

Choosing and Using a Telescope for Astronomy

For many people, the words ‘astronomy’ and ‘telescope’ are inseparable. Many newcomers to the hobby of astronomy mistakenly believe that it is important to get a telescope as quickly as possible. Because of the large variety in telescope designs, size, and quality, choosing a first telescope can be a daunting task that has large ramifications for the budding amateur astronomer. Choose a telescope that is too large or complex to use and it may never come out of storage for a quick viewing session. Pick one that’s too small, of poor optical or questionable mechanical quality, and it may kill the passion for visual astronomy altogether.

BINOCULARS

As outlined in our companion brochure, “Choosing and Using Binoculars for Astronomy,” the ideal first telescope for astronomy is actually binoculars. They give a wide field of view and a bright, right-side-up image of many interesting celestial objects. Binoculars are relatively inexpensive and versatile enough for other applications. A pair

of binoculars accompanied by a good astronomy guide like the Royal Astronomical Society of Canada’s *Observer’s Handbook* or *Beginner’s Observing Guide* is all you need to begin understanding the night sky.

TELESCOPE READINESS TEST

*“Space is mostly empty and you can find a whole lot of nothing with a telescope” ---
Richard Weis, former President of
RASC-Calgary Centre.*

If you can do the following, then you are ready to make full and rewarding use of a telescope:

- ✓ Find and name four circumpolar constellations
- ✓ Find and name three constellations seen in the southern sky in each of the four seasons
- ✓ Find and name - (a) 4 double stars (b) 4 variable stars (c) 5 star clusters (d) 5 nebulae or galaxies
- ✓ Have you seen all of the above objects with either the unaided eye or with binoculars?
- ✓ Can you find all of the above objects by yourself (using binoculars if necessary)?
- ✓ Are you familiar with at least one star atlas?
- ✓ Are you sure that you want to spend time learning how to operate a telescope so that you can explore the universe on your own?

TELESCOPE DESIGNS

Refractor

The refractor is what most people imagine a telescope should look like. This design uses lenses to bend, (refract) light to gather and focus light. The large lens on the skyward end is called the objective and at the other end is the eyepiece. A lens will not only bend the light, it will unfortunately spread it out into a small

rainbow, obscuring fine detail. The objective lens in achromat refractors is commonly made of two or more lenses of different glass types to



help correct this problem, known as chromatic aberration. This most commonly manifests itself as faint fringes of colour around objects like the Moon or Jupiter, but it is rarely fully cured except in very expensive apochromat refractors.

Advantages: Refractors, by default, have a totally clear aperture. No central obstruction causes light to be scattered from brighter to darker areas. Thus, contrast is good in refractors. Refractors are often chosen as the premier instruments for planetary and double-star observing. Refractors are also low in maintenance.

Disadvantages: refractors are very massive and expensive in larger sizes! Residual uncorrected colour haloes form around bright objects unless apochromatic lens are used.

Reflector



Reflectors use mirrors, coated on the front surface with aluminum, to collect and focus light. Better systems use Pyrex mirrors; cheaper telescopes have plate glass mirrors. In a Newtonian reflector light enters the tube, strikes the large primary

parabolic mirror at the bottom of the tube, is reflected to the flat secondary mirror near the top of the tube, and then is reflected sideways into the eyepiece.

The Cassegrain reflector also has a parabolic primary mirror. Light is reflected off a hyperboloidal secondary mirror through a central hole in the primary mirror, allowing the eyepiece, or a camera, to be mounted at the back end of the tube.

Advantages: Reflecting telescopes suffer no chromatic aberration. Mirrors have only one surface of careful tolerances and thus are less expensive to produce than refractor objectives, which require four surfaces to be refined.

Reflectors are generally more portable than refractors of similar aperture. Newtonian designs are the most comfortable to use since the eyepiece is nearly always at a convenient height.

Disadvantages: All Newtonian reflectors suffer from coma, a defect that causes stars near the edge of the field of view to look like a comet. The smaller the focal ratio of the Newtonian scope, the greater the coma.

Reflectors are quite sensitive to being bumped or transported. A reflector that is not set up as a permanent instrument should be collimated prior to each observing session.

Catadioptric or Compound Designs

The Schmidt-Cassegrain and Maksutov-Cassegrain are hybrids that have a mix of refractor and reflector elements in their design to fold the optical path back onto itself, resulting in a compact tube. Like the Cassegrain

reflector, a secondary mirror bounces light through a hole in the primary mirror to the eyepiece. The Maksutov telescope uses a thick spherical corrector lens while the Schmidt corrector plate has subtle curves. Newtonian



telescopes also exist.

