

About this book and how to use it

How many times have you said to yourself, ‘I wonder whether I can see Mercury this month?’ or ‘What will be the phase of the Moon next Tuesday?’ or even ‘Will I be able to see the solar eclipse in Boston?’ Perhaps you could turn to your local newspaper to find the information, or go down to your local library to consult the *Astronomical Almanac*. You may even have an astronomical journal containing the required information, or perhaps some computer software or a website that might do the trick. But you would not, we suspect, think of sitting down and calculating it for yourself. Yet even though you may not find mathematics particularly transparent, you can still do this for yourself. You can quite easily find the answer to many astronomical questions using this book of calculation recipes. You use it just as you would a recipe book in the kitchen – follow the recipe and produce a delicious dish! All you need in addition is a calculator, a piece of paper, a ruler and a pencil. (For those of us with access to a computer, we can use that instead of the calculator and carry out all the calculations in a spreadsheet program as further described below.)

Your calculator does not have to be a very sophisticated device costing a great deal of money; on the other hand it should be a little better than a basic four-function machine. At a minimum, it must have buttons for the trigonometric functions sine, cosine and tangent. It should also be able to find square roots and logarithms. Such calculators generally describe themselves as ‘scientific calculators’. Features other than these are not essential but can make the calculations easier. For example, having a number of separately-addressable memories in which you can store intermediate results would be useful. If you have a programmable calculator, you can write programs to carry out many of the calculations automatically with a subsequent saving of time and effort.

When choosing a calculator, don’t be led astray by arguments about whether ‘reverse Polish notation’ (RPN) or ‘algebraic notation’ (AN) is the better system. Each has its advantages and the same complexity of calculation may be made using either. It is important, however, to read the instructions carefully and to get to know your calculator thoroughly, whatever system it uses. Make sure that you like the ‘feel’ of the keypad, and that pressing a key once results in just one digit appearing in the display. Look out for special functions that can help you, like a key that gives you π (the constant 3.141 592 654), a key that converts between times or angles expressed as hours or degrees, minutes, and seconds, and their decimal equivalents, a key that takes any angle, positive or negative, and returns its equivalent value reduced to the range 0° to 360° , and a key that converts between rectangular and polar coordinates (very useful for removing the ambiguity of 180° on taking the inverse tangent of an angle).

When you go through the worked examples given with each calculation, do not be alarmed if your figures do not match ours exactly. There are several reasons why they may not, including rounding errors

and misprints. You should try to work with at least seven or eight significant figures. If you write your own programs to carry out any of the calculations on a computer, make sure that you use variables having sufficient resolution. Use double precision (eight-byte precision) everywhere if possible.

Having gathered together your writing materials, calculator and book, how do you proceed? Let us take as an example the problem of finding the time of sunrise. Turn to the index and look up 'sunrise'; you are directed to page 112 where you will find a paragraph or two of explanation and a list of instructions with a worked example in the form of a table. We have kept things brief on purpose and have made no attempt to provide mathematical derivations. We have also simplified the calculations. As you work through each step, write down the step number and the result in a methodical fashion. Take care here and it will save you a lot of time later!

Many calculations require you to turn back and forth between different sections. For example, step 1 of 'sunrise' directs you to another section to calculate the position of the Sun. Make the calculations in that section, and then turn back to carry on with step 2. You will find it useful to keep several slips of paper handy as bookmarks.

This book is not intended to match the precision of the results found in the *Astronomical Almanac*. As we have already mentioned, the calculations have deliberately been simplified although they are good enough for most purposes. If you have your own computer, you can use the methods to write programs displaying the evolving Solar System with a precision that is better than the resolution of the computer screen. But those of us with simple pocket calculators can find great satisfaction in simply being able to work out the stars for ourselves and to predict astronomical events with almost magical precision.