is.)	Atlantic	51 24 S	59 56 W
Ferro	Canaries	27 47 N	17 47 W
Formosa (Is.)	Pacific	23 30 N	121 0 E
Frankfort on Main	Prussia	50 8 N	8 34 E
Friendly (Is.)	Pacific	19 0 S	174 0 W
Geneva	Switzerland	46 12 N	6 9 E

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Genoa	Italy	44° 25′ N	8° 58′ E
Gibraltar	Spain	36 6 N	5 21 W
Gilolo (Is.)	Indian Ocean	0 40 N	127 40 E
Glasgow	Scotland	55 51 N	4 15 W
Gottenburg	Sweden	57 42 N	11 47 E
Gottingen	Germany	51 31 N	9 56 E
Greenwich	England	51 28 N	0 0
Guadaloupe (Is.)	Caribbean Sea	16 15 N	61 45 W
Guam (Is.)	North Pacific	13 20 N	145 30 E
Halifax	Nova Scotia	44 40 N	63 55 W
Hamburg	Germany	53 32 N	9 58 E
Hanover	Germany	52 30 N	9 30 E
Havannah	West Indies	23 8 N	82 35 W
Havre de Grace	France	49 30 N	0 6 E
Hecla (Mount)	Iceland	63 52 N	19 45 W
Hispaniola, Hayti, or St. Domingo	West Indies	18 30 N	60 49 W
Hull	England	53 45 N	6 20 W
Irkutsk	Asiatic Russia	52 16 N	104 0 E
Iscanderoon	Syria	37 0 N	36 20 E
Ismail	Russia	45 21 N	28 50 E
Ispahan	Persia	32 25 N	51 50 E
Jago	Cape Verd Islands	15 10 N	23 30 W
Jamaica	West Indies	18 10 N	77 15 W
Jeddo or Yeddo	Japan Islands	36 29 N	140 0 E
Jerusalem	Syria	31 48 N	35 14 E
Jesso	Japan Sea	42 2 N	143 18 E
Juan Fernandez	Pacific	33 40 S	78 58 W
Kerguelens (Is.)	Indian Ocean	48 41 S	69 2 E
Kingston	Jamaica	18 0 N	76 45 W
Konigsberg	Prussia	54 42 N	20 29 E
Ladrone (Is.)	Chinese Sea	21 57 N	113 43 E
Lancaster	England	54 4 N	2 45 W
Lassa	Tibet	29 30 N	91 6 E
Leghorn	Italy	43 33 N	10 16 E
Leipsic	Saxony	51 20 N	12 21 E
Lima	Peru	12 3 S	77 17 W
Lisbon	Portugal	38 42 N	9 8 W
Liverpool	England	53 24 N	2 58 W
Lizard Point	England	49 57 N	5 11 W
London	England	51 30 N	0 5 W
Lubeck	Germany	53 51 N	10 48 E

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Lyons	France	45° 47′ N	4° 46′ E
Macao	China	22 10 N	113 31 E
Madagascar (N. Pt.)	Indian Ocean	1 30 S	46 20 E
Madeira (Is.)	North Atlantic	3 37 N	16 58 W
Madras	India	4 N	80 22 E
Madrid	Spain	40 25 N	3 33 W
Magdeburg	Saxony	52 8 N	11 38 E
Magellan's Strait	South America	5 24 S	69 0 W
Mainland	Shetland	60 30 N	1 30 W
Malacca	East Indies	2 20 N	102 5 E
Malaga	Spain	36 43 N	4 25 W
Malta	Mediterranean	35 53 N	14 30 E
Manilla	Philippine Islands	14 6 N	120 58 E
Marquesas	Pacific Ocean	9 0 S	140 0 W
Marseilles	France	43 17 N	5 22 E
Martinique	West Indies	14 35 N	61 5 W
Mauritius	Indian Ocean	20 9 S	57 22 E
Mecca	Arabia	21 18 N	40 15 E
Medina	Arabia	24 40 N	39 40 E
Melville (Is.)	Polar Sea	75 0 N	110 0 W
Memel	Prussia	55 42 N	21 8 E
Mexico	North America	19 25 N	99 5 W
Mindanao	Philippine Islands	7 30 N	125 0 E
Mocha	Arabia	13 20 N	43 20 E
Moscow	Russia	55 50 N	37 40 E
Munich	Germany	48 8 N	11 36 E
Nankin	China	32 4 N	118 47 E
Naples	Ital	40 50 N	14 15 E
Narbonne	France	43 15 N	3 0 E
Narym	Siberia	58 30 N	83 0 E
Navarino	Greece	36 53 N	21 45 E
Navigators' Islands	South Pacific Ocean	14 9 S	169 1 W
Newcastle	England	54 58 N	1 37 W
New Caledonia	South Pacific Ocean	22 0 S	166 0 E
New Orleans	United States	29 57 N	90 11 W
New York	United States	40 42 N	73 59 W
Nice	Italy	43 41 N	7 16 E
Nootka Sound	North America	49 35 N	126 37 W
Norfolk (Is.)	South Pacific Ocean	29 1 S	168 10 E
North Cape	Lapland	71 10 N	26 0 E
Nova Zembla	Arctic Ocean	72 0 N	60 0 E
Okhotsk	Siberia	59 20 N	143 12 E

