Star Watcher

An observer's guide to the stars

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Getting Started

Star Watcher has been designed to cater for people with a wide range of backgrounds and skills. Many of you will therefore not need to read through this text from cover to cover in order to use the computer programs. To accelerate your progress, we suggest the following:

A. If you already understand the way in which the heavens are mapped, and are familiar with the constellations, simply turn to Chapter 7, where you will be shown how to use the Applications Program.

B. If you would like to be able to recognise the constellations, then turn to Chapter 5, and follow the instructions on how to use the Teaching Program.

C. If you are starting from scratch, if you don't have your Amstrad CPC464 handy, or if you just want to take a more leisurely approach, then please read through the Introduction first and go on from there.

NOTE

If you are not familiar with the procedures required to load the Teaching or Applications Program into your Amstrad CPC464, refer to Appendix 3, where you will find specific instructions for using the **Star Watcher** programs.

Notes on Style

Please note that the typestyles used in AMSOFT publications are intended to help identify the different operations and sequences used in computer operation:

Keyboard actions that instruct a command sequence but do not necessarily have a corresponding representation on screen are shown in Helvetica 75 typeface. Non-printing keys are shown enclosed in square brackets:

P	Where the letter 'P' appears on the screen display
P **[ESC]**	As a command, with no corresponding displayed character

General narrative and descriptive text will be shown in one of a variety of serif typestyles, eg: Century, Palatino, Times etc.

Contents

Introduction

Titles in the **BRAINPOWER** series are uniquely designed to harness the power of your Amstrad CPC464 to enable you to learn new skills in a simpler and more enjoyable way. The sophisticated interactive approach ensures that you can work at your own pace and, once you have mastered the topic, the Applications Program will continue to serve your Star Watching needs. We have made every effort to create a course which is straightforward to use, but if you think that we could improve upon it, please send us your written comments.

Star Watcher is a complete learning and applications course to help you find your way about the night sky. Your purchase consists of three elements;

1) The Text Book which you are now reading. You will find that you will be using it continuously in conjunction with your Amstrad CPC464.

2) The Teaching Program, which will be used to develop your skills of stellar observation.

3) The Applications Program, which you will be able to use to display any part of the sky at any time of day or night.

There is no need to work through the Teaching Program before you try the Applications. If you wish, you can use it immediately to find out, for instance, which stars are overhead at this very moment. Turn to Chapter 7, and you will find the detailed instructions for using the Applications Program.

Star Plotting

Before you delve into either the Teaching or Applications Program, you may wish to know a little more about the way that star plotting operates. There are many millions of stars in the heavens, although only a tiny proportion is visible to the naked eye. The actual number depends very much upon atmospheric conditions at the time. This program uses a machine code database of all 1482 'bright' stars listed in section H of The Astronomical Almanac for 1983.

To plot each star, its angle and bearing must be calculated using the trigonometric relationships shown in Appendix 2. If these were to be handled in **BASIC**, it would take nearly half a second per star, which would mean taking around 15 minutes to run through the whole database. We have therefore developed a machine code technique which is many times faster, being able to plot about 1000 stars per second.

Course Objectives

A person with a basic grounding in geography could be shown a map of a section of the world's surface, and might then be expected to know roughly what part of which continent he was looking at, and what other features lay nearby. A good star watcher will require a similar skill - to know what stars and constellations he is looking at, and in which direction to turn to find other features of the heavens. The **Star Watcher** Teaching Program is intended to develop this skill.

When you have completed the course, you can test your proficiency by attempting to identify features in the night sky or, if conditions outside are inclement, just use the Applications Program and your Amstrad CPC464 as your own home observatory instead.

Applications

The basic function of the Applications Program is quite straightforward; it plots views of the stars. However, the way in which it is harnessed has created a much more powerful tool. You can ask for a view for any time of the day or night in any direction and at any point on the earth's surface. For example, if you live in Europe, you can use it to study the parts of the southern sky which you can never see. Another exciting feature of the program allows you to see the pattern of starts which is obscured by sunlight during the day.

You can also use it to assist you in making astronomical observations. The precise bearing and elevation of any point on the computer screen, can be determined so that you can set up your telescope correctly.

Once you are familiar with the way in which **Star Watcher** functions, you will be able to:

— Determine the direction of any star or constellation at any time.

— Watch the way in which the sky changes from hour to hour, day to day or month to month.

— See how the sky changes as you move from one place to another.

We are confident that once you have mastered **Star Watcher**, you will find many useful, entertaining and educational applications for the program.

1. The Teaching Process

1.1 Teaching Method

Before we move into the stage of actually learning anything, we will quickly review how the Amstrad CPC464 is going to be used in conjunction with this book. The actual method of interaction changes from one section to another, depending upon the nature of the subject matter.

The basic information on stars and co-ordinate systems is presented in Chapters 2 to 4. Chapter 5 makes use of the computer to display the constellations and to test your recognition skills. Chapter 6 explains some simple mathematical procedures. Later in Chapter 6, you will be invited to use the Applications Program in conjunction with descriptions of what you can expect to find in the night sky.

1.2 The Teaching Sequence

The course divides into five elements;

1) An explanation of the way the sky is mapped, and the conventions used to describe the star positions (Computer not required).

2) The way in which the stars appear to move relative to an observer on earth (Computer not required).

3) The naming of stars (Computer not required).

4) The form and appearance of the constellations. - This involves use of the Teaching Program.

5) The positional relationships of the constellations. - This is used in conjunction with the Applications Program.

1.3 Getting Started

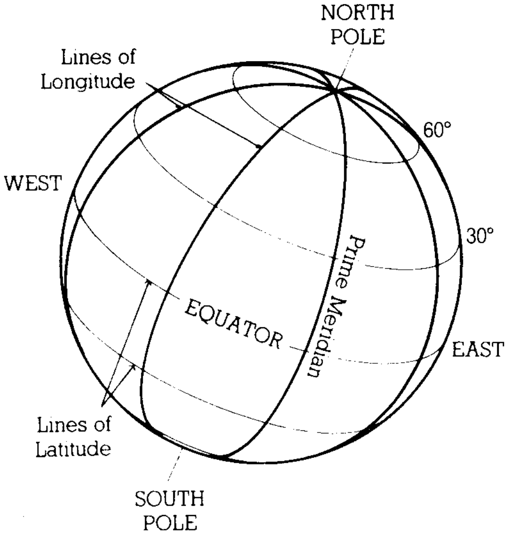
The course is designed to be read in sequence, but if you are more interested in some sections than others, you should find no difficulty if you want to jump about. In particular, if you are keen to examine the form of the various constellations, turn directly to Chapter 5 and follow the instructions to use the Teaching Program.

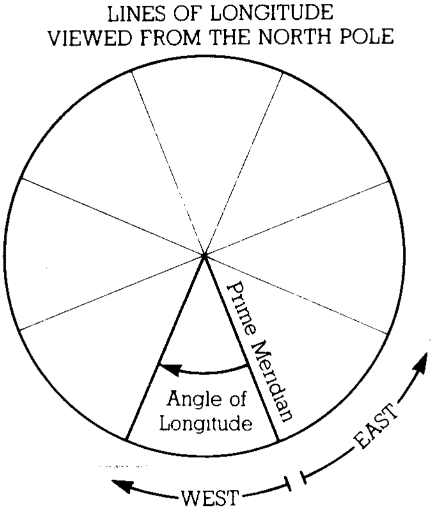
2. Sky Co-ordinates

(Computer not required)

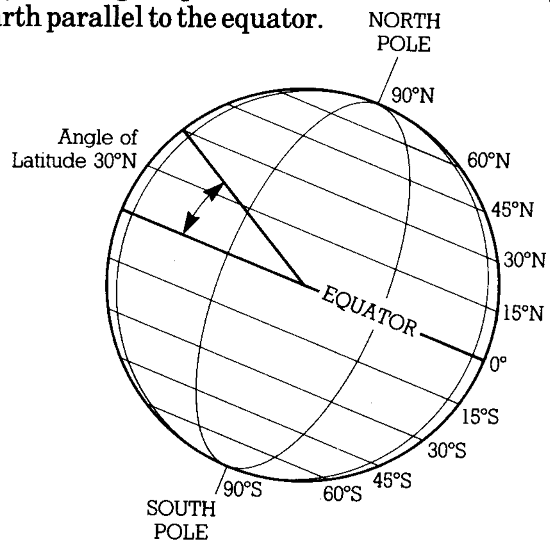
2.1 Down to Earth

The Earth is almost a sphere, spinning in space on an axis which passes through the north and south poles. On the surface of the earth, the location of any point can be defined by its **LATITUDE** and **LONGITUDE**, a pair of measurements which are related to the position of the poles. To define longitude, it is best to look down on the north pole. Imagine a straight line drawn on the earth's surface from the north to south pole. You will find that whichever direction you start out in, all straight lines from the north pole lead to the south pole. Early navigators selected the particular north pole to south pole line which passes through Greenwich in London, and called it the **PRIME** or **GREENWICH** meridian. From this line, you can measure the angle at the north pole to any other line from the north to south pole, and this angle is called the **LONGITUDE** of the line. Obviously, the longitude of the Prime Meridian is zero. The angle to any other line can be measured in a clockwise or anticlockwise direction. The clockwise direction is **WEST** and anticlockwise is **EAST**. By convention, the angle is measured in the direction which makes it less than 180 degrees.





If you mark the point on every longitude line which is half way between the north and south poles, and join all the points together, you will create a circle around the middle of the earth. This is called the **EQUATOR**. From the equator, you can measure the angle towards the north or south pole of any point on the earth's surface. This angle is called **LATITUDE**. The equator has a latitude of zero degrees, and the north and south poles have latitudes of 90 degrees **NORTH** and 90 degrees **SOUTH** of the equator respectively. Joining all points of the same latitude together will create a circle around the earth parallel to the equator.



This network of imaginary lines on the earth's surface is called a **CO-ORDINATE SYSTEM**. In summary, the key features of this particular system are; the north and south poles, the equator, the lines of latitude, and the lines of longitude. Thus, any point on the Earth's surface can be identified using this co-ordinate system by describing the position as a combination of latitude and longitude. For example;

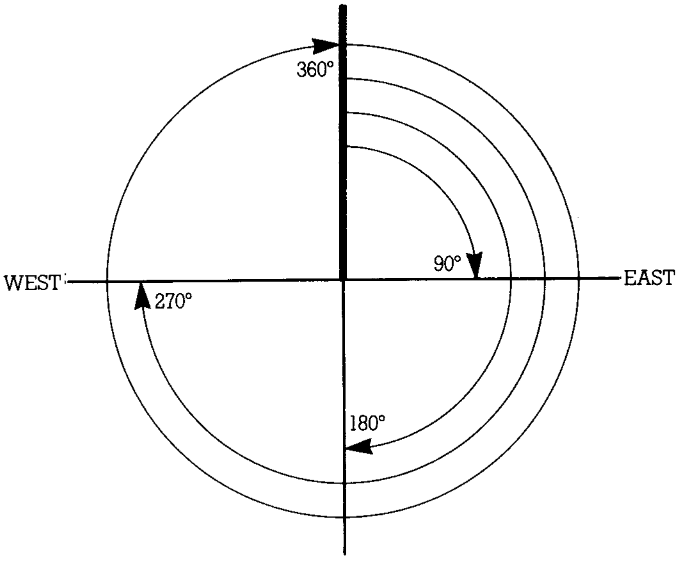
Location	Latitude	Longitude
London	51° 30′N	0° 10′W
New York	41° 15′N	74° 00′W
San Francisco	37° 45′N	122° 25′W
Singapore	1° 30′N	103° 45′E
Sydney	33° 55′S	151° 10′E

This co-ordinate system can be echoed exactly in the sky, but before explaining the relationship, there is one more point to be made about longitude, and that is its relationship to time.

If the time at a point on the Greenwich Meridian is 12 o'clock midnight, then the time at any point east of Greenwich is some time later than midnight. The exact relationship is simple; for every 15 degrees of longitude east of Greenwich, the time is 1 hour later. Hence, at 60°E, the time is 4 hours later, or 4.00 am local time, at 180°E, the time is 12.00 noon. Similarly, for every 15 degrees west of Greenwich, the time is 1 hour earlier; i.e., at 30°W, it is 10.00 pm local time. (which is written as 22.00, using the twenty-four hour clock system), and so on.

MEASURING ANGLES

The angle between two intersecting lines is measured in **DEGREES**, and the symbol ° is used to denote them. A degree is defined as 1/360th part of a circle; that is, the angle measured all the way around a circle is 360°. Hence a **RIGHT ANGLE**, or quarter circle has an angle of 90°, whilst the angle around half a circle is 180°.



For more accurate measurements, it may be neccessary to define an angle in terms of less than one degree. For this purpose, one degree can be subdivided into 60 **MINUTES**, and the symbol ′ is used to denote them. Hence half a degree can be written as 30′, and four and a quarter degrees is 4° 15′.

2.2 Transferring from Earth to Sky

In ancient times, astronomers believed that all of the stars were the same distance away from the earth, fixed onto the **CELESTIAL SPHERE** which surrounds us. Scientific study has since shown this to be untrue; the stars vary in distance from us; but, in fact, they are all so far away that for the purpose of observation, they may as well be assumed to be fixed to a Celestial Sphere. The earth's co-ordinates transfer very simply to this sphere:

1) The north and south **CELESTIAL POLES** are the points directly above and below the earth's poles.

