Buying Your First Telescope
By Mike Usher

A telescope should only be bought after due consideration. The first thing to understand is that a telescope is a high quality optical device and high quality optical devices are not inexpensive. Second mortgages are not required to buy one, but you are unlikely to find a telescope that is truly useful for under $350 – and then only in certain styles. Many well-meaning parents have given their offspring a cheap department store telescope and it winds up in the closet; the children are simply unable to see anything with it and give up in frustration. There is however an easy way to spotting a cheap department store telescope; *any telescope advertised based on the number of times it can magnify an object must be avoided.*

Aperture (the diameter of the lens or mirror) is the way quality telescopes are sold. In general, the larger the aperture the better the telescope assuming all other things are equal. (Often things are not equal, but we will get into that later).

The purpose of a telescope is to look at objects; the addition of electronics, while sometimes a convenience, does not make the object look any brighter or more detailed. Electronics do however make the telescope significantly more expensive. Inexperienced adults and especially children find electronics (except possibly for the top of the line models) rather difficult to calibrate. Electronics have another fault; many times, club members have taken their telescopes far outside of town, but find out upon arrival they have a dead battery or forgot some crucial electrical connection leaving their telescope worthless. Generally, I would recommend your first telescope have no electronics at all; spend the money you save on a larger telescope and a good star chart. The only exception would be if you decide to take the giant leap into astrophotography.

Types of Telescopes

There are three kinds of telescopes commonly encountered today:

Refractors
Reflectors
Catadioptrics

Each kind has their own advantages and disadvantages.

Refractors look like a traditional telescope; a lens at one end and an eyepiece at the other. When one casually mentions a telescope in conversation it's the image of a refractor that immediately leaps to mind. Of all the kinds of telescopes a good refractor will produce the sharpest, clearest image with the best contrast; the key word here is "good"-*department store refractors are, without exception, poor*. All refractors suffer from a defect called chromatic aberration caused by the various colors of light not coming to a sharp focus. Careful engineering can eliminate chromatic aberration almost entirely, but such engineering comes at a high cost. In addition, defect-free glass is difficult to make which also increases the cost. A good refractor can cost 5 or 10 times as much per inch of aperture as other kinds of telescopes. In general, refractors are best left for advanced amateurs.

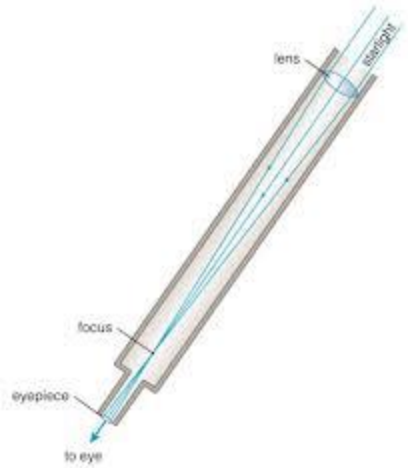
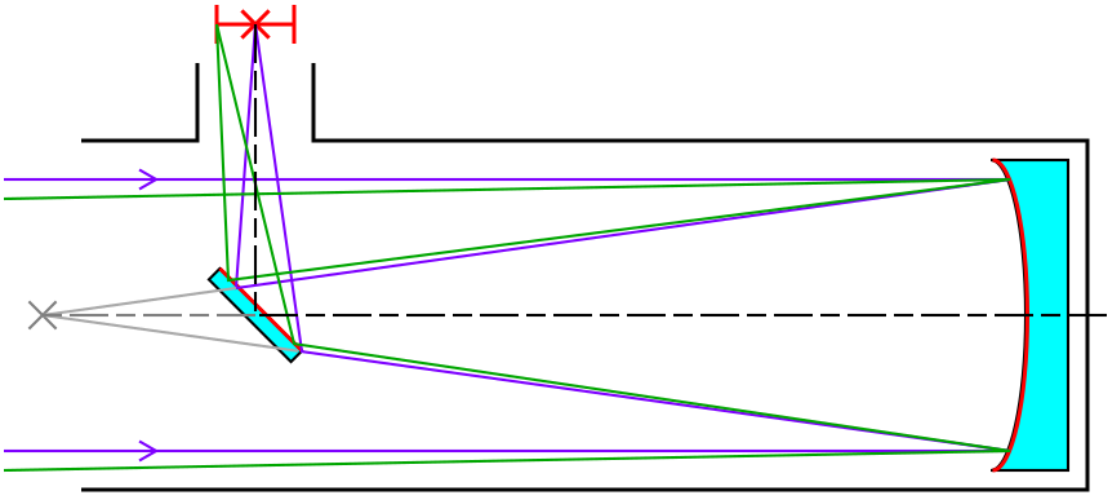