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Olmutz	Austria	49° 33′ N	17° 9′ E
Oonalashka	North Pacific Ocean	53 30 N	167 50 W
Oporto	Portugal	41 8 N	8 37 W
Oran	Africa	35 50 N	0 18 W
Ormuz (Is.)	Persian Gulf	27 7 N	56 37 E
Otaheite	Society Isles	17 29 S	149 35 W
Owhyhee (N. point)	Sandwich Islands	20 17 N	155 58 W
Oxford	England	51 45 N	1 15 W
Panama	America	8 58 N	79 27 W
Paramaribo	South America	6 0 N	55 30 W
Paris	France	48 50 N	2 20 E
Pegu	Birmah	17 45 N	96 20 E
Pekin	China	39 55 N	116 28 E
Pelew (Is.)	Pacific Ocean	6 53 N	134 21 E
Perpignan	France	42 42 N	2 56 E
Petersburg	Russia	59 56 N	30 18 E
Philadelphia	United States	39 56 N	75 11 W
Philippine (Is.)	Pacific	12 0 N	122 0 E
Pico	Azore Islands	38 38 N	28 33 W
Pitcairn's Islands	Pacific Ocean	25 4 S	130 25 W
Plymouth	England	50 22 N	4 7 W
Poictiers	France	46 35 N	0 21 E
Polotsk	Russia	55 30 N	28 34 E
Pondicherry	India	11 56 N	79 54 E
Porto Bello	South America	9 34 N	79 43 W
Port Jackson	New Holland	33 40 S	151 0 E
Port Mahon	Minorca	39 51 N	4 18 E
Port Royal	Jamaica	17 58 N	76 52 W
Port Sir Fr. Drake	New California	38 45 N	122 15 W
Portsmouth	England	50 48 N	1 5 W
Potosi	Bolivia	19 45 S	67 40 W
Prague	Austria	50 5 N	14 25 E
Presburg	Austria	48 12 N	17 2 E
Quebec	Canada	46 47 N	71 9 W
Queen Charlotte's Sd.	New Zealand	41 6 S	174 40 E
Queen Charlotte's Is.	North Pacific	53 0 N	132 0 W
Quito	Colombia	0 13 S	78 21 W
Revel	Russia	59 27 N	24 53 E
Rhode (Is.)	United States	41 30 N	71 20 W
Rhodes (Is.)	Archipelago	36 27 N	28 13 E
Riga	Russia	56 57 N	24 7 E
Rio Janeiro	Brazil	22 53 S	43 12 W

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Rochelle	France	46° 9′ N	1° 9′ W
Rome	Italy	41 53 N	12 29 E
Samarcand	Tartary	39 37 N	64 9 E
Sandwich (Is.)	Pacific Ocean	20 0 N	157 0 W
Santa Fe de Bogota	Colombia	4 37 N	74 10 W
Severn House	Hudson's Bay	56 10 N	88 0 W
Shiraz	Persia	29 45 N	52 15 E
Shrewsbury	England	52 42 N	2 43 W
Siam	India	14 30 N	101 10 E
Sierra Leone	Africa	8 30 N	13 15 W
Singapore	Malaya	1 30 N	104 0 E
Smyrna	Asia Minor	38 25 N	27 6 E
Society Islands	Pacific Ocean	17 0 S	151 0 W
Spitzbergen	Arctic Ocean	79 0 N	16 0 E
St. Christopher's (Is.)	West Indies	17 2 N	62 43 W
St. Helena	South Atlantic	15 55 S	5 43 W
St. John's	Newfoundland	47 33 N	52 39 W
St. Malo	France	48 40 N	2 0 W
St. Paul's (Is.)	Indian Ocean	38 42 S	77 18 E
St. Salvador	West Indies	24 20 N	75 40 W
Stockholm	Sweden	59 20 N	18 3 E
Stralsund	Prussia	54 18 N	13 3 E
Strasburg	France	48 32 N	7 45 E
Surat	India	21 10 N	73 12 E
Surinam	Guayana	5 0 N	55 30 W
Syracuse	Sicily	37 2 N	15 16 E
Teneriffe	Canaries	28 17 N	16 29 W
Tinian (Is.)	Ladrone Islands	15 0 N	146 0 E
Tobago	West Indies	11 15 N	60 40 W
Tobolsk	Russia	58 0 N	68 15 E
Tomsk	Siberia	56 30 N	84 10 E
Tongataboo	Friendly Isles	21 7 S	175 12 W
Tornea	Russian Finland	65 50 N	24 12 E
Torres Straits	New Guinea	10 0 S	142 0 E
Toulon	France	43 7 N	5 55 E
Tranquebar	India	11 0 N	79 53 E
Trincomalee	Ceylon	8 33 N	81 22 E
Trinidad (Is.)	West Indies	10 30 N	61 30 W
Truxillo	Peru	8 0 S	78 35 W
Tunis	Africa	36 44 N	10 22 E
Turin	Italy	45 5 N	7 40 E
Ulm	Germany	49 54 N	8 8 E