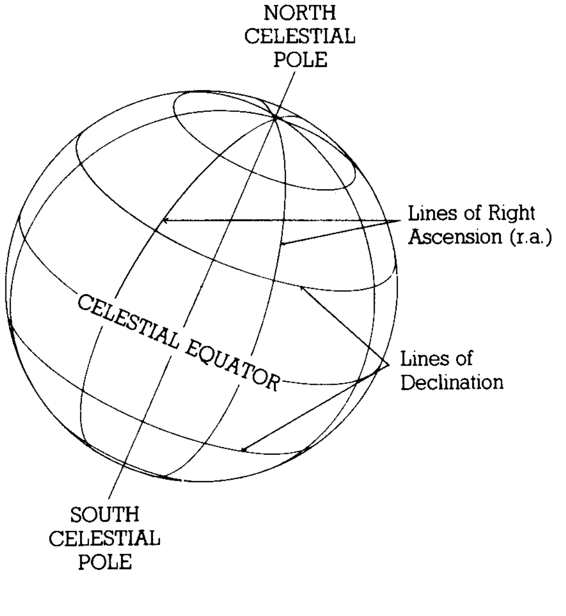
2) The **CELESTIAL EQUATOR** is the line in the sky directly above our equator.

3) The lines of latitude from the earth are projected directly onto the celestial sphere above them, but the name is changed. Instead of calling the angle above or below the equator 'latitude', in the sky it is called **DECLINATION**, but it is measured in exactly the same way and thus has a value from 90°N to 90°S. However, instead of N and S, declination (Dec) is made positive or negative; hence 50°N becomes +50°, whilst 50°S is -50°.

4) Celestial Longitude is slightly more complex for two reasons; firstly it is measured in hours, and secondly, the earth is spinning on its poles so that the sky above a particular point on the earth's surface is continuously changing. To transfer the longitude co-ordinates we must therefore make two adjustments; First, recalibrate the earth's lines of longitude to be measured in terms of the twenty-four hour clock time at each line when it is midnight in Greenwich; second, stop the earth spinning on its axis. We can now project the lines of longitude onto the celestial sphere. Longitude in the sky is called **RIGHT ASCENSION**, and has a value from 0 to 24 hours.

The exact time at which the earth was 'stopped' to project the lines relates to a calculation of the position of the sun at the **VERNAL EQUINOX** (refer to the Glossary), and is not of critical concern to the star watcher. The line of 0 hours right ascension (RA) is highest in the night sky in Autumn, and a description of the features which mark it can be found in Section 6.6.

The actual benefit of measuring right ascension in this way is simple: because of the relationship between time and longitude, a given line of right ascension will pass overhead that number of hours after 0 hours right ascension. i.e, the line of 5 hours RA will pass overhead 5 hours after 0 hours RA.



3. Star Movement

(Computer not required)

3.1 Stars Don't Move

We all know that the sun and stars don't move - the earth turns and generates the illusion. In fact, the stars are moving, but far too slowly to create any impression of change in our lifetimes. The illusion of sum and star movement is complicated by one additional issue - the earth also travels around the sun.

A **SOLAR DAY** is the time taken for the sun to 'move' from its highest point in the sky to it highest point once again. This is the definition of day we think about in normal life, but there is another way of defining a day; a **SIDEREAL DAY** is the time taken for a star to 'move' from its highest point in the sky to its highest point again. Because of the way in which the earth moves around the sun, there is in fact one more sidereal day than there are solar days in each year. This is the reason why the same stars do not rise and set at the same time every solar day.

3.2 Limited by Latitude

The latitude from which you observe the sky determines how much of it you can ever see. At any point in time, it is possible to see exactly half of the celestial sphere, but some of the stars will never set, whilst others will never rise. To determine which stars will pass through your part of the sky, just go through the following steps;

1) Determine your latitude, but ignore whether it is north or south for the moment.

2) Subtract the latitude from 90°. This tells you two things - which stars never set, and which never rise.

3) The stars which never set are in the same hemisphere (half a sphere) as you; these are the stars with declinations between the figure calculated in step (2) and 90°.

4) The stars which never rise are in the opposite hemisphere, again between the figure calculated in step (2) and 90°.

Here is an example: If you are at 50°N, subtract 50° from 90° to give 40°. This means that all stars from 40°N to 90°N will never set, and all the stars from 40°S to 90°S will never rise. In the southern hemisphere, at say 30°, the calculation is virtually the same, although the 'N' and 'S' are reversed: 90°−30°=60°, so stars between 60°S and 90°S never set, whilst stars between 60°N and 90°N will never rise.

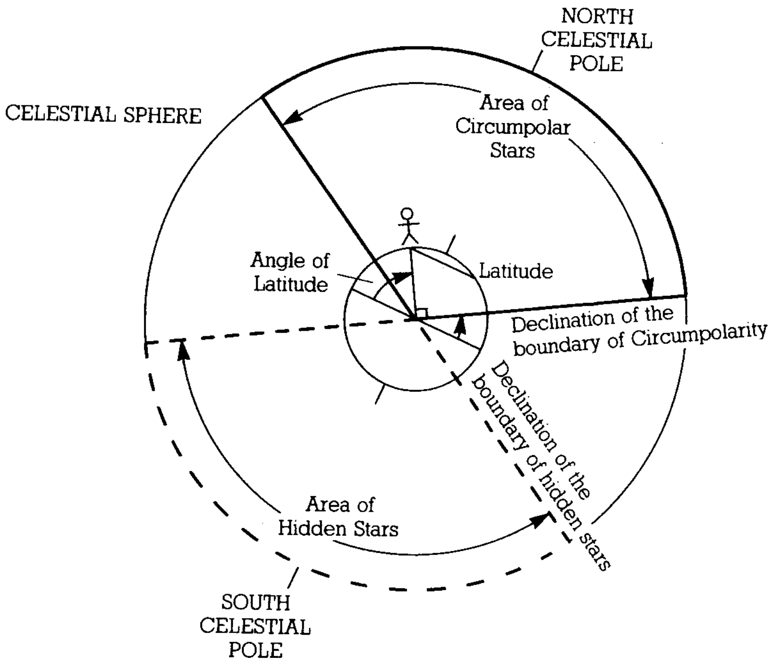
The stars which never set in the sky will be seen to move in a circle around the celestial pole, and are thus referred to as **CIRCUMPOLAR** stars. Notice that on the equator, all stars rise and set.

3.3 Around the Sun

For any latitude, the simple calculation in the previous section will tell you which part of the sky will be observable. The circumpolar stars will be in the sky all the time, whilst all the other stars in the calculated area will rise and set at some time during the sidereal day. However, there is one problem: for at least part of the time, the sun will be up, and the stars will be invisible!

Fortunately, because the sidereal and solar days are different, there will be some period in the year when any observable star rises and sets during darkness.

The part of the sky obscured by the sunlight is significant to another group of star watchers. The constellation which is directly beyond the sun is the star sign used in **ASTROLOGY** for that time of the year. This series of constellations through which the sun passes is referred to as the **ZODIAC**.



4. The Stars

(Computer not required)

4.1 Star Names

The Ancient Greeks and Arabs developed the first catalogues of the stars, locating each one precisely and assigning each a name. They also divided the star groups into many of the the constellations which are familiar today. However, as telescopes were developed, and an increasing number of stars were discovered, it became impractical to name each one individually. Hence many of the star names have fallen into disuse, apart from those of some of the brighter stars. Most of the names which you could find on star maps are listed in the catalogue in Appendix 1.

4.2 Constellations

As mentioned in the last section, the Greeks divided the star groups into constellations. Ptolemy listed 48 constellations in all, including the 12 constellations in the zodiac. Over the centuries, particularly as the southern hemisphere was explored, more constellations were listed. In 1925, the Interntional Astronomical Union agreed precise boundaries between the constellations along lines of right ascension and declination, and now every star can be assigned to a particular constellation. The agreement also determined a three letter code for each constellation to simplify written references. For instance Gemini's code is Gem, and Canis Major is CMa.

In 1603, the astronomer Bayer introduced a method of naming stars by using the Greek alphabet and the constellation names. Generally the brightest star of a constellation is assigned the first letter of the Greek alphabet, α (alpha), the second brightest β (beta), the third γ (gamma), and so on. Thus, the brightest star in Canis Major (Sirius) can also be described as α CMa. When a constellation contained too many stars for the Greek alphabet to cope, lower case and then upper case Roman (modern) letters were used.

All of the official names for the constellations are in Latin (there is a list of English translations in Appendix 1). One effect of this is that Latin grammatical rules are applied to the way the names are used. In ~~particular, when the~~ constellation name is used as part of a star name, the spelling changes (to what is known as the 'genitive' form). Hence Gemini becomes Geminorum and Orion changes to Orionis. In the example mentioned above, the official name for Sirius is pronounced as Alpha Canis Majoris.

By 1725, Flamsteed had prepared a catalogue of stars which numbered each star within each constellation, and this proved a more useful approach as more stars were discovered. In modern times, star catalogues have been developed which code stars without reference to constellation, but for amateur star watchers, it is adequate to use Bayer letters, or the Flamsteed numbers where a letter has not been assigned.

Appendix 1 lists all of the constellations, and the stars within each constellation which are included in the Applications Program database.

4.3 Magnitude

When you look into the night sky, you will notice that some stars appear to be brighter than others. The differences in brightness are the result of two elements. Firstly, some stars are actually brighter than others, and secondly, some are closer to us than others. For instance, the star Sirius appears bright because it is a very luminous star, although it is much farther away than many stars which appear dimmer (see the table at the end of this Chapter). There is no way of telling by simple observation which stars are close and which are far away. All that a star watcher need be concerned about is now bright any star appears to be.

A Greek philosopher called Hipparchus devised a simple system for describing brightness. He classified the brightest stars as being of **MAGNITUDE** 1, and the faintest as magnitude 6. Then all stars in between were measured in the range 2 to 5. The system has been used ever since, but when accurate measuring instruments became available, it was developed into a more precise measure. Each number now represents a brightness of exactly two and a half times the next larger. Hence magnitude 2 is two and a half times brighter than magnitude 3, and so on.

When this system was adopted, it was found that some stars were too bright to classify as magnitude 1, and so the scale was developed to magnitude 0 and some stars are so bright that they have been given negative numbers. The brightest star, Sirius, is magnitude -1.4. the faintest stars visible to the naked eye on a clear night are around magnitude 6, whilst the most powerful telescopes in the world can see stars up to magnitude 23.

4.4 Spectral Type

To the casual observer, the stars appear to be much the same as one another but, in fact, there are many different types of star. One variation which can sometimes be detected is in the colour of the star. A classification system based upon the type of light emitted by a star using the letters of the alphabet was developed at Harvard in the late Nineteenth Century. The precise details of the system are beyond the scope of this text book, but to take some advantage of the **SPECTRAL TYPE** data given in the star table (Appendix 1), it is useful to know what colour each type appears to have. The following list also includes the names of some prominent examples of the type;

A-type ... White	Altair (α Aql), Sirius (α CMa), Vega (α Lyr)
B-type .... Blue-White	Achernar (α Eri), Rigel (β Ori), Spica (α Vir)
F-type .... Yellowish	Canopus (α Car), Polaris (α UMi), Procyon (α CMi)
G-type ... Yellow	The Sun, Capella (α Aur), Matar (η Peg)
K-type ... Orange	Aldebaran (α Tau), Arcturus (α Boo), Pollux (β Gem)
M-type ... Red	Antares (α Sco), Betelgeuse (α Ori), Mirach (β And)

THE TEN BRIGHTEST STARS

Popular Name	Technical Name	Spectral Type	Apparent Magnitude	Distance (light years)	Absolute Magnitude
The Sun		G2	–26.6	.000016	4.7
Sirius	α Canis Majoris	A1	–1.43	8.8	1.4
Canopus	α Carinae	F0	–0.72	1200	−8.5
	α Centauri	G2	–0.27	4.3	5.7 & 4.4
Arcturus	α Bootis	K2	–0.06	36	−0.2
Vega	α Lyrae	A0	–0.04	26	0.5
Capella	α Aurigae	G8	0.05	42	0.3
Rigel	β Orionis	B8	0.08	900	−7.1
Procyon	α Canis Minoris	F5	0.37	11.4	2.6
Achernar	α Eridani	B3	0.51	85	−1.6

5. Constellation Recognition

(Teaching Program Required)

5.1 Introduction

The process which we have adopted to teach you how to recognise the various constellations is quite straightforward. The computer screen will first be used to display each constellation in turn as many times as you like. Each one will be shown together with data about its celestial co-ordinates and the time of year at which it reaches the highest point in the sky.

Once you have studied them, you will be able to request a test procedure which will show you constellations in random order and ask you to identify them. The constellations have been divided into four groups in terms of their distinctiveness. The first group contains the constellations which are most easily identified. The second and third groups are successively less easy to find, whilst the fourth group are so obscure that it is not worth while trying to find them, and they have not been included in the recognition routines.

5.2 Running the Program

Follow the instructions in Appendix 3 to load the Teaching Program into your Amstrad CPC464. When it is ready, it will ask you to give your latitude in whole degrees. This is because all of the exercises can be modified to present the constellations in the way that they appear from your position on the earth. In addition, only those constellations visible from that position will be included. If you are interested in how the sky appears from another earth position, then enter a latitude other than your own. You will be able to change the latitude figure again later if you wish.

```
              SELECTION MENU
    Use SPACE to move down the list,
    and ENTER to make your choice:
                   MENU
           Select Constellations
               Review  Group1
               Review  Group2
               Review  Group3
               Test on Group1
               Test on Group2
               Test on Group3
               Combined Test
           Change the Latitude
              Progress Report
             Finish the Module
      Latitude now set to 52° North
```

When you have given your latitude, a selection menu will appear on the screen. You will see that you have five basic choices; to request a particular constellation; to review one of the constellation groups; to test yourself; to change your latitude or to see a report on your progress. We suggest that you take a look through Group 1 constellations first, and if you feel confident about being able to recognise them, try your hand at the test.