Diagram of Refractor

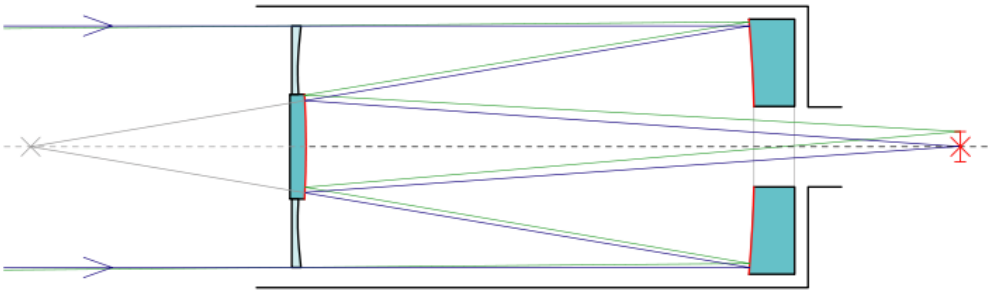
Reflectors are probably the most popular type of telescope today. Almost all large observatory telescopes are reflectors. (Including the Hubble) They come in several different configurations; the Newtonian style is almost universal among amateurs. A large mirror, called the primary, reflects light back to a much smaller mirror called the secondary which then reflects the light to an eyepiece. Unlike a normal mirror the reflective coating is on top of the glass, not under it. While this makes the mirror very fragile, it eliminates all chromatic aberration; and since the light does not go through glass, quality of the glass is not much of an issue compared to a refractor. The addition of a secondary mirror does reduce contrast of the image somewhat and the wires supporting the secondary produce diffraction spikes on bright stars. Photos taken with reflectors are published so often though that people have come to regard the diffraction spikes as natural looking. (Indeed, tiny defects in your eye can give stars similar spikes even without a telescope). All reflectors require collimation on a regular basis. Reflectors are the least expensive telescope per inch of aperture.



A diagram of a Newtonian Reflector

Catadioptrics are a compromise between the above two types, they have both lenses and mirrors. They come in several different styles, perhaps the Schmidt-Cassegrain is the most common. Catadioptrics are much valued for their compactness, being much shorter than reflectors or refractors of the same aperture. Condo owners just love

catadioptrics for their smaller storage space requirements. The contrast is a little worse than reflectors because the secondary mirror is relatively larger. The telescope may require occasional collimation.



A diagram of a Schmitt-Cassegrain catadioptric

	Refractors	**Reflectors**	**Catadioptrics**
Contrast	excellent	good	fair
Cost per inch	High	Low	Medium
Compact	No	No	Yes
Image	Upright and reversed	Upside down and normal	Upright and reversed
Advantage	Sharpest images	Eyepiece usually in a convenient spot	Easier to store
Disadvantage	Eyepiece often in *very* inconvenient spot	Rather bulky to transport and store	Larger ones can be difficult to singlehandedly place on mount

Mounts

A proper mount is an absolute necessity for astronomical viewing. A mount must hold the telescope rock steady or vibration will render the scope unusable. Except for Dobsonian mounts the rule of thumb is that the mount must cost the same as the telescope. (or more)

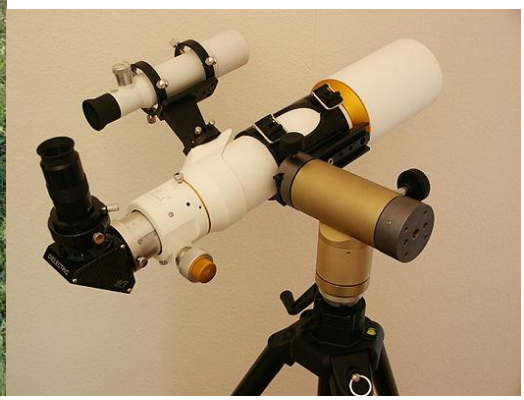
Types of Mounts

Alti-azimuth
Equatorial
Fork

Alti-azimuth mounts tend to be shipped with inexpensive telescopes, they do not follow the stars through the sky without constant human attention. Except for the Dobsonians they tend not to be very steady. All types are

unsuitable for photography. Dobsonians are a special classification of alti-azimuth mounts, they are both inexpensive and extraordinarily stable and a good choice for beginners and advanced users alike as long as photography is not an issue. Dobs, as they are called, are almost always used in conjunction with reflectors.