Names of Places.	*Sea or Country.*	*Latitude.*	*Longitude.*
Upsal	Sweden	60° 0′ N	17° 30′ E
Ushant (Is.)	France	48 28 N	5 3 W
Valencia	Spain	39 21 N	0 17 W
Van Diemen's Land, Hobart Town	New Holland	42 54 S	147 27 E
Venice	Italy	45 26 N	12 20 E
Vera Cruz	Mexico	19 11 N	96 8 W
Vesuvius (Mt.)	Italy	40 48 N	14 27 E
Vienna	Germany	48 12 N	16 22 E
Vologda	Russia	59 10 N	40 5 E
Warsaw	Poland	52 12 N	21 0 E
Washington	United States	38 55 N	76 58 W
Yarmouth	England	52 37 N	1 44 E
York	England	53 57 N	1 5 W

TABLE I.

Showing the Declination of the Sun for every Day in the Year.

Days	Jan. South.	Feb. South.	March. S. & N.	April. North.	May. North.	June. North.
1	23° 3′	17° 12′	7° 43′	4° 23′	14° 57′	22° 0′
2	22 58	16 55	7 21	4 47	15 15	22 8
3	22 53	16 38	6 58	5 10	15 33	22 16
4	22 47	16 20	6 35	5 33	15 51	22 24
5	22 40	16 2	6 12	5 55	16 8	22 31
6	22 33	15 44	5 48	6 18	16 25	22 37
7	22 26	15 25	5 25	6 41	16 42	22 43
8	22 18	15 6	5 2	7 3	16 59	22 49
9	22 10	14 47	4 38	7 26	17 15	22 55
10	22 1	14 28	4 15	7 48	17 31	23 0
11	21 52	14 8	3 51	8 10	17 47	23 4
12	21 43	13 49	3 28	8 32	18 2	23 8
13	21 33	13 29	3 4	8 54	18 17	23 12
14	21 23	13 8	2 41	9 16	18 32	23 16
15	21 12	12 48	2 17	9 37	18 46	23 19
16	21 1	12 27	1 53	9 59	19 0	23 21
17	20 49	12 6	1 30	10 20	19 14	23 23
18	20 37	11 45	1 6	10 41	19 28	23 25
19	20 25	11 24	0 42	11 2	19 41	23 26
20	20 12	11 3	0 19	11 23	19 54	23 27
21	19 59	10 41	0 5N	11 43	20 6	23 28
22	19 46	10 20	0 29	12 4	20 18	23 28
23	19 32	9 58	0 52	12 24	20 30	23 28
24	19 18	9 36	1 16	12 44	20 42	23 27
25	19 3	9 13	1 40	13 3	20 53	23 26
26	18 48	8 51	2 3	13 23	21 4	23 24
27	18 33	8 29	2 27	13 42	21 14	23 22
28	18 18	8 6	2 50	14 1	21 24	23 20
29	18 2		3 14	14 20	21 34	23 17
30	17 46		3 37	14 39	21 43	23 14
31	17 29		4 0		21 52	

TABLE I. (CONCLUDED.)

Showing the Declination of the Sun for every Day in the Year.

