Telescope Accessories (Visual)

Now that you have read the previous essay about what to look for in a telescope you have probably acquired a telescope or have seriously narrowed down the possibilities. It's time to think about purchasing some accessories. But first you need to run some numbers on your telescope to find out possibly what kind of accessories would be most useful. To help, I have put together an excel spreadsheet where you can just drop in a few numbers provided by the manufacturer and it spits out the answers. For those of you that do not have the ability to work with excel I have provided the appropriate equations in the glossary. Yes, a little math is required, but most of it is pretty simple and may well prevent you from making hundreds of dollars worth of mistakes.

The first numbers you need to know are your aperture in millimeters (mm) and your focal length, also in millimeters. Dividing focal length by aperture gives the f/ratio (likely your manufacturer has already calculated it for you). A low f/ratio (e.g. f/5) means your telescope is a wide or rich field telescope suited for viewing large objects such as star clusters. A high f/ratio (e.g. f/11) means the telescope will be best suited for smaller objects like planets. There are plenty of telescopes that fall in between.

This doesn't mean you can't view other types of objects, just that it's a little easier to view certain types. In a wide field telescope, it's easy to get low magnifications which will show a relatively broad sweep of the sky, while with an f/11 'scope it's easy to get high magnifications to view tiny objects like planets.

It's no secret, all things otherwise equal, that bigger is always better when looking at faint objects. Bigger telescopes will see fainter objects better than smaller telescopes. How faint? You need to figure your telescopes limiting magnitude; in other words, the faintest star you can see. Instructions how to do that are in the glossary. It's a pretty useful number to know. For the sake of the argument let's say it's 14.0. Right away you know that if you want to track down a particular quasar that shines at 14.2 - you're not going to see it. In point of fact, the calculated 14.0 is rather theoretical; innumerable outside conditions effect this calculated maximum, lowering it. The three biggest variables being weather conditions, light pollution and your own eyesight.

How much will your telescope magnify? In a mathematical sense any telescope can magnify any amount desired by selecting the right eyepiece. But no experienced person is going to expect to see anything using 600 power on a 3-inch aperture telescope. Consider for a moment a newspaper photo or a computer screen. Use a magnifying glass to magnify the image; at some point the picture will resolve itself into tiny dots (pixels). Increased magnification beyond this point revels no additional detail, just increased space between the pixels - no detail there to see. The real world view in a telescope is not composed of pixels of course, but you can and do lose contrast with increasing magnification. Long before you reach 600 power on the hypothetical example the image devolves into a dim gray fog.

The rule of thumb on magnification generally used is 50 power for every inch of aperture. For a three inch telescope the maximum power is no higher than 150. For a ten inch it's 500. That's the *maximum* power - most of the time you will prefer to use less than half of this amount. It gets even worse, located at the bottom of a sea of air a telescope is limited to around 400 power on a good night no matter how large it is; the atmosphere almost never allows you to make full use of magnification.

Strangely, your telescope also has a *minimum* magnification for greatest efficiency. If the magnification on your telescope is too low, the beam of light leaving your eyepiece (called the exit pupil) is too wide to entirely enter your own pupil and strikes the iris instead. The image you see may still be pleasing, but you are wasting light. You paid a lot of money to get that light so you might as well use it.

Related, *but not identical to*, magnification is resolution. For a telescope, resolution is defined as the closest distance, in arcseconds, two sixth magnitude stars can be and the telescope can still separate them. Generally speaking, resolution is directly proportional to aperture *i.e.* twice the aperture will give twice the resolution. As with everything else the atmosphere will put a limit on the possible resolution on any given night. The maximum resolution will only be achieved if your telescope is in orbit.

Accessories

Eyepieces are the first thing that pops into your head when telescope accessories are mentioned. Your telescope probably came with one or two and to tell the truth you might only *need* two eyepieces. One for low power and one for high power. Still you might want to upgrade the eyepieces that came with the scope or you have a fancy to try very low power eyepieces or even higher power eyepieces, larger fields view, better eye relief etc. If so, read on.