Home-made dobsonian mount

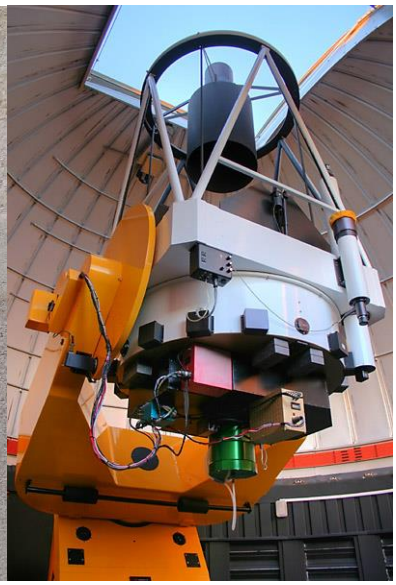


An Alti-azimuth mount

Bottom mounted Dobsonian

Equatorial mounts are rather heavy and comparatively difficult to set up, but are indispensable for photography. The telescope must be balanced with a counterweight. A motor will enable this mount to turn the telescope and follow the stars. They are often computerized. Any type of scope may be paired with an equatorial.

An Equatorial mount



A very large fork mount

Fork mounts are almost always seen on catadioptric telescopes and are typically fully computerized. They will follow the stars once properly set up and are actually a modification of an equatorial mount without the counterweights. Despite being fully computerized they can be remarkably difficult for the beginner to set up.

So Which Kind Do I Buy?

The proper kind of telescope to own is the one that you will use; all other considerations are meaningless unless you can be motivated to drag it outside on a regular basis. Bigger is better for a telescope, but if it is so heavy you can't move it there is no point in owning it. Conversely small scopes are easily portable, but you just can't see as much with them; you will be disappointed with the scope and it will remain in the closet. If you love photography, you probably won't like a Dob. The point is to find a happy medium.

There are several purely practical considerations that must be carefully considered *before* purchase:

1. **How much money can you afford?**
   As mentioned above a useful instrument can be had for as little as $350 in a dobsonian style and the price goes up - way up – from there. Still it's possible to get a decent sized dobsonian reflector without electronics that will give you a lifetime of magnificent viewing for well under $1,000. Electronics and/or sophisticated mounts make the telescope cost sharply higher. Cost increases still more if you want to take photos.

2. **What is your physical condition? (How heavy an item can you lift?)**
   "Portable" telescopes can run from 20 pounds to well in excess of 200 pounds. Many telescopes can breakdown into smaller pieces for transport – some cannot.

3. **Where can you store it?**
   Telescopes are bulky objects; they tend not to fit in closets very well. They often wind up in living rooms – spouses may object. On the other hand, they make interesting conversation pieces…

4. **What kind of vehicle is available to transport it?**
   Gross weight of the telescope is not a large factor for vehicular transport, except if you must lift the scope into the vehicle - *volume* of the telescope is. Telescope tubes run between 4 and 8 feet long depending on the aperture and other factors. Catadioptric telescopes are about half that. Truss tube telescopes may be disassembled. Don't forget you must transport the mount also!

Ask any telescope owner and he/she will tell you several workarounds to all these questions, but in the final analysis at least one of these questions is going to be the limiting factor.

The Solution

The solution is simple: Try before you buy! Come out to our dark site on one of the viewing nights. There you will find at least a dozen different kinds of telescopes with owners happy to show you how to use them. Soon you will find a telescope type that suits you.