Days.	July. North.	Aug. North.	Sept. N. & S.	Oct. South.	Nov. South.	Dec. South.
1	23° 10′	18° 10′	8° 28′	3° 1′	14° 19′	21° 46′
2	23 6	17 55	8 6	3 24	14 38	21 55
3	23 2	17 39	7 44	3 48	14 57	22 4
4	22 57	17 24	7 22	4 11	15 16	22 13
5	22 52	17 8	7 0	4 34	15 35	22 21
6	22 46	16 52	6 38	4 57	15 53	22 28
7	22 40	16 35	6 15	5 20	16 11	22 35
8	22 34	16 18	5 53	5 43	16 29	22 42
9	22 27	16 1	5 30	6 6	16 46	22 48
10	22 20	15 44	5 7	6 29	17 3	22 54
11	22 12	15 26	4 45	6 52	17 20	23 0
12	22 4	15 9	4 22	7 15	17 37	23 5
13	21 56	14 51	3 59	7 37	17 53	23 9
14	21 47	14 32	3 36	8 0	18 9	23 13
15	21 38	14 14	3 13	8 22	18 25	23 17
16	21 28	13 55	2 50	8 44	18 40	23 20
17	21 18	13 36	2 26	9 7	18 55	23 22
18	21 8	13 17	2 3	9 29	19 9	23 24
19	20 58	12 57	1 40	9 50	19 24	23 26
20	20 47	12 38	1 16	10 12	19 38	23 27
21	20 36	12 18	1 53	10 34	19 52	23 28
22	20 24	11 58	0 30	10 55	20 5	23 28
23	20 12	11 38	0 6	11 16	20 18	23 28
24	20 0	11 17	0 17S	11 37	20 30	23 27
25	19 47	10 57	0 41	11 58	20 42	23 26
26	19 34	10 36	1 4	12 19	20 54	23 24
27	19 21	10 15	1 28	12 40	21 5	23 22
28	19 7	9 54	1 51	13 0	21 16	23 19
29	18 53	9 33	2 14	13 20	21 27	23 16
30	18 39	9 11	2 38	13 40	21 37	23 13
31	18 25	8 50		14 0		23 9

TABLE II.

Of the Sun's Right Ascension.

Days.	Jan.	Feb.	March.	April.	May.	June.	Days.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	
1	18 43	20 56	22 49	0 43	2 34	4 37	1
2	18 48	21 0	22 53	0 46	2 38	4 41	2
3	18 52	21 4	22 56	0 50	2 42	4 45	3
4	18 57	21 8	23 0	0 54	2 45	4 49	4
5	19 1	21 12	23 4	0 57	2 49	4 53	5
6	19 6	21 16	23 8	1 1	2 53	4 57	6
7	19 10	21 20	23 11	1 4	2 57	5 1	7
8	19 14	21 24	23 15	1 8	3 1	5 5	8
9	19 19	21 28	23 19	1 12	3 5	5 9	9
10	19 23	21 32	23 22	1 16	3 9	5 14	10
11	19 27	21 36	23 26	1 19	3 12	5 18	11
12	19 32	21 40	23 30	1 23	3 16	5 22	12
13	19 36	21 44	23 33	1 26	3 20	5 26	13
14	19 40	21 48	23 37	1 30	3 24	5 30	14
15	19 45	21 52	23 41	1 34	3 28	5 34	15
16	19 49	21 56	23 44	1 38	3 32	5 38	16
17	19 53	21 59	23 48	1 41	3 36	5 43	17
18	19 57	22 3	23 52	1 45	3 40	5 47	18
19	20 2	22 7	23 55	1 49	3 44	5 51	19
20	20 6	22 11	23 59	1 52	3 48	5 55	20
21	20 10	22 15	0 3	1 56	3 52	5 59	21
22	20 15	22 19	0 6	2 0	3 56	6 3	22
23	20 19	22 23	0 10	2 4	4 0	6 8	23
24	20 23	22 27	0 13	2 7	4 4	6 12	24
25	20 27	22 30	0 17	2 11	4 8	6 16	25
26	20 31	22 34	0 21	2 15	4 12	6 20	26
27	20 35	22 38	0 24	2 19	4 16	6 24	27
28	20 40	22 42	0 28	2 22	4 20	6 28	28
29	20 44	22 45	0 32	2 26	4 24	6 33	29
30	20 48		0 35	2 30	4 28	6 37	30
31	20 52		0 39		4 32		31

TABLE II. (CONCLUDED.)

Of the Sun's Right Ascension.