5.3 Review Process

In which ever group you select, those constellations visible from your chosen latitude will be shown one at a time. First, those stars which form the characteristic shape will be shown, then all of the other stars in the constellation, next the key stars of the adjoining constellations will be added and finally all of the background stars. With the display, you will also be given the RA, Dec, and month of the year when it reaches its highest point in the sky at midnight, local time. If it is circumpolar at your latitude, this will also be noted.

5.4 Testing Yourself

You can have a test on any one of the three groups, or on all three groups together. When you make your selection, you will be asked what type of display you want. The display can show any of the four forms used in the review process explained above; that is, key stars of the constellation only; all stars of the constellation; key adjacent stars; or all adjacent stars as well. You will probably find that the fourth option is the most difficult, although that will depend on the particular constellation you are viewing.

All you have to do when each screen is shown is to enter the three letter code of the constellation displayed. You will be warned if the exact combination of upper and lower case letters is not used. The constellations in each group, and the code of each are shown in the following tables.

GROUP 1 CONSTELLATIONS

Andromeda	And	Aquila	Aql	Auriga	Aur
Canis Major	CMa	Carina	Car	Cassiopeia	Cas
Centaurus	Cen	Crux	Cru	Cygnus	Cyg
Gemini	Gem	Leo	Leo	Lyra	Lyr
Orion	Ori	Pegasus	Peg	Perseus	Per
Scorpius	Sco	Taurus	Tau	Ursa Major	UMa
Vela	Vel				

GROUP 2 CONSTELLATIONS

Aquarius	Aqr	Ara	Ara	Aries	Ari
Bootes	Boo	Capricornus	Cap	Cephus	Cep
Cetus	Cet	Corona Borealis	CrB	Corvus	Crv
Draco	Dra	Grus	Gru	Hydra	Hya
Lepus	Lep	Musca	Mus	Puppis	Pup
Saggittarius	Sgr	Triangulum Australe	TrA	Ursa Minor	UMi
Virgo	Vir				

GROUP 3 CONSTELLATIONS

Antila	Ant	Cancer	Cnc	Canis Minor	CMi
Corona Australis	CrA	Delphinius	Del	Dorado	Dor
Eridanus	Eri	Hercules	Her	Hydrus	Hyi
Libra	Lib	Lupus	Lup	Ophiuchus	Oph
Pavo	Pav	Phoenix	Phe	Pisces	Psc
Pisces Austrinus	PsA	Sagitta	Sge	Serpens	Ser
Triangulum	Tri				

6. Stellar Signposts

(Applications Programs Required)

6.1 Calculating the Overhead Position

Before we start to survey the sky in detail, it is useful to make an estimate of what part of the sky should currently be visible. We have learnt of the stellar grid co-ordinate system involving RA (right ascension) and Dec (declination). Now let us calculate the co-ordinates for the part of the sky overhead.

For most observation points, there is no tidy way of visualising the stellar grid because of the geometric relationship between our globe and the celestial sphere. It tends to run through the sky in curves at strange angles which are dependent upon our latitude. The only positions from which the relationship is simplified are the poles and the equator.

However, one line and five points in the sky can be determined with reasonable accuracy from most points on the earth. These are: the line passing from north to south directly over our heads, known as the **CELESTIAL MERIDIAN**; the co-ordinates of the horizon due north, south, east and west of our position; and the location of the nearer celestial pole.

The point directly overhead is called the **ZENITH**, and has a declination equal to your latitude. A close approximation of the RA of the Celestial Meridan can be quickly calculated as follows:

1) Calculate the RA for midnight on the 21st of the month by multiplying the month number by 2, and adding 6; if the result is more than 24, then just take 24 away. This works because the line of zero RA is at the zenith at midnight on month 9 (September), and reaches the zenith 2 hours earlier each month.
   e.g.:

   For May: $(5 \times 2) + 6 = 10 + 6 = 16$ hours.

   For November: $(11 \times 2) + 6 = 22 + 6 = 28$ hours;
   subtracting 24 gives 4 hours.

2) Adjust for the day of the month by adding 4 minutes for each day after the 21st, or subtracting 4 minutes for each day before the 21st of the month. This adjustment of 4 minutes per day totals to 2 hours over 30 days, based upon the principal of step (1). e.g.:

   Midnight on the 29th July: $(7 \times 2) + 6 = 20$ hours;
   Add 4 minutes for each day after 21st = $(4 \times 8) = 32$ minutes;
   Final result is; 20 hours 32 minutes.
   Midnight on the 9th January: $(1 \times 2) + 6 = 8$ hours;
   Take 4 minutes for each day before 21st = $-(4 \times 12) = -48$ minutes;
   Final result is; 7 hours 12 minutes.

3) Adjust for the time of day by adding 1 minute for each minute after midnight, or subtracting one minute for each minute before midnight. e.g.:

> 8.30 pm on the 27th August:
> $(8 \times 2) + 6 = 22$ hours:
> plus $(4 \times 6) = 24$ minutes:
> minus the time from 8.30 pm to midnight = 3 hours 30 minutes:
> = 22 h + 0 h 24 m − 3 h 30 m = 18 hours 54 minutes.
>
> 2.15 am on the 3rd December:
> Note that the calculation starts from midnight on the 2nd.
> $(12 \times 2) + 6 - 24 = 6$ hours:
> minus $(4 \times 19) = 1$ hour 16 minutes:
> plus 2 hours 15 minutes:
> = 6 h 0 m − 1 h 16 m + 2 h 15 m = 6 hours 59 minutes.

This entire calculation is quite simple, because you only need to know your local time to perform it. You must take some care, because your true local time may not be quite the same as the time-zone time. In particular, many time zones are quite large, and a further error can be brought about by the introduction of summer time. Check the true local time in the following way:

1) Find out your longitude

2) Multiply your longitude by 4.

3) If you are west of Greenwich, then this is the number of minutes you are behind GMT, whilst if you are east, this is the number of minutes you are ahead.

4) Find out how your local time zone compares with GMT, and if this is the same as you calculated in (3), you can use the time on your watch or clock to do the calculations.

5) If there is a large difference, then you should work out a correction factor to apply to your 'official' time.

6.2 Horizon and Pole

The calculation for finding the Dec of the north and south horizon has already been indirectly demonstrated in Chapter 3 when we calculated which stars never rise and which never set. If you remember, you subtract your latitude from 90 to give the Dec of stars that never rise or never set. This is also the Dec of north and south points on the horizon, positive in the north and negative in the south. e.g.;

> For latitude 57°N, the Dec of the north point is $+(90-57) = +33°$, and the Dec of the south point is $-(90-57) = -33°$.

East and west is far simpler; the Dec of east and west points on the horizon is zero.

Finally, we must calculate the RA of the north, south, east and west points. The horizon point opposite the pole (i.e. southern horizon in the northern hemisphere and northern horizon in the south) has the same RA as your zenith already calculated. The horizon below the pole is directly opposite this point. Therefore, simply add or subtract 12 hours from the zenith respectively.

Now, the co-ordinates of all of these points have been determined, simply by knowing the time and your latitude. In summary, if your latitude is expressed as 'L', and the RA of the zenith, calculated by the process shown in 6.1 is 'Z', the compass points of the horizon have the following co-ordinates:

		RA	**Dec**
In the Northern Hemisphere:			
	North	Z+12	90−L
	South	Z	L−90
	East	Z+6	0
	West	Z−6	0
In the Southern Hemisphere:			
	North	Z	90−L
	South	Z+12	L−90
	East	Z+6	0
	West	Z−6	0

6.3 The Whole Sky

The next four sections provide a description of the way the night sky appears during the different seasons. The simplest way to develop your recognition skills is to read through the section closest to the present time of year, and then try to relate the view of the sky to the description. You can look at the sky, either by going outside, or by running the Applications Program, which has the added advantage of being able to present the view at other times of year and from other places.

If you intend to use the Applications Program, then we recommend that you stop working on this section, turn to Chapter 7 and familiarise yourself with it. When you feel familiar with it, return here and attempt to relate these descriptions to what you can produce with the program.

In all of the following descriptions, the constellation and technical star name abbreviations are given in brackets. If the abbreviation includes a Greek letter, it must be a star name; otherwise it is a constellation name,

6.4 The Spring Sky

At midnight on the 21st March, the RA of the zenith will be 12 hours precisely. The east and west horizons will have RA's of 18 hours and 6 hours respectively. If you are in the northern hemisphere, look northward, and up at an angle equal to your latitude, where you should find Polaris (α UMi). The rest of Ursa Minor (UMi) runs upward and to the right. Observers north of latitude 35° should be able to find the 'W' of Cassiopeia (Cas) between Polaris and the northern horizon. Higher in the sky Ursa Major (UMa), the Great Bear will be clearly visible. If we take an imaginary walk towards the south, whilst looking straight up, starting at around 60°N, where we can see UMa, then the next significant feature we will see will be Leo (Leo), just to the west at 20°N, with Virgo (Vir) slightly to the east at 0°. The brightest star in Virgo, Spica (α Vir), is the farthest to the east.

Just to the south of the equator, there is a tract of relatively barren sky, although the small square of Corvus (Crv) may be seen. Further to the south there is a very bright region. Find the southern celestial pole by looking south and up at an angle equal to your latitude. There is no signigicant star to mark the pole, which is in the obscure constellation of Octans (Oct). About 30° higher in the sky will be the brilliant constellation, Crux (Cru), the Southern Cross. This is clearly identified because the four principal stars are very bright and very close together. The longer axis of Crux points back towards the south pole. Crux is almost surrounded by the very much larger constellation of Centaurus (Cen), which contains many bright stars. These constellations are visible to observers up to 30° north of the equator at this time of year.

6.5 The Summer Sky

At midnight on 21st June, the RA of the zenith is 18 hours, with 12 hours on the western horizon and 0 hours on the eastern horizon. In the northern hemisphere, look northward, and up at an angle equal to your latitude to find Polaris (α UMi). Ursa Minor (UMi) stretches up and to the left, whilst further over to the left is Ursa Major (UMa), pointing down towards the horizon. The constellation above Ursa Minor is Draco (Dra), not particularly prominent.

Taking a walk southward, and looking straight up in the sky, the most visible star is Vega (α Lyr), which will be directly overhead at 40°N. East of Vega lies the constellation of Cygnus (Cyg), which should be easily recognised by its characteristic 'crossform'. Continuing on our southern track, we pass under Ophiuchus (Oph) and Serpens Cauda (Ser), as we reach the equator.

Looking south from the equator reveals a number of prominent constellations. Slightly to the west of a southerly bearing and high in the sky lies the brilliant spectacle of Scorpius (Sco), with Sagittarius (Sgr) just to the east. Both can be seen from as far north as 55°N. A little south of Sagittarius is the faint, but identifiable ring of Corona Australis (CrA). Further south lies the small triangle of Ara (Ara), whilst 20° above the pole is Triangulum Australe (TrA). Immediately west of TrA, you can find Alpha Centauri (α Cen), with the rest of Centaurus (Cen) and Crux (Cru) spreading away to the west, and Vela (Vel) and Carina (Car) low in the south west (only visible from 10° south of the equator).

6.6 The Autumn Sky

At midnight on 21st September, the RA of the zenith is 0 hours, with 6 hours on the eastern horizon and 18 hours on the western horizon. In the northern hemisphere, look northward, and up at an angle equal to your latitude to find Polaris (α UMi). Ursa Minor (UMi) stretches down and to the left, whilst Ursa Major (UMa) is only visible from latitudes north of 35°N. Polaris is flanked in the east by Capella (α Aur) and in the west by Vega (α Lyr). Both of these stars are of magnitude zero, and are about half way to the horizon in their respective directions. Immediately above UMi is the characteristic shape of Cassiopeia (Cas), but looking more like an 'M' than a 'W' at this time of year.

Taking a southerly walk, looking straight up will bring us to the 'Square of Pegasus' (Peg) at 20°N. The square is easily found, but in fact the north eastern corner star is Alpheratz (α And) in Andromeda (And). Over the equator lies Pisces (Psc), a fainter zodiac constellation.

Looking south from the equator reveals a fairly bland sky with only a few prominent features. Just south of the equator, Cetus (Cet) stretches across to the east. Then further south and to the west you may see Formalhaut (α PsA), with the more distinct form of Grus (Gru) beyond. Look east from Grus to find the bright star, Achernar (α Eri), and then there is not much more to see down to the pole. If your are more than 30°S, you will see the brilliant constellations of Crux (Cru), Centaurus (Cen) and Carina (Car) close to the southern horizon.

6.7 The Winter Sky

At midnight on 21st December, the RA of the zenith is 6 hours, with 12 hours on the eastern horizon and 24 hours on the western horizon. In the northern hemisphere, look northward, and up at an angle equal to your latitude to find Polaris (α UMi). Ursa Minor (UMi) stretches down and to the right, whilst further to the right, Ursa Major (UMa) is rising in the sky. Above UMi, there is the relatively bare patch of Camelopardus (Cam), but then high in the sky for northern hemisphere observers lies zero magnitude Capella (α Aur). Capella is visible from up to 40° south of the equator.

Now, walking south and looking directly overhead, a number of brilliant constellations appear. Firstly, to the east of zenith lies Gemini (Gem); then, immediately to the west is Taurus (Tau), with its characteristic star clusters, the Hyades and Pleiades. Next, directly above the equator comes the unmistakable form of Orion (Ori). Finally, south and east of Orion you will find Canis Major (CMa), with Sirius (α CMa), the brightest star in the sky.

Looking south from the equator reveals a fairly barren area to the south west, but almost due south you will see Canopus (α Car) and Carina (Car), Puppis (Pup) and Vela (Vel) stretch across to the east. These stars can be seen from up to 30° north of the equator. Observers south of the equator will also find Crux (Cru) and Centaurus (Cen) across to the east from the south celestial pole.