Advantages: Most compact of the three designs; less expensive than refractors; huge assortment of after-market accessories; can be totally computer driven; very popular.

Disadvantages: More expensive than reflectors; most dew-prone of the telescope types.

MOUNTING SYSTEMS

An unstable mount will render the finest telescope unable to deliver quality images. If the mount is undersized, wind — the bane of most large telescopes — will not be your only enemy.

You will experience ‘bouncing’ images even when you are focusing. The test of a quality mount is its ‘damp-down factor.’ This is the time it takes an image to stabilize (for the vibrations to dampen) after the telescope is moved or refocused. Under no circumstances should the image take more than five seconds to damp down.

Alt-Azimuth

An alt-azimuth mount is the simplest type of telescope mount. The word derives from altitude, the distance above the horizon and

azimuth, the compass heading. A telescope on this type of mount will move up and down, left and right, but will not readily compensate for the motion of the Earth.

Dobsonian mounts are a version of the alt-azimuth mount that is commonly made of wood. This simple design is very rigid and is ideal for a Newtonian telescope tube.

Equatorial

If Earth did not move, an alt-azimuth mount would be all that any of us would ever need. An equatorial mount readily compensates for the motion of the Earth. It does this since one of its axes is parallel to Earth’s spin. There are two main types of equatorial mounts; the German Equatorial, which places the telescope on one end of a shaft and a counterweight on the other, and the fork mount, which looks like a tilted alt-azimuth mount and has no counterweight. These mounts both come in two versions, manual and motorized. If you have a choice, select the motorized version.

Although most beginners chose this mount to try astrophotography, avoid any thoughts of astrophotography for now because the steep learning curve, complexity, and difficulty of this aspect of the hobby can dissuade you from more enjoyable parts of astronomy.

GoTo drives

A GoTo system combines a small computer with a dual-axis motor driver. GoTo drives require you to initially centre one or two stars for alignment. Most go-to telescopes manufactured today have a large database of objects from which you can select. Such systems can operate in either alt-azimuth or equatorial modes.

TELESCOPE BASICS

In spite of the variety of designs, there are certain key functions all telescopes perform.

Light-Gathering Power & Aperture

Gathering light is the single most important function a telescope performs since many astronomical targets are faint. On top of this, the act of magnifying an image spreads out the light. Aperture is the size of the telescope's light-gathering element; whether it is an objective lens, as in a refractor, or its main mirror, as in a reflector. The bigger the lens or mirror, the more light the telescope will gather, and the brighter the image will be. Telescope apertures are circles, and the areas of circles increase with the square of the radius, so moving up in aperture, even modestly, can yield big results.

Resolution

Resolution is a measure of how sharp and well-defined an image the telescope can produce. A telescope's ability to resolve fine detail depends on a combination of both the size of its aperture and the quality of the telescope's optics. In most cases, good resolution of an image is more important than magnification.

Magnification

The best magnification in a telescope is the lowest one that will show you the details (quite different from how small department or camera store telescopes are pitched to an unsuspecting public).

Avoid any cheap refractor sold on the basis of its magnification as it is almost certainly a piece of junk. These telescopes are little more than toys and will likely kill your budding enthusiasm.

Claims of 500x for such telescopes are meaningless. Normally, a well-made telescope's maximum useful magnification is usually given as 50x per inch or 2x per mm of aperture. Thus, a typical 60-mm refractor is, at best, really only a 120x telescope. So, if a low-quality, high-power eyepiece is included with the telescope, high (albeit empty) magnifications can be achieved. A 4-inch telescope can be used with eyepieces that provide up to about 200x, and so on.

Magnification can be changed by simply switching eyepieces in the telescope. To find out how much magnifying power an eyepiece gives, divide the focal length of the telescope by that of the eyepiece, using the same units, of course. So, $1200\text{mm}/25\text{mm} = 48\text{x}$.

Focal Length

This is the effective length of the telescope's light path, from the main mirror or objective lens, to the focal point (the location of the eyepiece). The longer the focal length, the higher the magnification the telescope will produce for any given eyepiece. The telescope's focal length is usually marked on the telescope tube.

Focal Ratio

Focal ratio is an indication of the photographic 'speed' of the telescope's optical system, and is given by the focal length divided by the aperture. Longer focal lengths (over $f/8$) are 'slower,' while shorter (under $f/6$) are referred to as being 'faster.' For visual use, these numbers can help in deciding what telescope to buy. Most 'fast' systems are more compact than their 'slow' brethren but are more likely to be prone to optical shortcoming – chromatic aberration in refractors and coma in reflectors, for equivalent optical designs

Accessories

Because of the generally narrow fields of view, most telescopes require some type of aiming device. Traditionally, this has been a finder scope, a small low-power wide-field telescope mounted parallel with the main optical system. Choose one with good optics and it will allow for pleasing views of star fields or large star clusters that are too large for the main telescope. 6x30 or 8x50 are good sizes to choose.

