Telescope Basics

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Introduction

In the short time that I have been interested in Astronomy, one of the most frequently found articles on the internet is a description of the different types of telescope. What I have found harder to locate is an article that attempts to explain the differences, what these differences mean and then goes on to explain which telescope is best.

This article, together with it's partner article "Telescope Types" is an attempt at filling this void. Starting with the basics, then progressing to the various types of common telescope types and explaining how they differ by referring back to the basics, I hope to enlighten the absolute novice and to assist you in choosing your ideal telescope.

The Basics

Telescope basics can be separated into a number of sections. What a telescope is, aperture size, focal length, focal ratio and magnification. Each of these items will be considered separately.

What a telescope is

When you see a telescope advertised in a superstore, it is sometimes advertised as a powerful telescope with a magnification of say 250x or 500x. Therefore, it can be forgiven for novices to believe a telescope is a device to magnify images of the night sky.

The above is an incorrect way of describing a telescope. The correct description is that a telescope is a device for collecting light and to bring this light to a focus at an eyepiece (or CCD sensor) for viewing.

Aperture size

The aperture is the large open end at the front of the telescope. Some telescope types have an open end, others have a glass plate or lens at the front.

The larger the aperture, the greater the amount of light that the telescope collects. For a given type of telescope, the larger the aperture, the more light and hence the brighter the image that is focused at the eyepiece or on the CCD Sensor.

Considering that telescopes are circular, the light gathering capability can be calculated easily by the following formulae...

$$Aperture\ Area = PI\ x\ R^2$$

where

Aperture Area	Is the light gathering capability of the telescope
PI	Is 3.1415
R	Is the radius of the telescope in mm

Hence the table below shows the Aperture area for a number of telescope sizes.

Telescope Diameter	Radius	Aperture Area
80mm	40mm	5026.4
120mm	60mm	11309.4
150mm	75mm	17671
200mm	100mm	31415

As you can see from the table, a small change in the telescope diameter, creates quite a large change in the Aperture area.

In reality however, most telescopes have a secondary mirror that obstructs the main aperture, hence to get a true aperture area value, you should subtract from the above, the area of the secondary obstruction. See a later section of this article to obtain information relating to the various types of telescope for information on which types have this secondary obstruction.

Focal length

The Focal length of the telescope is the distance that the light takes as it passes through the various optical elements within the telescope.

Some telescopes fold the light one or more times within the main tube of the telescope. This has the effect of creating a telescope with a focal length that could be as large as 2 or 3 meters into a tube that is 60cm or so in physical length.

The Focal length of a telescope is one of the parameters quoted by the suppliers of good quality instruments in the information that they provide. Be aware of telescopes that do not quote a focal length.

Focal ratio

The Focal ratio of a telescope is a calculation based upon the Focal length and the Aperture. There is a web based calculator in the Tools section of this website that will calculate the Focal ratio of the telescope given the other parameters.

The Focal ratio is a key parameter for a telescope when you are using the telescope for imaging. The lower the focal ratio, the faster the telescope and hence the shorter the exposure time required for a given object.

In photography, people are familiar with focal ratios being fixed numbers like f/1.4, f/2, f/2.8, f/4, f/5.6.... This relates to 2x, 4x, 8x, 16x, 32x exposure times. For example, an object photographed with a focal ratio of f/5.6 will require double the exposure time that it would require if photographed at a focal ratio of f/4.

With a telescope however, the focal ratios are not defined as standard numbers. But the exposure times can still be calculated. See a future article on the subject of astrophotography of deep sky objects.

The focal ratio of a telescope can be calculated by a simple formulae...

$$Focal\ Ratio = \frac{Telescope\ Focal\ Length}{Aperture}$$

for example, the Focal ratio of a 80mm telescope with focal length of 600mm is

$$Focal\ Ratio = \frac{600}{80} = 7.5 = f/7.5$$

Magnification

The Magnification of a telescope is relative to visual astronomy. It relates to the Telescope focal length and the focal length of the eyepiece that is inserted. Both focal length figures must be in the same units, usually in mm.

There is a web based calculator in the Tools section of this website that can be used to determine the magnification of the telescope.

The simple formulae for this calculation is...

$$Magnification = \frac{Telescope\ Focal\ Length}{Eyepiece\ Focal\ Length}$$

As you insert different eyepieces of smaller and smaller focal length, then the magnification of the telescope optics becomes greater. As an example, consider the table below which uses a 127mm aperture telescope with a focal length of 1900mm and a number of different eyepieces to show the different magnifications that can be achieved.

Telescope Focal Length	Eyepiece Focal Length	Magnification
1900mm	32mm	59x
1900mm	26mm	73x
1900mm	15mm	127x
1900mm	9.7mm	196x
1900mm	5mm	380x
1900mm	3mm	633x

The above table looks great, if you want a nice large image of Jupiter, then slot in a 3mm eyepiece and hey presto you get a image of jupiter that is 633x magnification. However, things are not really that easy in reality.

Firstly, the greater the magnification used, the dimmer the image. For something as bright as jupiter, you may be able to see it still at 633x, but because it is dimmer than at 196x, you may also start to loose the detail.

Secondly, there is general maximum magnification that can theoretically be applied to any telescope. Increasing magnification beyond this limit will increase the image size, but will not show any more detail in the image. This maximum magnification figure can be said to be approximately 2 x Aperture. Hence the maximum magnification of a selection of telescopes is shown in the table below.

Telescope Diameter	Maximum Magnification
80mm	160x
120mm	240x
127mm	254x
150mm	300x
200mm	400x

Hence you can see that there is not much point in using an eyepiece greater than 9.7mm in the example telescope with an aperture of 127mm because the maximum magnification figure would be exceeded.