7. Applications

7.1 Introduction

The **Star Watcher** Applications Program is formed of two components; a routine written in **BASIC** through which the user communicates with the Amstrad CPC464, and a machine code routine which analyses the star database and plots the visible stars on the screen. The machine code element operates very quickly, plotting a screen of stars in less than two seconds, but setting up the various parameters in accordance with the user's requests takes rather longer. Whenever the program is working on the data, a flashing 'Thinking' message will appear on the screen to confirm to you that the computer is operating normally.

Facilities are provided to plot a view of the sky from any point on the earth; to plot a series of views; to plot in real time at 1 minute intervals; to show only some stars or constellations; to find the exact co-ordinates of any point, and to produce a printout of the screen. In addition, Appendix 1 lists details of all the constellations and of almost 300 named stars. Armed with this information you will be able to examine and familiarise yourself with any part of the sky in detail.

7.2 Starting the Program

Follow the instructions in Appendix 3 to load the Applications Program. When it is ready, the computer will ask you for some initial details. These are the current time and date, the relationship between your local time and Greenwich Mean Time, and your latitude and longitude. This data will be used later if you require a 'real time' plot of the sky (refer to section 7.4). The cursor will be found waiting on the screen at the point where the date is to be typed. You can continue typing until all five questions have been answered -the cursor will automatically move to the next line as you go. The **[DELETE]** key will allow you to go back and change things, or you can continue to go forward, and the cursor will return to the top line when it reaches the end. Once all the data is correct, press **[ENTER]** and the program will continue. The computer will then load the next part of the program (taking a few minutes to do so). When loading is complete, you will be presented with a screen display divided into six areas as follows:

1) The **REAL TIME CLOCK**, which continuously displays the current time and date, based on your original data.

2) The **DATA DISPLAY**, below the date and time. This is where the computer displays the information about the current star plot, and where you define details of the next plot.

3) The **SKY WINDOW** which occupies most of the rest of the screen. This is where the stars are displayed. The window represents a view of the sky which is 90° wide and 45° high. The colour of the window changes in various situations. If a night plot is selected, the window is black. A twilight plot will produce a dark blue window, whilst a daytime plot will be in light blue with the stars shown in black to remind you that they would not actually be visible.

4) The **MESSAGE LINE** at the bottom of the screen. The various menu options available to the user can be scrolled through this space, one at a time by using the **[SPACE]** bar (it is also used to display various messages from the computer).

5) The **STATUS DISPLAY** at the top right, used to display various items of useful information.

6) The **DIRECTION INDICATORS** to the right of the screen window. The upper indicator shows the compass direction in which you are looking, and the lower one shows the angle above the horizon.

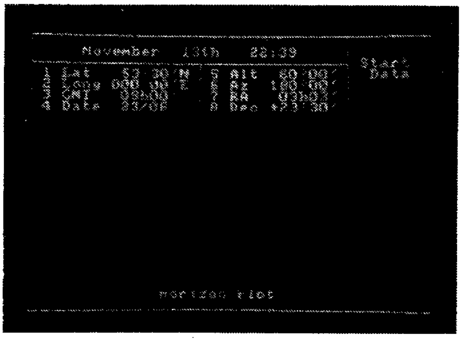
When the screen is first presented, the Data Display will contain the co-ordinates of an easily recognised part of the sky, but you must now instruct the computer to plot the view. At the bottom of the screen, the Message Line will be displaying the words '`Starting Data`'. If you press **[SPACE]** once, the line will change to '`Finishing Data`'; press it again and it will display '`Star Selection`'. Press the **[SPACE]** key a number of times, and each time the message will change, until the first message reappears - give it a try.

Use **[SPACE]** to display the message '`Horizon Plot`' (which is an abbreviation for 'plot the screen using Horizon Co-ordinates'), then press **[ENTER]** to tell the computer that this is what you want to do. The message line will now read '`Number of steps`'. Ignore this for the time being by pressing **[ENTER]** again. A new flashing message, '`Thinking`' will now appear to tell you that the computer is working on the data. Within a few seconds, a view of stars will be displayed in the Sky Window.

The view is from a point on the equator, and so the constellation of Orion will appear to be lying on its side, but the three stars of the belt should be easily recognised. Near the bottom of the screen to the right you will find the bright star of Aldebaran, surrounded by the star cluster, Hyades, in the constellation Taurus. To the left of the barren area at the top of the screen, the brightest star in the sky, Sirius, will be readily seen.

7.3 Setting Up a Fixed Display

To set up a star plot to your own parameters, use **[SPACE]** to run through the menu on the message line to find '`Starting Data`' and then press **[ENTER]**. A flashing cursor will appear on the first number in the Data Display, which is laid out like this:



The cursor can be moved forward from one figure to the next by pressing the **[SPACE]** key, or in the opposite direction using the **[DELETE]** key. In addition, you can jump it to the start of any line by pressing **[SHIFT]** and the line number at the same time. The figure at the cursor position can be changed by using the number keys, although some of the data required will be in the form of a letter (in **Lat** and **Long**) or a + or − sign (in **Dec**). When you have made all the changes, press **[ENTER]**. The computer will check the figures to make sure that they are within the permitted ranges (see the explanations below), and if it finds an error, it will return the cursor to the line containing the error and wait for you to change it. A warning message will be displayed. If they are correct, it will await your next instruction. If you are unclear about what the various lines in the Data Display are about, here is an explanation:

The first four entries set where and when you are looking from.

Lat — The Latitude of the observation point. The computer expects a figure between 00°00′ and 89° 59′, followed by N for north or S for south.

Long — The Longitude of the observation point. This should be between 00° 00′ and 180° 00′, either East or West.

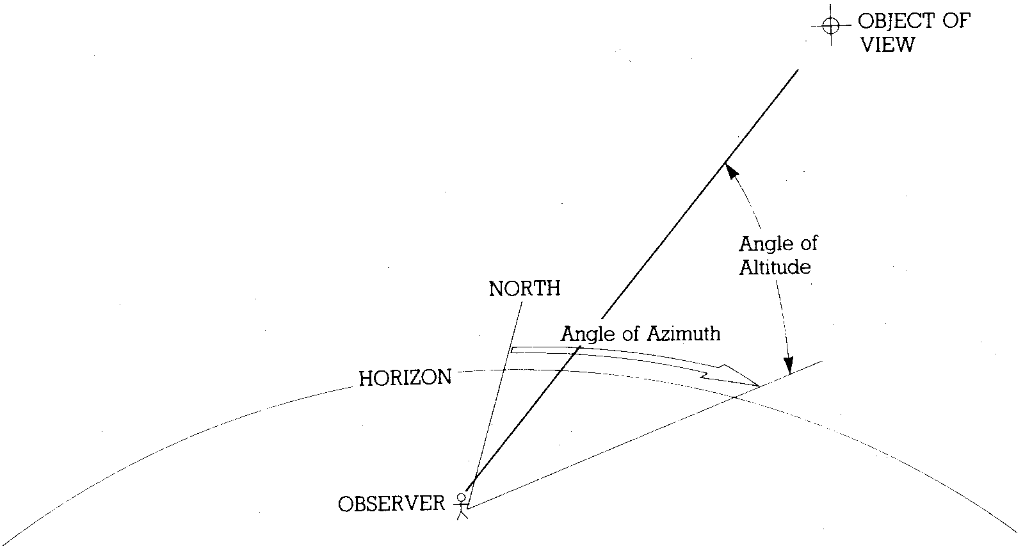
GMT — The time of the observation. This must be expressed as Greenwich Mean Time (Universal Time) in twenty four hour clock format, between 00h 00′ and 23h 59′.

Date — The date of the observation. This too must be expressed in terms of the time a Greenwich in the form date/month (both of two digits. e.g. 1st February is 01/02). The computer will test for impossible dates.

The next two entries set the direction in which you wish to look, in terms of an angle above the horizon, and a direction. If you use the '`Horizon Plot`', the computer will read these values and automatically calculate RA (Right Ascension) and Dec (Declination).

Alt — Altitude, the angle from the horizon to the centre of the screen. This tells the computer how high above the horizon you wish to look. Remember that the screen is only 45° high. Therefore, if you want the horizon at the bottom of the screen, the centre screen must be set at 23°. The computer will accept a minimum value of 23° 00′, and a maximum of 90° 00′. The Alt of the sky window currently plotted is displayed on the lower direction indicator.

Az — Azimuth, the bearing of the observation. Azimuth is measured as an angle in degrees from due north in a clockwise direction. Hence North is 000°00′, East is 090°00′, South is 180°00′, and West is 270°00′. The computer expects a value between 000°00′ and 360°00′. The Az of the sky window currently plotted is displayed on the upper direction indicator.



The last two entries set the position of the particular point on the celestial sphere that you wish to look at. These co-ordinates may be used **INSTEAD OF** the previous two (Alt and Az), not as well as them. If you select the '`Equatorial Plot`', the computer will read the RA and Dec from this table and automatically caluculate the Alt and Az. This is explained in the next section, so do not bother to set these values at all for now.

Once you have **[ENTER]**ed the data, use **[SPACE]** to move through the menu to find '`Horizon Plot`' and press **[ENTER]**. This command instructs the computer to read the position, time, date, altitude and azimuth from the Data Display; calculate the RA and Dec.; enter them in the Data Display; and finally plot the view of the stars in the sky window, and update the direction indicators. When you press **[ENTER]**, it will ask '`Number of steps`', but ignore this feature until you read section 7.6 by pressing **[ENTER]** a second time.

You should now have the view of the sky which you requested. By selecting '`Starting Data`' you can enter information to look in a different direction, from a new position or on any other time or date you wish.

7.4 Computer-Controlled Plotting

As you have scrolled through the various items on the message line, using **[SPACE]**, you will have noticed the '`Real Time Plot`' option. If you select this, by pressing **[ENTER]**, the computer will load the data for your local time and position into the Data Display, and then plot the current sky view from that location. It will continue to update that view at one minute intervals, until you press the **[ESCAPE]** key twice. Note that the Alt and Az used by the real time plot will be the ones you last inserted in the Data Display. You will see that, if your local time and date are not the same as the time and date at Greenwich, a calculation will be made to determine current GMT.

A further option available in the message window is called '`Continuous Plot`'. This behaves in the same way as the '`Real Time Plot`', but it starts from the time and place you enter in the data Display, instead of at your own time and place. This is useful for plotting a real time display from another point on the earth, or for another time or date.

7.5 Finding Stellar Features

If you want to look at a particular part of the sky, for instance a certain constellation, but you do not know in which direction it lies, look up the sky co-ordinates in an almanac, or in Appendix 1 of this text book, and insert them in the Data Display in lines 7 and 8:

RA The Right Ascension of the centre of the screen. RA is the 'longitude' of a position in the sky, and must be in the range 00h00′ to 23h59′.

Dec The Declination of the centre of the screen. Dec is the 'latitude' of a position in the sky, and must be in the range −90°00′ to +90°00′

A complete explanation of Right Ascension and Declination can be found in section 2.2 of the Teaching Program.

When you have **[ENTER]**ed this date, select '`Equatorial Plot`' instead of '`Horizon Plot`', again pressing **[ENTER]** twice to avoid the '`Number of steps`' question. This tells the computer to plot the sky using the Equatorial Co-ordinates which you have just entered. To do this, it reads the RA and Dec from the Data Display; calculates the correct Alt and Az; inserts them in the Data Display, and finally plots the star view. When the plot is completed, your selected point will be at the centre of the screen.

During this process, it is possible that one of two error messages may appear on the Message Line:

1) '`Point below Horizon`' - this means that the point in the sky which you wish to see is not visible from the nominated place and time. Press any key to return to the menu. If you particularly want to see the selected stars, you must choose a new time, date or viewing location.

2) 'Point Too Low' - this indicates that the point which you have requested is visible, but it is too close to the horizon to plot in the centre of the screen. The true Azimuth and Altitude have been entered in the Data Display, so you can use these figures to locate the feature in the real sky. Press any key, and the computer will recalculate the co-ordinates of a point directly above the chosen position, with the horizon at the bottom of the screen. You will then be able to see the point you selected, somewhere between centre screen and the horizon.

Remember that when an equatorial or horizon plot is requested, the co-ordinates shown in the Data Display are adjusted. In an equatorial plot, the RA and Dec are read from the display and the Alt and Az are recalculated. On the other hand, for a horizon plot, the Alt and Az are read and the RA and Dec are recalculated. Hence to find which direction to look in the real sky to locate a particular feature, bring that feature up on the screen using an equatorial plot and then read off the Alt and Az from the Data Display, then look into the sky in that direction.

7.6 Setting Up a Multi-Step Display

The program allows you to set up any two sets of parameters you like and move, step by step between them. You can use this is many ways. For instance, you could imagine yourself standing at a point and scanning the sky as you turn in a circle; or you could look in a fixed direction and watch how the view changes over a period of time. You could even combine changes to watch how the sky view alters as you fly in an airliner from one place to another.

To use this feature, first select 'Starting Data' and enter the data for your starting point. Next select 'Finishing Data' and use the Data Display to enter the parameters for the end point. You will notice that when you call this routine, it automatically sets the figures to be the same as the start point until you edit them. This makes it a simple matter to alter just one of the figures, such as the time or azimuth.

When both sets of figures have been **[ENTER]**ed, select 'Horizon Plot' and give the number of steps to take to move from the start to the end. Any number from 0 to 99 can be used. The computer will then move the view from one point to the other, as requested, updating the Data Display as it goes. The interval between screens of stars will be about 7 seconds.

For example, choose the view due south (Az=180), looking up at an angle of 45 degrees at 22h00m on 1st January by entering this data when you select 'Starting Data'. Next, call up 'Finishing Data' and just change the date to 1st July. Finally select 'Horizon Plot' and key in **6 [ENTER]** when asked 'Number of Steps'.This will plot the southerly sky view at monthly intervals for a six month period.