At its core an eyepiece is nothing more than a specialized magnifying glass. The telescope lens or mirror forms a virtual image inside your focuser and the eyepiece takes this image and magnifies it. You could even use a regular magnifying glass instead of an eyepiece if you tried hard enough. It would be foolish to do though; the modern eyepiece is optimized to preserve the best contrast while losing the minimum amount of light along with creating what's called a flat field. Also eyepiece design is hugely important in creating a good field of view.

Eyepieces made for serious amateurs come in two different sizes 1.25 inch and 2 inch. Clearly it goes without saying you need to understand which size(s) fit your focuser. The two inchers create a "picture window" view of the sky while the 1.25 inch ones are better for magnification. Typically, if you own an eight inch telescope or larger a 2-inch compatible focuser is a good idea.

The same eyepiece can create different magnifications in different telescopes. The magnification an eyepiece provides is given by dividing telescope focal length by eyepiece focal length. For example a 25mm eyepiece will give 50 power on a 1250mm telescope focal length and 100 power on a 2500mm focal length telescope.

Good eyepieces can be expensive. It's easy to drop way over $200 on one. In general, in a given model line, the longer the eyepiece focal length - the greater the price. It works the opposite way also, the shorter the focal length - the smaller the price. The various models available can be rather confusing and the best advice is don't buy any of them right away. Instead, borrow some eyepieces from your friends and try them out on your telescope some evening. You will find out pretty quickly which eyepieces you like best.

You will likely find out that plossals are good general purpose eyepieces at an affordable price while Naglers are the Cadillac of eyepieces. There are plenty of models in between.

Two more considerations for eyepiece purchase: Apparent Field of View (AFOV) and eye relief. AFOV is simply the available field of view when looking through the eyepiece as opposed to the actual field of view. In a top of the line eyepiece the AFOV might be 100 degrees while the actual field of view may be only a small fraction of one degree. The minimum acceptable AFOV is considered to be around 45 degrees. Sometimes in two different eyepieces the AFOV and the focal length combine in such a way as to yield the same actual field of view. Likely you should not bother to purchase both of them. The spreadsheet has a calculation that shows when this happens.

Eye relief is the furthest distance your eye can be from the surface of the eyepiece and still see the entire AFOV, measured in millimeters (mm). While a comfort to everyone it is of enormous importance to eyeglass wearers. For this purpose, the eye relief should be about 20mm. The actual distance may vary between different pairs of eyeglasses which is yet another reason to try before you buy. In general, eye relief decreases as the focal length goes down and the AFOV goes up. There is a clever trick available to keep the eye relief up to acceptable levels discussed later.

Many eyeglass wearers can remove their glasses while viewing as your focuser can compensate easily for nearsightedness or farsightedness, but be aware if you give public viewings your scope will be out of focus for everyone else. Astigmatics must keep their glasses on as a focuser can not compensate for that vision problem.

A barlow lens is a handy accessory to own. It is a tube containing a negative lens that gets inserted between your focuser and eyepiece. The function of the negative lens is to increase the effective focal length of your telescope and proportionately increase the magnification of any eyepiece attached to it. Doubling barlows (2x) are the most common, but 3x and even 5x ones are available. Owning a barlow will double the range of magnifications your eyepiece collection can provide at a very reasonable cost. As a major bonus, while the eyepiece magnification is doubled or tripled, the eye relief the eyepiece provides remains the same. thus endearing barlows to eyeglass wearers everywhere.

When using a barlow there are a couple of caveats. First, the extra lens will absorb a little extra light and you will not be able to see dim objects quite as well with the barlow in place. Many people do not use them for that reason. Secondly, the barlow must be of comparable quality to the eyepiece you are using. In other words, don't expect your $300 eyepiece to perform well if your barlow is a $30 fire sale special.

Finders are an accessory every telescope owner must own. You need at least one and will probably want two unless you own a marvelous computer. (I have four!) As mentioned above, eyepieces only have an actual field of view of a fraction of a degree; it's just not possible to locate a particular object in the sky except by incredible luck – thus the finder was invented. They come in a number of different styles; the best one is a matter of personal choice.