Days.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Days.
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	
1	6	41	8	46	10	42	12	30	14	26	16	30	1
2	6	45	8	49	10	45	12	33	14	30	16	34	2
3	6	49	8	53	10	49	12	37	14	34	16	39	3
4	6	53	8	57	10	53	12	41	14	38	16	43	4
5	6	57	9	1	10	56	12	44	14	42	16	48	5
6	7	1	9	5	11	0	12	48	14	46	16	52	6
7	7	6	9	9	11	3	12	52	14	50	16	56	7
8	7	10	9	12	11	7	12	55	14	54	17	0	8
9	7	14	9	16	11	11	12	59	14	58	17	5	9
10	7	18	9	20	11	14	13	3	15	2	17	9	10
11	7	22	9	24	11	18	13	6	15	6	17	14	11
12	7	26	9	28	11	21	13	10	15	10	17	18	12
13	7	30	9	31	11	25	13	14	15	14	17	23	13
14	7	34	9	35	11	29	13	18	15	18	17	27	14
15	7	38	9	39	11	32	13	21	15	22	17	31	15
16	7	42	9	43	11	36	13	25	15	27	17	36	16
17	7	46	9	46	11	39	13	29	15	31	17	40	17
18	7	50	9	50	11	43	13	32	15	35	17	45	18
19	7	54	9	54	11	47	13	36	15	39	17	49	19
20	7	58	9	58	11	50	13	40	15	43	17	54	20
21	8	2	10	1	11	54	13	44	15	47	17	58	21
22	8	6	10	5	11	57	13	48	15	52	18	3	22
23	8	10	10	9	12	1	13	51	15	56	18	7	23
24	8	14	10	12	12	5	13	55	16	0	18	11	24
25	8	18	10	16	12	8	13	59	16	4	18	16	25
26	8	22	10	20	12	12	14	3	16	9	18	21	26
27	8	26	10	23	12	15	14	7	16	13	18	25	27
28	8	30	10	27	12	19	14	11	16	17	18	29	28
29	8	34	10	31	12	23	14	14	16	22	18	34	29
30	8	38	10	34	12	26	14	18	16	26	18	38	30
31	8	42	10	38			14	22			18	42	31

TABLE III.

Of the mean Right Ascensions in Time, Declinations, and Magnitudes, of forty remarkable Fixed Stars, with their Names and literal Characters.

Names of the Stars.	Ch.	M.	Rt. Ascen.		Declinat.		
Pole Star, Alruccabah	α	2	0h	52m	88°	14′	N
Andromeda's Girdle, Mirach......	β	2	0	59	34	33	N
Andromeda's Foot, Almaach.... .	γ	2	1	51	41	22	N
Ram's Following Horn	α	2	1	56	22	31	N
Whale's Jaw, Menkar	α	2	2	51	3	18	N
Medusa's Head, Algol	β	2	2	55	40	10	N
Perseus's Side, Algenib............	α	2	3	10	49	8	N
Brightest of the Seven Stars	η	3	3	36	23	29	N
Bull's Eye, Aldebaran	α	1	4	24	16	6	N
Auriga's Shoulder, Capella	α	1	5	2	45	47	N
Orion's Left Foot, Rigel	β	1	5	5	8	26	S
Bull's North Horn..................	β	2	5	14	28	26	N
Orion's Left Shoulder, Bellatrix ..	γ	2	5	14	6	9	N
Orion's Girdle	ε	2	5	26	1	20	S
Orion's Right Should. Betelguese	α	1	5	44	7	22	N
Great Dog, Sirius	α	1	6	36	16	27	S
First Twin, Castor..................	α	1	7	22	32	19	N
Little Dog, Procyon	α	1	7	29	5	44	N
Second Twin, Pollux...............	β	2	7	33	28	30	N
Hydra's Heart, Alphard...........	α	2	9	17	7	47	S
Lion's Heart, Regulus	α	1	9	58	12	56	N
Great Bear, Lower Pointer........	β	2	10	50	57	27	N
Great Bear, Upper Pointer	α	1	10	51	62	50	N
Lion's Tail, Deneb.................	β	2	11	39	15	42	N
Great Bear's Tail, Alioth	ε	2	12	45	57	3	N
Virgin's Spike	α	1	13	15	10	7	S
Dragon's Tail........................	α	2	13	59	65	20	N
Boötes Arcturus......................	α	1	14	6	20	14	N
Libra, South Scale..................	α	2	14	40	15	12	S
Libra, North Scale..................	β	2	15	6	8	38	S
North Crown	α	2	15	26	27	24	N
Scorpion's Heart, Antares.........	α	1	16	17	25	58	S
Hercules' Head, Ras Algethi	α	2	17	5	14	38	N
Head of Serpentarius..............	α	2	17	26	12	43	N
Dragon's Head, Rastaben...	γ	2	17	52	51	31	N
The Harp, Lyra	α	1	18	30	38	36	N
The Eagle, Atair.....................	α	2	19	41	8	21	N
S. Fish, Fomalhaut	α	1	22	47	30	41	S
Pegasus' Wing, Markab.......	α	2	22	55	14	7	N
Andromeda's Head	α	2	23	58	28	10	N

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