7.7 Choosing Particular Stars

To make it possible to study constellations in isolation, or to look at different magnitude stars, it is possible to switch the stars 'on' and 'off'. To do this, select the 'Star Selection' command. This will clear the screen and draw up a selection table (the disc version will take a short time, because it loads this screen in from the disc drive). This table lists all 88 constellations by their three letter code, plus two other codes, 'ALL' and 'MAG'. Each constellation can be switched on at either of two levels or switched off. When the program is loaded, all stars are set to the '1-on' level. The three settings are as follows:

0 (Black)	No stars in that constellation will be plotted.
1 (Blue)	Those stars of the constellation which make up its characteristic shape will be plotted, but not the 'background' stars.
2 (Red)	All of the stars in that constellation will be plotted.

There is a cursor which initially appears at the top left of the table. This can be moved around the table using the arrow keys. To change the setting of any constellation, simply move the cursor over it and press a 0,1 or 2 key. To change the setting of all the constellations at once, place the cursor over ALL and press 0,1 or 2. This is useful if you just want one constellation turned on. First turn all of them off, and then move to the required constellation and turn it on. The constellation names and their three letter codes are all included in Appendix 1.

The next selection feature is the 'MAG' code at the bottom right of the screen. Move the cursor over this and press 0,1 or 2 as if it were a constellation. Instead of turning it on or off, this generates the message 'Minimum Magnitude?' at the bottom of the screen. The database contains stars down to around magnitude 5.5. (Remember, the larger the number, the dimmer the star). The number which you enter in response to this question is the lowest magnitude star which you would like plotted. e.g. if '3' is entered, no star dimmer than magnitude 3 will be plotted. This selection will work in conjunction with all other plotting instructions. When you have keyed in your chosen number, press **[ENTER]** to return to the table.

Once the selection process has been completed, press **[ENTER]** again to return to the normal screen. One final selection feature remains; as you return to the main screen, the computer checks the position of the cursor on the constellation table. It then automatically enters the RA and Dec of that constellation in the Data Display. If you want that constellation plotted, just call up 'Equatorial Plot', and if it is visible from your position, it will plot at centre screen, together with its name to remind you of the one you selected.

This 'switching' facility does create one risk; it is possible that the sky area which you instruct to be plotted contains no 'switched on' stars. To tell you that this problem has occurred, the computer will display the message 'NO STARS PLOTTED'. You should check whether you have set the Data Display correctly. Perhaps you plotted by horizon instead of equatorial co-ordinates. You can also use 'Complete View' (see 7.9) to overrule the 'switching' and display the view.

The different magnitude groups can be identified on the screen to some extent. Stars plotted as a single point are less than magnitude 3.25; the next larger plots are up to magnitude 1.5, and the largest size are over magnitude 1.5

If you simply want to know what various constellations look like, you may find it easier to use the 'Constellation Selection' unit of the Teaching Program.

7.8 Using the Cursor

When a screen of stars has been plotted, you can generate a small cross-hair cursor by selecting the 'Cursor Mode' command. The cross-hairs will appear at the centre of the screen. Move it about by using the arrow keys. Pressing **[SHIFT]** and an arrow key together will mover it to the edge of the screen in the arrow's direction, whilst pressing **[COPY]** will move it back to centre screen.

When the cursor has been moved to a new position, press **[ENTER]**, and the computer will replot the sky with the new cursor position at the centre of the screen. Before it does this, it will recalculate the figures on the right hand side of the Data Display. Pressing **[ENTER]** is the only way to escape from the cursor routine, and so if you do not want to change the screen picture, be sure to move the cursor back to centre screen before you press **[ENTER]**.

7.9 Filling in the Screen

Once a screen of stars has been displayed, it is possible to plots all other visible stars which are brighter than the currently selected magnitude, regardless of the way the individual constellations have been switched. For instance, if you switch all off except Scorpius, you can plot Scorpius on its own, and when it is displayed, you can fill in all the stars around it by selecting 'Complete View'. This can also be used to add the second level stars to a constellation if it has been plotted with main stars only.

To reverse the process, select either 'Horizon Plot' or 'Equatorial Plot' and **[ENTER]** the screen again without changing the Data Display.

7.10 Hard Copy Printouts

To produce a hard copy of the current screen display on your Amstrad DMP1 printer, select 'Copy to Printer' on the menu. Remember, to select a feature on the menu, use **[SPACE]** to run through the options and then press **[ENTER]** to activate it.

WARNING - do not select this option unless you have a printer connected and turned on, or the program will simply stop.

SUMMARY OF COMMANDS

Complete View -	Replots the current view with all constellations turned to mode '2', subject to the limiting magnitude currently set.
Continuous Plot -	Plots views of the sky at 1 minute intervals, starting from the time and place entered in the **Data Display**.
Copy to Printer -	Copies the current screen to an Amstrad DMP1 printer.
Cursor Mode -	Selects cross-hair cursor, and replots the view to centre on cursor position when **[ENTER]** is pressed.
Equatorial Plot -	Plots screen using **RA** and **Dec** from the **Data Display**.
Finishing Data -	Edit **Data Display** for final plot in a multi step view.
Horizon Plot -	Plots screen using **Alt** and **Az** from the **Data Display**.
Real Time Plot -	Plots the current view of the sky from your latitude and longitude, updated at 1 minute real time intervals.
Star Selection -	Presents a menu to select constellations and the minimum magnitude stars to be used.
Starting Data -	Edit **Data Display** for next screen plot.

7.11 Accuracy

The accuracy of the screen plot is limited by the size of the individual pixels (or points on the screen) that the computer can define. This limits accuracy to around plus or minus half a degree in most cases. The actual equations used to plot the stars are fairly straightforward, but it is a complex task to implement them in machine code. They are listed in Appendix 2 for your interest.

APPENDIX 1
Catalogue of Constellations

NOTES:

1) The constellations are listed in alphabetical order, with the standard three letter code shown on the right hnd side. The original 48 constellations listed by Ptolemy are marked by an asterisk (*). The approximate RA and Declination of the centre of each constellation is also shown.

2) All stars included in the Applications Program database are listed by their constellation, using their Bayer letter, or Flamsteed number. Those stars which have niether are identified by the 'Yale Bright Star Catalog' number, and are marked - ′ -.

3) Within each constellation, the stars are listed in order of right ascension.

4) The stars marked in bold type are those which form the characteristic shape of the constellation, and can be called up separately by the Applications Program.

ANDROMEDA * RA = 1h, Dec = + 35° And
ο λ ι κ ψ **α** 22 σ ϱ R π 157′ ε **δ** ζ **ν μ** η φ **β** ξ ω υ 51 **γ**^{1} 645′ 62

ANTLIA RA = 10h 30m, Dec = −32° Ant
ε θ η 4086′ **α ι**

APUS RA = 16h, Dec = −79° Aps
θ **α** κ^1 **δ**^{1} **λ β** ι

AQUARIUS * RA = 22h 30m, Dec = −8° Aqr
ε 3 μ **ν** 18 **β** ξ **α** ι θ 47 **γ** π **ζ**^{1} **ζ**^{2} σ υ **η** κ 68 τ **λ δ** 86 **88** φ **ψ**^{1} **ψ**^{2} **ψ**^{3} **98** 99 8924′ ω^2 106

AQUILA * RA = 19h 30m, Dec = 0° Aql
ε 12 **ζ λ** 20 ω 31 **δ** 36 μ **ι** κ **γ α η** 7575′ **β θ ϱ** 69 71

ARA * RA = 17h, Dec = −52° Ara
η ζ ε^1 **β γ** δ **α** μ **θ**

ARIES * RA = 2h 30m, Dec = +20° Ari
β α ν 35 41 σ **δ** ζ 999′ **τ**

AURIGA * RA = 5h 30m, Dec = +40° Aur
ι ε ζ η μ **α** λ χ ο ν ξ δ **β θ** π κ ψ^1 ψ^5 ψ^6 63 66

BOOTES * RA = 14h 30m, Dec = +30° Boo
τ υ **η** 5270′ 5299′d **α** ι λ 5361′ 18 θ 22 **ϱ γ σ** 33 ζ **(5477′)** ζ **(5478′)** 34 **ε β** ψ
45 δ μ^1 ν^1 φ

CAELUM RA = 4h 30m, Dec = −37° — Cae
δ α β

CAMELOPARDUS RA = 6h, Dec = + 70° — Cam
1009′ 1035′ 1040′ 1105′ 1155′ γ 1270′ 1327′ 1 4 α 7 β 1686′36 2209′
2401′ 43 2527′ 3075′ 4084′

CANCER * RA = 8h 30m, Dec = +20° — Cnc
β χ η γ δ ι α σ^3 κ ξ

CANES VENATICI RA = 13h, Dec = +40° — CVn
3 6 4783′ β Y α^2 14 20 5110′

CANIS MAJOR * RA = 7h, Dec = −25° — CMa
ζ β 2305′ λ ξ^1 2392′ ξ^2 ν^2 ν^3 α κ θ ο^1 ι ε σ ο^2 γ δ 27 ω τ η

CANIS MINOR * RA = 7h 30m, Dec = +5° — CMi
β γ 6 α 11 ζ

CAPRICORNUS * RA = 21h, Dec = −20° — Cap
α^1 α^2 β υ ψ ω 20 θ 24 8110′ ι ζ 36 γ δ μ

CARINA * **(Part of Ptolemy's "ARGO NAVIS")** RA = 8h, Dec = −58° — Car
α 2435′ 2513′ 2554′ 2683′ 2934′ χ 3153′ ε 3457′ 3498′ 3571′ 3582′
3643′ a 3663′ β 3696′ ι 3821′ R 3825′ 1 υ ω 4050′ 4102′ 4114′ 4140′
4159′ θ η 4257′ 4337′

CASSIOPEIA * RA = 1h, Dec = +60° — Cas
8752′4 9013′ ρ β κ ζ α ο η 233′ γ μ θ φ δ ψ 40 ε 50 ι 743′

CENTAURUS * RA = 13h 30m, Dec = −50° — Cen
4350′ π λ 4466′ 4511′ 4522′ 4537′ 4546′ 4600′ 4618′ δ ρ σ 4748′
τ γ 4874′ 4888′ 4889′ ξ^2 5006′ ι 5035′ 5089′ ε 5134′ 1 5171′ 2 ν μ ζ
5241′ φ υ^1 υ^2 β χ θ 5358′ ψ 5378′ η α^1 α^2 5471′ 5485′ 5558′ κ

CEPHEUS * RA = 22h, Dec = +70° — Cep
α β 9 11 μ ν 13 ξ 20 19 24 ζ λ ε 8546′ δ 31 30 ι 8748′ π 8952′ γ

CETUS * RA = 1h 30m, Dec = −78° — Cet
2 7 ι 118′ β φ^2 20 η θ 48 500′ τ 513′ χ ζ υ ξ^1 67 ο ρ ξ^2 σ ν 753′ δ γ π μ λ α 94 κ

CHAMAELEON RA = 10h 30m, Dec = −78° — Cha
α θ η γ δ^2 β

CIRCINUS RA = 14h 30m, Dec = −65° — Cir
α β γ

COLUMBA RA = 6h, Dec = −35° — Col
ο ε α β γ η κ δ

COMA BERENICES RA = 13h, Dec = +22° **Com**
12 γ 23 24 31 β

CORONA AUSTRALIS * RA = 19h, Dec = −40° **CrA**
θ η^1 γ α β

CORONA BOREALIS * RA = 15h 30m, Dec = +30° **CrB**
β θ α γ δ κ ε T τ

CORVUS * RA = 12h 30m, Dec = −20° **Crv**
α ε γ δ η β

CRATER * RA = 11h 30m, Dec = −15° **Crt**
α β δ γ θ ζ η

CRUX AUSTRALIS RA = 12h 30m, Dec = −60° **Cru**
θ^1 η δ ζ ε α^1 α^2 γ β μ^1

CYGNUS * RA = 20h 30m, Dec = +40° **Cyg**
κ ι β 8 θ 7495′ 16 (7503′) 16(7504′) 15 δ χ 7589′ η 28 33 o^1 o^2 P γ 39 41 49
α 52 ε λ 55 8023′ ν 59 ξ 61(8085′) 61 (8086′) ζ τ σ υ 69 71 ρ 74 75 π^2

DELPHINUS * RA = 20h 30m, Dec = +10° **Del**
ε β κ α δ γ^2

DORADO RA = 5h, Dec = −60° **Dor**
γ α R ζ θ β δ ν

DRACO * RA = 17h, Dec = +65° **Dra**
3751′ 4126′ λ 3 4646′ κ 8 10 α 5552′ 5589′ ι 5886′ 5960′ θ η 15
6237′ ζ β ν^1 ν^2 27 ω ψ 35 ξ γ 36 φ χ 39 50 ο υ δ τ σ ε 73

EQUULEUS * RA = 21h, Dec = +5° **Equ**
γ δ α

ERIDANUS * RA = 4h, Dec = −30° **Eri**
α χ φ κ ι τ^1 τ^2 η 875′ θ^1 θ^2 τ^3 ζ τ^4 1008′ 17 ε τ^5 20 1106′ δ 24 π τ^6 1195′ γ 35
o^1 o^2 41 1367′ ξ 43 υ^1 υ^2 ν 53 54 μ ω β λ

FORNAX RA = 3h, Dec = −30° **For**
ν μ κ β α δ

GEMINI * RA = 7h, Dec = +25° **Gem**
1 η μ ν γ ε 30 ξ θ ω ζ τ 48 51 λ δ ι ρ α (2890′) α (2891′) υ σ κ β 81 π φ χ

GRUS RA = 22h 30m, Dec = −45° **Gru**
γ λ α ν δ^1 δ^2 β ε 8685′ ζ θ ι

HERCULES * RA = 17h, Dec = +30° **Her**
χ κ φ τ γ ω β σ 42 ζ η 51 53 ε 59 60 α^1 δ π 6452′ 72 λ ι 84 μ 89 θ ξ ν 93 ο 6791′
102 109 110 111