Almost everyone will own some version of a red dot finder. (Technically it is called a "reflex sight"). This device, while providing no actual magnification, will appear to throw a red dot, (or circles, rectangles or cross hairs depending on the model) upon the sky. The owner simply places the red dot on the object to be viewed and then looks through his eyepiece. It just does not get any easier than that. Always carry a spare battery!

The obvious limitation of a red dot finder is you have to be able to actually see an object with your naked eye to point your telescope at it. With some practice you can get pretty close to an invisible object, but rarely hit it the first time. Charts have been developed that show where the reflex finders circles should be placed in relation to nearby stars so the invisible object will be centered.

Many, many times the reflex finder just can't do the job. You can get close, but just can't seem to hit the object. For that you need a small auxiliary telescope attached to the main one. It only magnifies the sky a tiny bit, 5 or 10 times, and thus has a fairly wide field of view – usually around 5 degrees. The reflex finder's job then is to get you close, and then switch to the magnifying finder to bring you in the rest of the way. Even if the object is still invisible, background stars will always show up to help you pin down the exact location.

Standard magnifying finders come in three different configurations, straight through (upside down image), right angle (reversed image) and right angle (correct image). Again the configuration you choose is a very personal choice. The upside down image probably is most useful if you own a reflector as then the image will match the orientation in the main telescope. Likewise, the reversed image configuration will match up well with a refractor as the main 'scope. The correct image finder is used by those that get disoriented switching between the reflex, magnifying finder and charts. (At least I do.) The proper approach to selecting a finder is to try out someone else's.

Magnifying finders are sold using the same descriptions binoculars are sold by: i.e. 7x35, 9x50. The first number is the magnification the second is the diameter of the objective in millimeters. Probably any objective under 30mm just isn't worth the money or trouble.

Large ones like 80mm might cause your small telescope to become unbalanced and are rather expensive.

Careful thought must be given as to how the finder(s) will be mounted. Finders sold by a different manufacturer than your main scope will likely not fit your telescope. A different mounting bracket will be required. This means drilling new holes in your telescope; if you are uncomfortable doing this, consider a different finder. As mentioned above, a finder may cause your telescope to become unbalanced. If so, you have two choices: 1) rebalance the telescope using weights, 2) move the finder closer to the center of gravity.

Filters are a great asset to the amateur astronomer. They enhance the detail of the object viewed by (usually) increasing the contrast between the object and the background. They come in two sizes identical to eyepieces: 1.25 inch and 2 inch. Threads are cut in the barrel end where a filter may be screwed in. If your 2 inch focuser has an adapter for 1.25 eyepieces it may have 2 inch threads on the bottom end. If so, you will be able to use a 2 inch filter with 1.25 inch eyepieces. Otherwise you will need buy such an adapter.

Filter types	Purpose
Colored, red, green, blue etc	Used for viewing planets
Neutral Density	Used for viewing the Moon, Venus
OIII	Emission Nebula viewing
Hydrogen Beta	Emission Nebula viewing
Light Pollution	Emission Nebula viewing
Solar	The Sun

Colored filters subtly enhance the surface features of planets. Probably not worth buying unless planets are your main interest.

Neutral Density filters only allow 10% or so of light through – sort of like sunglasses for the Moon! Hint: If you don’t want to buy a neutral density filter actually wear real sunglasses when viewing the Moon!

OIII only allows light from the ionized oxygen atom through. Provides huge amount of contrast on both bright and faint nebulas. Only usable on telescopes 8 inches and up. If you can only own one filter, pick the OIII if your telescope is large enough.

Hydrogen Beta only allows light from ionized Hydrogen through. Most useful on special nebulas like the Horsehead and the California. Probably need at least a 10 inch or larger for this filter.

Light Pollution filters block light from manmade sources such as streetlights. Makes the sky darker but dims the stars too. Works fairly well on nebulas. They are cheaper than OIII filters and function decently on smaller telescopes than the OIII does.