Glossary of Common Telescope Terms

Aberration:	A defect in an optical system.
Achromatic:	A lens corrected for chromatic aberration using two lenses glued together.
Aperture:	Diameter of the lens or main mirror.
Apochromatic:	A lens corrected for chromatic aberration using three or more lenses glued together.
Catadioptric:	One of the three common types of telescopes – uses lenses and mirrors.
Collimation:	The process of aligning the optical axis of a reflector.
Coma:	A flaring of star images.
Diffraction:	Tiny bending of light around an object. Unavoidable in all optical systems.
Dobsonian:	A simply constructed and very useful mount invented by John Dobson.
Equatorial:	A mount that allows your telescope to rotate around Earth's axis.
Eyepiece:	A special kind of magnifying glass located at the end of a telescope's light path.
Eye Relief:	The maximum distance between your eye and eyepiece where the full field of view can still be seen. Of most use for people who wear glasses.
Field of View:	What the eye can see through the eyepiece. Can be actual or apparent. Usually measured in degrees.
Focal Length:	The distance from objective to the focal point. Usually given in millimeters.
Focus:	The point where light rays converge to form an image.
Fork mount:	A common type of computerized telescope mount.
Limiting Magnitude:	The faintest star a person with normal eyesight can see on a dark night.
Magnification:	Calculated by dividing the focal length of the eyepiece into the focal length of the telescope. Maximum useful magnification is 50 power for every inch of aperture, but your best views will be less than half that.
Maksutov:	A common type of Catadioptric telescope
Newtonian:	The most popular type of reflecting telescope - invented by Sir Isaac Newton
Objective:	The main light gathering device for a telescope. Either a lens or a mirror.
Paraboloid:	A surface that is curved like a parabola (like a telescope mirror).
Reflector:	One of the three common types of telescopes – uses mirrors.
Refractor:	One of the three common types of telescopes – uses lenses.
Resolution:	Calculated as the minimum distance two sixth magnitude stars can be apart and still be seen as separate. Usually given in seconds of an arc. Not the same as magnification.
Schmidt-Cassegrain:	A common type of Catadioptric telescope
Setting Circles:	A pair of graduated circles on an equatorially mounted telescope used for locating a celestial object.

Other Telescope Solutions

If you have gotten this far you must be fairly serious about buying a telescope. Above is a list of four considerations that must be taken into account before purchase – I also hinted some possible workarounds if one or more of these considerations is preventing you from owning your dream telescope. No solution is perfect however! By circumventing one consideration you may run head on into another one!

1. Not enough money. **Solution:** make your own telescope. This won't save money on the smaller telescope sizes if you purchase a mirror. Making your own telescope does save you money on the larger sizes, say 16 inches on up at a guess, even if you do purchase the mirror. Needless to say, you must be reasonably competent with tools and follow the instructions with almost religious fervor. Still, lots of people do it – I've made two. Making your own mirror can save you a bundle – but it takes a great deal of time; if you are good at it you can make a mirror better than the commercial ones. Whether you make your own mirror or not, dollar for dollar a home-made telescope tends to be better than the commercial ones.

2. Telescope too big to fit in small car. **Solution:** A truss tube telescope is the way you want to go if you can't upgrade the car. You can put a ten-inch f/5 truss-tube reflector in a subcompact car easy, although you may not fit any passengers. It does take time to assemble and disassemble the telescope, but is far better than having a tiny telescope instead. You can also consider a catadioptric.

3. Telescope too heavy to pick up. **Solution:** There are several solutions, but they require a fairly large vehicle or a trailer. You can put a 20-inch, 200-pound telescope in a minivan or SUV with a pair of wheelbarrow wheels and a ramp. It might even go into a hatchback. You can put a 500-pound telescope in a pickup truck with 4 trailer jacks attached to the scope and an electric winch – and you won't even raise a sweat or hurt your back. You can do similar things with smaller scopes and smaller vehicles.

4. No storage space. **Solution:** No doubt the very hardest problem of all! If a catadioptric won't work for you, you could custom design a truss tube telescope to fit inside of its own (box) stand, put a piece of plywood over it, add a lamp and call it an end table. You could easily put the truss poles in a closet, they take up almost no space. Your spouse probably won't go for it, but the solution would work very well for a dorm room or singles apartment. I never claimed the end table/telescope idea was easy!

Out of the Box Hint

Always, always, always assemble your new telescope for the first time at home in broad daylight. You must be thoroughly familiar with the assembly and operation of your new telescope before you take it to a dark site. Remember you must be able to assemble, operate, and disassemble your telescope in complete darkness. Dropping a small part in the dark could mean its loss as telescope nuts and bolts are typically painted black.