HOROLOGIUM RA = 3h 30m, Dec = −50° Hor
λ ζ R μ 977′ **α**

HYDRA * RA = 11h 30m, Dec = −15° Hya
3314′ **δ σ 6 η** 12 **ε ρ** 14 **ζ θ α** 3808′ 3834′ ι κ **υ**^{1} 3923′ υ^2 λ **μ** 44 **ν χ**^{1} ξ ο
4532′ **β γ** 47 π 52 56 **58**

HYDRUS RA = 2h 30m, Dec = −70° Hyi
β λ η^2 **α δ** κ μ ε θ γ

INDUS RA = 21h, Dec = −60° Ind
α η **β** θ ο δ ε

LACERTA RA = 22h 30m, Dec = +45° Lac
8485′ **1** β **5 6 α** 10 8626′ 11 13 8726′

LEO * RA = 11h, Dec = +45° Leo
κ λ ξ **ο** ψ ε R **μ** π **η** 31 **α** ζ **γ**^{1} **γ**^{2} **ρ** 51 53 54 58 60 χ **δ θ** φ **σ ι τ** υ 93 **β** 95

LEO MINOR RA = 10h, Dec = +35° LMi
10 19 20 **21 β** 37 41 42 **46**

LEPUS * RA = 5h 30m, Dec = −20° Lep
ε ι μ κ λ β α γ ζ δ η 17 2180′

LIBRA * RA = 15h 30m, Dec = −15° Lib
5390′ **α**^{1} **α**^{2} ξ^2 16 δ σ ι **β** 37 γ υ τ κ λ θ 48 49

LUPUS * RA = 15h, Dec = −40° Lup
ι τ^1 τ^2 σ ρ **α** 5495′ ο **β λ κ** ζ 1 2 **μ δ φ**^{1} ε **φ**^{2} **γ** 5784′ ω **χ η** θ

LYNX RA = 8h, Dec = +50° Lyn
2 15 24 2999′ 27 **31** 34 3579′ 3612′ 36 **38 α**

LYRA * RA = 19h, Dec = +35° Lyr
κ **α ζ**^{1} 7064′ **β δ**^{2} **R** γ ι η θ

MENSA RA = 6h, Dec = −75° Men
η γ **α**

MICROSCOPIUM RA = 21h, Dec = −35° Mic
ι γ ζ ε θ^1

MONOCEROS RA = 7h, Dec = 0° Mon
γ 7 8 10 13 2395′ 15 18 2534′ 20 δ 25 **α** 27 ζ

MUSCA RA = 12h 30m, Dec = −70° Mus
λ ε γ **α β δ** η

NORMA RA = 16h, Dec = −50° Nor
5798′ **δ κ γ**^{2} **ε**

OCTANS RA = 21h, Dec = −85° Oct
θ ζ ι δ χ σ α ν ε β τ

OPHIUCHUS * RA = 17h, Dec = 0° Oph
δ ε ψ χ λ φ ω ζ 6196′ 20 ι κ 30 η ξ θ 44 σ 6493′ 45 α 58 β γ ν 67 68 70 72 74 6985′

ORION * RA = 5h 30m, Dec = 0° Ori
$\pi^3 \pi^2 \pi^4 o^1 \pi^5 o^2 \pi^6$ 11 16 ϱ β τ 22 29 η γ 32 δ (1852′) δ (1851′) ϕ^1 λ 1890′
1891′ ι ε ϕ^2 σ ζ (1948′) ζ (1949′) κ χ^1 α 60 μ χ^2 ν ξ 74

PAVO RA = 20h, Dec = −65° Pav
η π ξ ζ λ κ ε δ α β ο γ

PEGASUS * RA = 23h, Dec = +20° Peg
1 2 5 ε 9 κ 14 16 ι π θ 31 38 ζ η λ ξ μ β α 55 59 τ υ 70 φ 82 ψ γ χ

PERSEUS * RA = 3h 30m, Dec = +40° Per
φ 4 641′ 14 θ η 16 τ 24 γ ϱ β ι κ 29 α 1029′ σ ψ δ ο ν ζ ε ξ λ 48 μ 54 58 1533′

PHOENIX RA = 1h, Dec = −50° Phe
ι 8959′ ε κ α λ^1 μ η β υ ζ γ δ ψ φ

PICTOR RA = 6h, Dec = −50° Pic
η^2 ζ 1856′ β γ 2049′ δ α

PISCES * RA = 0h 30m, Dec = +15° Psc
β γ κ θ ι λ 20 27 ω 30 33 41 δ 64 ε χ τ ζ 89 υ 94 η ν ο ξ α

PISCES AUSTRINUS * RA = 22h 30m, Dec = −30° PsA
ι μ λ β ε γ δ α 8732′ π

PUPPIS * **(Part of Ptolemy's "ARGO NAVIS")** RA = 7h 30m, Dec = −35° Pup
ν 2518′ τ 2591′ 2666′ 2740′ 2748′ π σ 2906′ 2937′ 2948′ R 3 3017′ 4
3037′ ο ξ 3055′ 3080′ 3084′ 3090′ 11 3113′ V 3131′ ζ ϱ 16 3225′
20 3243′ 3270′ 3282′

PYXIS RA = 9h, Dec = −30° Pyx
3315′ β α γ θ

RETICULUM RA = 4h, Dec = −60° Ret
κ β δ α ε η

SAGITTA * RA = 19h 30m, Dec = +15° Sge
α β δ 9 γ

SAGITTARIUS * RA = 19h, Dec = −30° Sgr
X W γ μ η δ ε λ φ σ ξ^2 ζ ο τ π 43 ϱ^1 υ β^1 β^2 α 52 54 55 56 7552′ ι 61 θ^1 62

SCORPIUS * RA = 17h, Dec = −30° Sco
ϱ π δ ζ β^1 β^2 ω^1 ω^2 ν 6077′ σ α 6143′ τ 6166′ ε μ^1 μ^2 ζ^2 η υ λ 6546′ θ κ ι^1 6630′

SCULPTOR RA = Oh 30m, −30° Scl
γ β μ δ θ α π ε

SCUTUM RA = 18h 30m, Dec = −10° Sct
γ α δ ε β R

SERPENS * Ser
- Serpens Caput; RA = 15h 30m, Dec = +10°
3 τ^1 δ α β λ κ μ ε γ σ
- Serpens Cauda; RA = 18h, Dec = −5°
ν ξ ο η 60 θ^1

SEXTANS RA = 10h, Dec = −5° Sex
α ε δ

TAURUS * RA = 4h 30m, Dec = +20° Tau
ο ξ 5 10 17 19 29 20 23 η 27 λ ν 37 1279′ 43 44 μ 48 γ 57 δ 63 κ 68 υ 71 θ^1 ε θ^2 ϱ
88 α 90 τ 97 ι β 115 119 ζ 130 136

TELSCOPIUM RA = 19h, Dec = −50° Tel
ε 6819′ α ζ λ ι ν ξ

TRIANGULUM * RA = 2h, Dec = +30° Tri
490′ α β γ 12 14

TRIANGULUM AUSTRALE RA = 16h, Dec = −65° TrA
γ ε β δ ζ α

TUCANA RA = Oh, Dec = −65° Tuc
α δ γ ε ζ β^1 λ^2 ι κ

URSA MAJOR * RA = 11h, Dec = +55° UMa
3182′ ο ι ϱ κ 15 σ^2 23 θ 24 26 3881′ υ λ μ 4072′ 36 37 4181′ 4191′
47 β α ψ ξ ν 55 61 χ γ δ 74 ε 78 ζ (5054′) ζ (5055′) 80 5085′ η

URSA MINOR * RA = 15h, Dec = +80° UMi
α 4 5 β 5691′ γ ζ 19 η ε δ

VELA * (Part of Ptolemy's "ARGO NAVIS") RA = 9h 30m, Dec = −50° Vel
γ^1 γ^2 3426′ ο 3445′ 3477′ δ 3487′ 3591′ 3614′ λ κ ψ N 3836′ φ
4023′ 4074′ 4080′ 4143′ 4167′ 4180′ μ 4293′

VIRGO * RA = 13h 30m, Dec = −5° Vir
ν β π ο η 16 χ υ (4825′) γ (4826′) γ (4828′) ϱ d^2 ψ δ ε θ σ 61 α 68 70 78 ζ
82 89 τ κ ι λ 5392′ φ μ 109 110

VOLANS RA = 8h, Dec = −70° Vol
ι γ^1 γ^2 δ ζ ε β α

VULPECULA RA = 20h, Dec = +25° Vul
α 10 15 24 29 32 33

SOME CONSTELLATION NAMES IN ENGLISH

(The Zodiac Constellations are in bold print)

Air Pump	Antlia	Keel	Carina
Altar	Ara	Lesser Bear	Ursa Minor
Arrow	Sagitta	Lesser Dog	Canis Minor
Archer	**Sagittarius**	**Lion**	**Leo**
Bee	Apus	Lion Cub	Leo Minor
Berenice's Hair	Coma Berenices	Lizard	Lacerta
Bull	**Taurus**	Mariner's Compass	Pyxis
Centaur	Centaurus	Microscope	Microscopium
Charioteer	Auriga	Net	Reticulum
Clock	Horologium	Northern Crown	Corona Borealis
Compasses	Circinus	Painter	Pictor
Crab	**Cancer**	Peacock	Pavo
Crane	Grus	Poop	Puppis
Crow	Corvus	**Ram**	**Aries**
Cup	Crater	River	Eridanus
Dolphin	Delphinus	Sails	Vela
Dove	Columba	**Scales**	**Libra**
Dragon	Draco	**Scorpion**	**Scorpius**
Eagle	Aquila	Sculptor's Chisel	Caelum
Fish	**Pisces**	Shield	Scutum
Fly	Musca	Snake	Hydrus
Flying Fish	Volans	Southern Cross	Crux Australis
Foal	Equuleus	Southern Crown	Corona Australis
Fox	Vulpecula	Swan	Cygnus
Furnace	Fornax	Swordfish	Dorado
Giraffe	Camelopardus	Table	Mensa
Goat	**Capricornus**	**Twins**	**Gemini**
Great Bear	Ursa Major	Unicorn	Monoceros
Great Dog	Canis Major	**Virgin**	**Virgo**
Hare	Lepus	**Water Bearer**	**Aquarius**
Herdsman	Bootes	Watersnake	Hydra
Hunter	Orion	Whale	Cetus
Hunting Dogs	Canes Venatici	Wolf	Lupus
Indian	Indus		

BRIGHTEST NAMES STARS

Popular Name	Apparent Magnitude	Spectral Type	Technical Name	Co-ordinates RA	Dec
Acamar	2.91	A5	θ^1 Eridani	02h 58m	-40° 22′
- Double Star	4.42	A1	θ^2 Eridani	02h 58m	-40° 22′
Achernar	0.51	B3	α Eridani	01h 37m	-57° 19′
Achird	3.44	G0	η Cassiopeiae	00h 49m	57° 49′
Acrux	1.58	B0.5	α^1 Crucis Australi	12h 26m	-63° 00′
- Double Star	2.09	B1	α^2 Crucis Australi	12h 26m	-63° 00′
Acubens	4.25	A3	α Cancri	08h 58m	11° 51′
Adhafera	3.44	F0	ζ Leonis	10h 17m	23° 25′
Adhara	1.48	B2	ε Canis Majoris	06h 58m	-28° 57′
Agena	0.63	B1	β Centauri	14h 02m	-60° 18′
Ain	3.54	K0	ε Tauri	04h 29m	19° 11′
Aladfar	4.39	B2	η Lyrae	19h 14m	39° 09′
Alamak	2.14	K3	γ^1 Andromedae	02h 02m	42° 14′
Al Azah - please refer to Azha					
Albaldah	2.89	F2	π Sagittarii	19h 09m	-21° 03′
Albali	3.77	A1	ε Aquarii	20h 48m	-09° 30′
Albireo	3.07	K3	β Cygni	19h 30m	27° 55′
Alcor	4.01	A5	80 Ursae Majoris	13h 25m	55° 05′
Alcyone	2.86	B7	η Tauri	03h 46m	24° 03′
Al Dhanab	2.17	M5	β Gruis	22h 42m	-46° 58′
Aldebaran	0.86	K5	α Tauri	04h 35m	16° 29′
Alderamin	2.44	A7	α Cephi	21h 18m	62° 31′
Aldhibah	3.17	B6	ζ Draconis	17h 09m	65° 43′
Aldhibain	2.71	G8	η Draconis	16h 24m	61° 33′
Al Furud - please refer to Phurad					
Algeiba	1.99	K0	γ^1 Leonis	10h 19m	19° 56′
- Double Star	1.90	G7	γ^2 Leonis	10h 19m	19° 56′
Algenib	2.84	B2	λ Pegasi	00h 12m	15° 05′
Algenubi - please refer to Asad Australis					
Al Gieda	4.24	G3	α^1 Capricorni	20h 18m	-12° 31′
- Double Star	3.57	G9	α^2 Capricorni	20h 18m	-12° 33′
Algjebbah	3.36	B1	η Orionis	05h 24m	-02° 24′
Algol	2.06	B8	β Persei	03h 07m	40° 53′
Algorab - please refer to Algorel					
Algorel	2.95	B9	δ Corvi	12h 30m	-16° 31′
Alheka	3.00	B2	ζ Tauri	05h 38m	21° 09′
Alhena	1.93	A0	γ Geminorum	06h 37m	16° 25′
Alhes - please refer to Alkes					
Alifa	4.32	A3	ζ Ursae Minoris	15h 44m	77° 48′
Alioth	1.79	A0	ε Ursae Majoris	12h 53m	56° 03′
Alkaffaljidhina	3.47	A2	γ Ceti	02h 43m	03° 14′
Alkafzah	3.71	K0	χ Ursae Majoris	11h 46m	47° 47′
Alkaid	1.87	B3	η Ursae Majoris	13h 47m	49° 24′
Alkalurops	4.31	F0	μ^1 Bootis	15h 24m	37° 23′
Alkes	4.08	K0	α Crateris	11h 00m	-18° 18′
Alkhiba	4.02	F2	α Corvi	12h 08m	-24° 44′