Solar filters allow safe viewing of the Sun. Only use full aperture filters! Only use on solid tube telescopes – not truss. Follow manufacturer's instructions carefully as solar viewing can be hazardous!

Focusers are an indispensable accessory found on all telescopes. They come in three different basic styles. The helical, rack and pinion, and the crayford. Focusers come in different sizes as well, the two most useful to amateurs are 1.25 inch and 2 inch (just like eyepieces, no surprise there!)

Helical focusers are rarely seen anymore except perhaps on telescopes made prior to the 1970's. They function by screwing the eyepiece holder in and out in order to achieve focus; helicals are very precise, achieve excellent focus, and are fairly inexpensive. However, they are *slow*; switch an eyepiece and it seems like forever before you can screw it down enough to get it back in focus, by which time the object you are looking at has left the field of view. It's no wonder you don't see them anymore.

Rack and pinion focusers use a gearing system connected to a wheel. They are fast, intuitive and probably your telescope came with one pre-installed. The only real fault they have is that sometimes it can be difficult to get absolutely perfect focus; pretty good is easy, but perfect not so much.

Crayford focusers have a frictional device attached to a wheel and can focus very precisely. Many have an additional wheel geared 10:1 for extremely fine focus. A good many amateurs will want to upgrade to a crayford.

If you own an 8-inch or larger telescope with a 1.25 inch focuser you will probably want to upgrade to a 2 inch focuser at some point. This can be easy or quite difficult depending on your equipment and you might have to make modifications to your telescope. It pays to study the situation before plunking down your hard earned cash on a top of the line focuser.

Collimation tools are a requirement for anyone who owns a reflector. Whole *books* have been written on the art of proper collimation. Unless you have disassembled your telescope for cleaning, collimation of your telescope normally takes only a couple of minutes each time you take it outside. A lot of collimation tools are available for purchase but the two most commonly encountered are Laser Collimators and Collimating Eyepieces. The collimating eyepieces will do an almost perfect job with practice, but require daylight for ease of use. Manufacturers claim a flashlight can be used after dark, but don't believe them! Laser collimators can be used in both daylight and darkness but the operator can be fooled fairly easily into doing a poor job; when that happens the only recovery is to use a collimating eyepiece. Lasers tend to work best for a quick tune-up after darkness falls.

See next page for a Glossary.

Glossary:

Angular measurements: One degree = 60 minutes of arc (arc minutes) = 3600 seconds of arc (arcseconds)

Aperture: The diameter of your main lens or mirror measured in millimeters (mm)

Barlow Lens: An accessory containing a negative lens which effectively doubles (or more) the magnification an eyepiece can give

Collimation: The process of aligning the optical axis of your telescope.

f ratio (f/): calculated by [telescope focal length ÷ aperture]

Filter: a glass plate inserted into the optical pathway used to enhance the view.

Finder: an auxiliary pointing aid attached to your telescope.

Focal Length: The distance in millimeters from your lens or main mirror to the point where all light rays converge. Usually given by the manufacturer. Both telescopes and eyepieces have focal lengths.

Limiting Magnitude: The faintest star your telescope can see given perfect conditions. Calculated by [2.7+ 5(log(aperture))]

Magnification: The amount the telescope + eyepiece will increase the natural size of the object viewed. Calculated by [telescope focal length] ÷ [Eyepiece focal length]

Magnification, Maximum Theoretical: A rule of thumb calculation given by 50x for every inch of aperture or [2 x aperture(mm)]

Magnification, Minimum: The least amount of magnification you should use so your eye receives the greatest amount of light available. Approximately given by

$$\frac{\text{Telescope focal length}}{\text{f/ratio} \times 7}$$

Objective: the main light gathering device of your telescope – can be either a lens or a mirror. Diameters can be stated in inches or millimeters.

Resolution (Dawes Limit) the minimum distance two 6th magnitude stars can be separated and the telescope will still be able to split them. Angular separation is measured in arcseconds. Given by [116 ÷ aperture]