A red dot or 'heads-up' display creates the illusion of a red reticule in the sky – showing you exactly where you are pointed. But it does not magnify, or show objects fainter than your unaided eye can see.

Eyepieces

In spite of the wide selection available, you really don't need more than 3 or 4 carefully chosen eyepieces, a Barlow, and perhaps a filter or two. Eyepiece designs vary primarily by focal length (magnification) and apparent field of view (AFOV). Larger AFOVs lead to wider true fields of view in the telescope. Eyepiece eye relief is a consideration, especially for glasses wearers. It is typically better in longer focal lengths.

Ramsden and **Huygenian** are inexpensive 2-lens eyepiece designs with narrow fields of view commonly supplied with inexpensive telescopes. These eyepieces should be replaced with better-quality eyepieces.

The **Kellner** and related **Modified Achromat** eyepieces are three-lens designs that have 40-45 degree AFOV. **Orthoscopics** are 4-element eyepieces popular for planetary work. They have a 45 degree AFOV. The popular **Plossl** eyepiece

uses 4 or 5 elements, to provide a 50-52 degree AFOV. **Erfiles** use 6 elements, and have a wide 60-65 degree FOV, with increasing distortions near the edge.

Newer designs, using 6 to 8 lens elements provide high-quality AFOVs of 60 to 84 degrees and some have amazing eye relief, regardless of focal length, and are a godsend to those who must wear glasses while observing.

A **Barlow lens** is a valuable accessory. Inserted between the focuser and your eyepiece, a Barlow will typically double or triple the magnification of any eyepiece. For \$60-\$100, you can effectively double the size of your eyepiece collection. A Barlow preserves the eye relief of your longer-focal-length eyepieces, thus reducing the amount of squinting you have to do, especially if you must wear glasses to correct astigmatism.

Purchasing a Telescope

There is no such thing as a good, inexpensive telescope. Department store telescopes may look attractive at first glance but they are usually more of a deterrent to an astronomy hobby than a help. Their optical components are cheap and of poor quality. They are usually supplied with unstable mountings that wiggle, making it impossible to keep a steady view. They offer too much magnification with a very narrow field of view. This makes it nearly impossible to find your target. The cheap lenses give fuzzy, poor-quality images. Altogether, they are disappointing and frustrating to use.

Two good places to start are your local library and your local astronomy club. Your library should have a list of clubs and organizations to

help you locate the nearest astronomy club. In Canada there is the Royal Astronomical Society of Canada (RASC) with branches in many Canadian cities. Check the RASC Web page (www.rasc.ca) for links to the RASC Centre nearest you. Try to observe through any model you're considering. Observe through as many telescopes as you can, and ask as many questions as you can think of. Ask about setup time, maintenance, accessories, and cost. If you can't find an astronomy club nearby, call or visit a local planetarium. The staff there will be aware of any astronomy clubs in your area.

When you are ready to buy a good starter telescope, contact a reputable dealer. Your local astronomy club can steer you in the right direction – they have had the experience of doing business with many different dealers and their advice will be sound! Or visit our resource directory (www.rasc.ca/resource/home.html) for a listing of Canadian suppliers of astronomical equipment.

Expect to pay from \$500 to \$1000 to get decent aperture and a scope that's relatively portable. Look for an 80-mm refracting telescope, or larger, on a stable mount or, 4.5", 6", or 8" reflecting telescopes. Beginners need early success, and the 6" or 8" aperture is big enough to throw up a bright pleasing image of most common celestial objects. A 6" Dobsonian is simple, cheap and will teach you a lot. The simple design is an asset, since you will want to spend your time aiming and observing with your telescope, rather than playing around with the sometimes-complicated controls on an equatorial mount. Finally, the probability that a telescope will be used is inversely proportional to its size. This seems to apply to just about

everyone, regardless of experience. It is possible to get a telescope that is too big!

You will need to spend lots of quality time with your telescope. The more you look, the more you will see, and the better you will get. An experienced observer might enjoy deep-sky objects in an 80-mm refractor, while a beginner with a "light bucket" is still struggling to find the Orion Nebula.

Find out more

To learn more about the Royal Astronomical Society of Canada, or membership in the Society, contact your local Centre or the Society's National Office:

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