Almaak and Almach - please refer to Alamak						
Alnair	1.76	B7	α	Gruis	22h 07m	-47° 03′
Alnasr	2.97	K0	γ	Sagittarii	18h 05m	-30° 26′
Al Nath	1.65	B7	β	Tauri	05h 25m	28° 36′
Alnilam	1.70	B0	ε	Orionis	05h 35m	-01° 13′
Alnitak	1.77	09.5	ζ	Orionis	05h 40m	-01° 57′
-Double Star	4.21	B3	ζ	Orionis	05h 40m	-01° 57′
Alniyat	2.89	B1	σ	Scorpii	16h 21m	-25° 36′
Alpha Centauri	0.33	G2	α^1	Centauri	14h 38m	-60° 46′
-Double Star	1.70	K1	α^2	Centauri	14h 38m	-60° 46′
Alphard	1.98	K3	α	Hydrae	09h 27m	-08° 35′
Alphekka	2.23	A0	α	Coronae Borealis	15h 34m	26° 46′
Alpheratz - please refer to Sirrah						
Alpherg	3.62	G8	η	Piscium	01h 31m	15° 21′
Alphirk	3.23	B2	β	Cephei	21h 29m	70° 34′
Alrai	3.21	K1	γ	Cephei	23h 39m	77° 38′
Alrakis	4.68	K0	σ	Draconis	19h 32m	69° 40′
Al Rijil - please refer to Alpha Centauri						
Al Rischa	3.79	A2	α	Piscium	02h 02m	02° 46′
Alsafi - please refer to Alrakis						
Alshain	3.71	G8	β	Aquilae	19h 54m	06° 22′
Al Suhail al Wazn	2.24	K4	λ	Velae	09h 07m	-43° 22′
Altair	0.77	A7	α	Aquilae	19h 50m	08° 49′
Al Tarf	3.52	K4	β	Cancri	08h 17m	09° 11′
Alterf	4.31	K5	λ	Leonis	09h 32m	22° 58′
Althalimain	3.44	B8.5	λ	Aquilae	19h 06m	-04° 53′
Aludra	2.46	B5	η	Canis Majoris	07h 23m	-29° 16′
Alula Australis	3.79	G0	ξ	Ursae Majoris	11h 18m	31° 32′
Alula Borealis	3.48	K3	ν	Ursae Majoris	11h 18m	33° 06′
Alwaid	2.77	G2	β	Draconis	17h 30m	52° 19′
Al Wasat - please refer to Wasat						
Alya	4.06	A5	θ^1	Serpentis	18h 55m	04° 11′
Alzirr	3.36	F5	ξ	Geminorum	06h 45m	12° 54′
Ancha	4.16	G8	θ	Aquarii	22h 17m	-07° 47′
Angetenar	3.69	M3	τ^4	Eridani	03h 20m	-21° 45′
Ankaa	2.39	K0	α	Phoenicis	00h 25m	-42° 24′
Antares	0.92	M1.5	α	Scorpii	16h 28m	-26° 24′
Arcturus	-0.06	K2	α	Bootis	14h 15m	19° 16′
Arich	2.75	F0	γ	Virginis	12h 42m	-01° 27′
Arkab	3.93	B8	β1	Sagittarii	19h 23m	-44° 28′
Arneb	2.58	F0	α	Leporis	05h 32m	-17° 50′
Asad Australis	2.99	G1	ε	Leonis	09h 45m	23° 51′
Ascella	2.61	A2	ζ	Sagittarii	19h 02m	-29° 54′
Asellus	4.05	F7	θ	Bootis	14h 25m	51° 51′
Asellus Australis	3.94	K0	δ	Cancri	08h 45m	18° 09′
Asellus Borealis	4.66	A1	γ	Cancri	08h 43m	21° 28′
Asmidiske	3.34	G3	ξ	Puppis	07h 49m	-24° 52′
Aspidiske - please refer to Tureis						
Ati	3.83	B1	ο	Persei	03h 44m	32° 17′
Atik	2.85	B1	ζ	Persei	03h 54m	31° 53′
Atlas	3.63	B8	27	Tauri	03h 49m	24° 03′

Atria	1.93	K2	α	Trianguli Australe	16h 47m	-69° 00′
Avoir	1.97	K3	ε	Carinae	08h 22m	-59° 27′
Azelfafage	4.67	B3	π^1	Cygni	21h 42m	51° 11′
Azha	3.89	K1	η	Eridani	02h 56m	-08° 53′
Baten Kaitos	3.73	K2	ζ	Ceti	01h 51m	-10° 20′
Baten Kaitos Shemali	3.56	K2	ι	Ceti	00h 19m	-08° 49′
Beid	4.04	F2	o^1	Eridani	04h 12m	-06° 50′
Bellatrix	1.64	B2	γ	Orionis	05h 24m	06° 20′
Benetnasch - please refer to Alkaid						
Betelgeuse	0.50	M2	α	Orionis	05h 54m	07° 24′
Biham	3.53	A2	θ	Pegasi	22h 10m	06° 12′
Botein	4.35	K2	δ	Arietis	03h 12m	19° 44′
Canopus	-0.72	F0	α	Carinae	06h 24m	-52° 41′
Capella	0.05	G8	α	Aurigae	05h 15m	45° 59′
Castor	1.58	A5	α	Geminorum	07h 34m	31° 56′
- Double Star	1.59	A1	α	Geminorum	07h 34m	31° 56′
Cebalrai - please refer to Cheleb						
Chaph	2.26	F2	β	Cassiopeiae	00h 08m	59° 03′
Chara	4.26	G0	β	Canum Venaticorum	12h 34m	41° 21′
Cheleb	2.77	K2	β	Ophiuchi	17h 43m	04° 34′
Choo	2.95	B3	α	Arae	17h 32m	-49° 53′
Chort	3.34	A2	θ	Leonis	11h 14m	15° 26′
Cih - please refer to Tsih						
Cor Caroli	2.90	B9.5	α^2	Canum Venaticorum	12h 55m	38° 25′
Cujam	4.57	A0	ω	Herculis	16h 30m	14° 02′
Dabih	3.08	K0	β	Capricorni	20h 20m	-14° 50′
Deneb	1.26	A2	α	Cygni	20h 41m	45° 13′
Denebalchedi - please refer to Deneb al Giedi						
Deneb al Giedi	2.87	A5	δ	Capricorni	21h 47m	-16° 08′
Denebola	2.14	A3	β	Leonis	11h 48m	14° 40′
Dhanab	3.01	B8	γ	Gruis	21h 54m	-37° 22′
Dheneb	2.99	A0	ζ	Aquilae	19h 05m	13° 50′
Diphda	2.02	K1	β	Ceti	00h 43m	-18° 05′
Dschubba	2.34	B0.5	δ	Scorpii	15h 59m	-22° 34′
Dubhe	1.81	K0	α	Ursae Majoris	11h 03m	61° 51′
Dziban	4.58	F5	ψ	Draconis	17h 42m	72° 09′
Dzuba - please refer to Dschubba						
Edasich	3.29	K2	ι	Draconis	15h 25m	58° 58′
Electra	3.70	B6	17	Tauri	03h 43m	24° 07′
El Kophrah - please refer to Al Kafzah						
El Nath - please refer to Al Nath						
Eltamin	2.21	K5	γ	Draconis	17h 56m	51° 29′
Enif	2.31	K2	ε	Pegasi	21h 43m	09° 48′
Formalhaut	1.19	A3	α	Pisci Austrinus	22h 57m	-29° 43′
Gamma - please refer to Alphekka						
Garnet Star	4.08	M2	μ	Cephei	21h 43m	58° 42′
Giansar	3.84	M0	λ	Draconis	11h 31m	69° 20′
Giedi - please refer to Al Gieda						
Gienah	2.46	K0	ε	Cygni	20h 46m	33° 54′
Girtab	2.39	B1.5	κ	Scorpii	17h 41m	-39° 01′
Gomeisa	2.91	B7	β	Canis Minoris	07h 26m	08° 19′

Graffias	2.62	B0.5	β^1	Scorpii	16h 04m	-19° 45′
- Double Star	4.92	B2	β^2	Scorpii	16h 04m	-19° 45′
Hadar - please refer to Agena						
Hamal	2.00	K2	α	Arietis	02h 06m	23° 23′
Han	2.57	09.5	ζ	Ophiuchi	16h 30m	-10° 32′
Hassaleh	2.69	K3	ι	Aurigae	04h 57m	33° 10′
Hatysa	2.76	09	ι	Orionis	05h 35m	-05° 55′
Heka	3.39	08	λ	Orionis	05h 35m	09° 56′
Heze	3.37	A3	ζ	Virginis	13h 35m	-00° 36′
Homan	3.40	B8.5	ζ	Pegasi	22h 41m	10° 50′
Hyadum	3.63	K0	γ	Tauri	04h 20m	15° 38′
Izar	2.37	K0	ε	Bootis	14h 44m	27° 09′
Jabbah	4.00	A0/B2	ν	Scorpii	16h 12m	-19° 28′
Jabhat al Akrab	3.96	B1	ω^1	Scorpii	16h 07m	-20° 40′
Juza	3.75	K2	ξ	Draconis	17h 54m	56° 52′
Kaus Australis	1.81	A0	ε	Sagittarii	18h 23m	-34° 24′
Kaus Borealis	2.80	K2	λ	Sagittarii	18h 27m	-25° 26′
Kaus Meridionalis	2.71	K2	δ	Sagittarii	18h 20m	-29° 50′
Keid	4.43	K1	o^2	Eridani	04h 15m	-07° 39′
KeKouan	2.68	B2	β	Lupi	14h 59m	-43° 08′
Kerb	3.95	G4	τ	Persei	02h 54m	52° 46′
Khambalia	4.52	A0	λ	Virginis	14h 19m	-13° 22′
Kiffa Australis - please refer to Zubenelgenubi						
Kiffa Borealis - please refer to Zubenelchemale						
Kocab	2.04	K4	β	Ursae Minoris	14h 51m	74° 14′
Koo She	1.95	A0	δ	Velae	08h 44m	-54° 39′
Kornephoros	2.78	G8	β	Herculis	16h 29m	21° 32′
Kraz	2.65	G5	β	Corvi	12h 34m	-23° 24′
Kurdah	4.29	F7+G	ξ	Cephei	22h 04m	64° 38′
Kursa	2.79	A3	β	Eridani	05h 07m	-05° 06′
Lesath	2.71	B2	υ	Scorpii	17h 30m	-37° 14′
Maia	3.88	B7	20	Tauri	03h 46m	24° 22′
Marfak	4.33	A7	θ	Cassiopeiae	01h 11m	55° 09′
Marfik	3.82	A1	λ	Ophiuchi	16h 31m	01° 59′
Markab	2.50	B9.5	α	Pegasi	23h 04m	15° 07′
Markeb	2.45	B2	ϰ	Velae	09h 22m	-54° 56′
Masym	4.41	K4	λ	Herculis	17h 31m	26° 07′
Matar	2.95	G8	η	Pegasi	22h 42m	30° 08′
Mebsuta	3.00	G8	ε	Geminorum	06h 43m	25° 09′
Megrez	3.31	A3	δ	Ursae Majoris	12h 15m	57° 08′
Mekbuda	3.79	G0	ζ	Geminorum	07h 04m	20° 34′
Men	2.30	B1	α	Lupi	14h 42m	-47° 23′
Menkar	2.54	M1.5	α	Ceti	03h 01m	04° 01′
Menkarlina	1.86	A2	β	Aurigae	05h 58m	44° 57′
Menkent	2.17	A0	γ	Centauri	12h 41m	-48° 52′
Menkib	4.04	07	ξ	Persei	03h 59m	35° 47′
Merak	2.37	A1	β	Ursae Majoris	11h 01m	56° 28′
Merope	4.18	B6	23	Tauri	03h 46m	23° 57′
Mesartim	4.68	A	γ	Arietis	01h 54m	19° 18′
- Double Star	4.59	B9	γ	Arietis	01h 54m	19° 18′
Miaplacidus	1.67	A1	β	Carinae	09h 13m	-69° 39′

Minelauva	3.38	M3	δ	Virginis	12h 56m	03° 24′
Mimosa	1.28	B0.5	β	Crucis Australi	12h 47m	-59° 36′
Minkar	2.59	B8	γ	Corvi	12h 33m	-23° 18′
Mintaka	2.23	09.5	δ	Orionis	05h 31m	-00° 18′
- Double Star	6.85	B2	δ	Orionis	05h 31m	-00° 18′
Mira	2 to 10	M5.5	o	Ceti	02h 18m	-03° 03′
Mirach	2.02	M0	β	Andromedae	01h 09m	35° 32′
Mirphak	1.80	F5	α	Persei	03h 23m	48° 48′
Mirzam	1.96	B1	β	Canis Majoris	06h 22m	-17° 57′
Misam	3.80	K0	κ	Persei	03h 09m	44° 51′
Mizar	2.05	A2	ζ	Ursae Majoris	13h 23m	55° 00′
- Double Star	3.95	A1	ζ	Ursae Majoris	13h 23m	55° 00′
Muliphen	4.11	B8	γ	Canis Majoris	07h 04m	-15° 38′
Muscida	3.36	G4	o	Ursae Majoris	08h 30m	60° 43′
Muthallah - please refer to Rasalmothallah						
Naos - please refer to Sudail Hadar						
Nashira	3.68	F0	γ	Capricorni	21h 40m	-16° 40′
Nekkar	3.50	G8	β	Bootis	15h 02m	40° 23′
Nembus	4.04	B3	υ	Persei	04h 09m	47° 43′
Nihal	2.81	G5	β	Leporis	05h 28m	-20° 46′
Nunki	2.12	B2.5	σ	Sagittarii	18h 54m	-26° 19′
Nusakan	3.68	F0	β	Coronae Borealis	15h 28m	29° 06′
Okda - please refer to Al Rischa						
Phad	2.44	A0	γ	Ursae Majoris	11h 53m	53° 47′
Phakt	2.64	B7	α	Columbae	05h 39m	-34° 05′
Phekda - please refer to Phad						
Pherkad Major	3.05	A3	γ	Ursae Minoris	15h 21m	71° 50′
Phurad	3.02	B3	ζ	Canis Majoris	06h 20m	-30° 04′
Polaris	2.01	F8	α	Ursae Minoris	02h 15m	89° 11′
Polis	3.86	B8	μ	Sagittarii	18h 14m	-21° 04′
Pollux	1.16	K0	β	Geminorum	07h 44m	28° 04′
Postvarta - please refer to Arich						
Praecipua	3.83	K0	46	Leonis Minoris	10h 53m	34° 13′
Procyon	0.37	F5	α	Canis Minoris	07h 38m	05° 16′
Propus	3.28	M3	η	Geminorum	06h 15m	22° 30′
Rana	3.54	K0	δ	Eridani	03h 43m	-09° 46′
Rasalgethi	3.08	M5	α^1	Herculis	17h 14m	14° 25′
Ras Alhague	2.09	A5	α	Ophiuchi	17h 34m	12° 34′
Rasalmothallah	3.41	F6	α	Trianguli	01h 53m	29° 35′
Rassalas	3.88	K2	μ	Leonis	09h 53m	26° 00′
Regulus	1.36	B7	α	Leonis	10h 07m	12° 03′
Rigel	0.08	B8	β	Orionis	05h 14m	-08° 13′
Rigel Kent - please refer to Alpha Centauri						
Rotanev	3.54	F5	β	Delphini	20h 38m	14° 36′
Ruchbah	2.67	A5	δ	Cassiopeiae	01h 25m	60° 09′
Rukbat	3.97	B8	α	Sagittarii	19h 24m	-40° 37′
Rutilicus	2.81	G1	ζ	Herculis	16h 41m	31° 38′
Saak	2.69	G0	η	Bootis	13h 54m	18° 29′
Sabik	2.46	A2.5	η	Ophiuchi	17h 09m	-15° 42′
Sadachiba	3.84	A0	γ	Aquarii	22h 22m	-01° 23′
Sadalbari	3.48	KO	μ	Pegasi	22h 50m	24° 36′

Sadalmelik	2.96	G2	α	Aquarii	22h 06m	-00° 19′
Sadalsuud	2.86	G0	β	Aquarii	21h 31m	-05° 39′
Sadatoni	3.75	K4	ζ	Aurigae	05h 02m	41° 05′
Sadr	2.22	F8	γ	Cygni	20h 22m	40° 12′
Saiph - please refer to Heka						
Salm	4.60	A5	τ	Pegasi	23h 21m	23° 44′
Sargas	1.86	F0	θ	Scorpii	17h 36m	-42° 59′
Sarin	3.14	A3	δ	Herculis	17h 15m	24° 50′
Sceptrum	3.87	K2	53	Eridani	04h 38m	-14° 18′
Scheat	3.27	A2	δ	Aquarii	22h 55m	-15° 49′
Scheat	2.42	M2.5	β	Pegasi	23h 03m	27° 59′
Segin	3.38	B3	ε	Cassiopeiae	01h 54m	63° 40′
Seginus	3.05	A7	γ	Bootis	14h 31m	38° 23′
Shaula	1.60	B1.5	λ	Scorpii	17h 32m	-37° 06′
Shedir	2.23	K0	α	Cassiopeiae	00h 40m	56° 27′
Sheliak	3.45	Bpe	β	Lyrae	18h 49m	33° 21′
Sheratan	2.68	A5	β	Arietis	01h 54m	20° 44′
Sirius	-1.43	A1	α	Canis Majoris	06h 44m	-16° 42′
Sirrah	2.06	B9	α	Andromedae	00h 08m	29° 00′
Spica	0.91	B1	α	Virginis	13h 24m	-11° 04′
Subra	3.52	A5	o	Leonis	09h 41m	09° 53′
Suhail Hadar	2.23	05	ζ	Puppis	08h 03m	-39° 57′
Sulaphat	3.24	B9	γ	Lyrae	18h 59m	32° 41′
Svalocin	3.77	B9	α	Delphini	20h 40m	15° 55′
Syrma	4.08	F6	ι	Virginis	14h 16m	-06° 00′
Tais	3.07	G9	δ	Draconis	19h 13m	67° 40′
Talita	3.14	A7	ι	Ursae Majoris	08h 59m	48° 02′
Tania Australis	3.05	M0	μ	Ursae Majoris	10h 22m	41° 30′
Tania Borealis	3.45	A2	λ	Ursae Majoris	10h 17m	42° 55′
Tarazed	2.67	K3	γ	Aquilae	19h 45m	10° 34′
Taygete	4.30	B6	19	Tauri	03h 45m	24° 28′
Tejat Prior	2.92	M3	μ	Geminorum	06h 22m	22° 31′
Theemini	3.82	K0	υ^2	Eridani	04h 35m	-29° 46′
Thuban	3.65	A0	α	Draconis	14h 04m	64° 27′
Toliman - please refer to Alpha Centauri						
Tsih	2.47	B0.5	γ	Cassiopeiae	00h 56m	60° 38′
Turais	2.80	F5	ρ	Puppis	08h 07m	-24° 15′
Tureis	2.80	A9	ι	Carinae	09h 17m	-59° 12′
Tyl	3.83	G8	ε	Draconis	19h 48m	70° 16′
Unukalhai	2.65	K2	α	Serpentis	15h 43m	06° 29′
Vega	0.04	A0	α	Lyrae	18h 36m	38° 46′
Vindemiatrix	2.86	G8	ε	Virginis	13h 01m	11° 03′
Wasat	3.53	F2	δ	Geminorum	07h 20m	21° 59′
Wei	2.28	K2.5	ε	Scorpii	16h 49m	-34° 16′
Wezea	1.85	F8	δ	Canis Majoris	07h 08m	-26° 22′
Wezn	3.12	K2	β	Columbae	05h 50m	-35° 46′
Yed Post	3.24	G8	ε	Ophiuchi	16h 18m	-04° 42′
Yed Prior	2.72	M0.5	δ	Ophiuchi	16h 13m	-03° 39′
Yildun	4.36	A1	δ	Ursae Minoris	17h 32m	86° 35′
Zaniah	3.89	A2	η	Virginis	12h 39m	-00° 40′
Zaurak	2.95	M0	γ	Eridani	03h 58m	-13° 31′

Zavijava	3.61	F8	β	Virginis	11h 51m	01° 46′
Zibal	4.80	A3	ζ	Eridani	03h 16m	-08° 49′
Zozma	2.57	A4	δ	Leonis	11h 13 m	20° 37′
Zubenalgubi	3.29	M4	σ	Librae	15h 04m	-25° 17′
Zubenelchemale	2.61	B8	β	Librae	15h 16m	-09° 19′
Zubenelgenubi	5.15	F3	α^1	Librae	14h 50m	-15° 56′
- Double Star	2.75	A2	α^2	Librae	14h 50m	-15° 58′
Zubenelhakrabi	3.91	G8	γ	Librae	15h 36m	-14° 47′

Bright stars with no popular name;

	1.63	M4	γ	Crucis	12h 30m	-57° 01′
	1.78	WC8	γ^2	Velorum	08h 09m	-47° 17′

SOME OTHER POPULAR STAR NAMES

Big Dipper	α β γ δ ε ζ and η Ursae Majoris.
Charles' Wain	Another name for the Pointers.
Dog Star	Sirius, α Canis Majoris.
Hyades	Star cluster in Taurus adjacent to Aldebaran (α Taurus)
North Star	Polaris, α Ursae Minoris
Pan Handle	Another name for the 'Big Dipper'.
Pleiades	Star cluster in Taurus at 03h45m, 23°.
Plough	Yet another name for the 'Big Dipper'.
Pointers	Dubhe and Merak, α and β Ursae Majoris.
Pole Star	Another name for Polaris.
Seven Sisters	Another name for the Pleiades.

THE GREEK ALPHABET

α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	ο	Omicron	φ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ε	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

APPENDIX 2
Trigonometric Functions

To calculate Alt and Az from RA and Dec:

a	Altitude in radians
A	Azimuth in radians
α	Right Ascension in radians
d	Day of the Year
δ	Declination in radians
GMT	Greenwich Mean Time
H	Hour Angle in radians
λ	Longitude in radians
ϕ	Latitude in radians

$$H = .261799\,(.0657098\,d + 1.002738\,GMT - 17.393506) + \lambda - \alpha)$$

$$\sin a = \sin\delta \sin\phi + \cos\delta \cos\phi \cos H$$

$$\cos A = \frac{\sin\delta - \sin\phi \sin a}{\cos\phi \cos a}$$

Low precision formula from section C of the Astronomical Almanac used to calculate the position of the Sun and hence to determine the periods of daylight and twilight:

L	Corrected Mean longitude of the Sun
g	Mean anomaly
λ	Ecliptic longitude

$$L = 4.87116 + .017203\,d$$

$$g = 6.22131 + .017202\,d$$

$$\lambda = L + .03342 \sin g + .000349 \sin 2g$$

$$\alpha = \tan^{-1}(.91747 \tan\lambda)$$

$$\delta = \sin^{-1}(.39781 \sin\lambda)$$

APPENDIX 3
Loading Procedures

A3.1 Cassette Version

The Teaching Program is on Cassette No. 1 and the Applications Program is on Cassette No. 2. Both programs load and auto run as follows: Press **[CTRL]** and the small **[ENTER]** key (on the numeric key pad) at the same time. Then press **[PLAY]** on the cassette recorder. Do not turn the tape recorder off until the main screen display, which includes the sky window, is displayed.

A3.2 Disc Version

The Teaching and Applications Programs are both on a single Disc. Insert the disc in the drive and key `RUN " TEACH` **[ENTER]** to run the Teaching Program, or `RUN " APPLY` **[ENTER]** to run the Applications Program. Leave the disc in the drive when you are using a program, because the computer will need to access it from time to time.

Glossary

Absolute Magnitude, the magnitude that a given star would appear to have if it was exactly 32.6 light years away
Altitude, the vertical angle between the line to the horizon and the line along which the observer is looking.
Apparent Magnitude, the apparent brightness of a star viewed from earth.
Asterism, an identified group of stars within a constellation.
Astrology, the theory that the stars and planets have an occult influence over human affairs.
Astronomy, the science of the study of the Sun, stars and planets.
Autumnal Equinox, the exact time at which the Sun crosses the **Celestial Equator** from north to south. This occurs once per year in September.
Azimuth, the horizontal angle between the line running due north and the line along which the observer is looking, measured in a clockwise direction.
Celestial Equator, the line around the **Celestial Sphere** directly above the Earth's **Equator**.
Celestial Meridian, the **Great Circle** on the **Celestial Sphere** passing through the observer's **Zenith** and the **Celestial Poles**. It is the line running from north to south over the observer's head.
Celestial Poles, the points on the **Celestial Sphere** directly above the Earth's north and south **Poles**.
Celestial Sphere, an imaginary sphere which surrounds the Earth.
Circumpolar Star, a star which remains permanently above the horizon with respect to the observer's position.
Constellation, a named group of stars, frequently having mythological significance.
Co-ordinates, a method of defining the position of an object in a unique way. In astronomy, the normal co-ordinate system defines the position of an object in terms of its **Right Ascension** and **Declination**.
Culmination for a star is the time at which that star crosses the observer's **Celestial Meridian**.
Day, normally means **Solar Day**, but also refer to **Sidereal Day**.
Declination, the angular distance of an object from the **Celestial Equator**, equivalent to **Latitude** on the Earth's surface.
Equator, the line around the earth which is equidistant from the north and south poles.
Equinox - refer to **Autumnal Equinox** and **Vernal Equinox**.
Great Circle is a circle on the surface of a sphere which divides the sphere into two equal halves. On the Earth, the **Equator** and all lines of **Longitude** are great circles.
Greenwich Mean Time, the time at Greenwich, calculated by the position of the Sun. Also known as **Universal Time**.
Greenwich Meridian, the line of **Longitude** passing through Greenwich from which all other lines of longitude are measured.
Latitude of a position on the Earth's surface is the angular distance between the **Equator** and that position.

Light Year, 5,880,000,000,000 miles, the distance travelled by light in a year.
Longitude, of a position on the Earth's surface is the angular distance between the **Greenwich Meridian** and that position.
Magnitude, a quantitative measure of the brightness of a star.
Poles, are the northern and southern points of the axis upon which the Earth spins.
Prime Meridian, refer to **Greenwich Meridian**.
Sidereal Day, is the length of time between two successive **culminations** of any given star.
Solar Day, is the length of time between two successive **culminations** of the Sun (the Sun culminates at noon).
Spring Equinox, refer to **Vernal Equinox**.
Universal Time, refer to **Greenwich Mean Time**.
Vernal Equinox, the exact time at which the Sun crosses the Celestial Equator from south to north. This occurs once per year in March.
Year, the time taken for the Earth to circle the Sun once,
Zenith, the point in the sky directly above the observer.
Zodiac, the series of twelve constellations in front of which the Sun passes during the year.

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