Astronomy with low-moderate cost equipment

As we enjoy the cool, crisp nights of fall and the holidays not so far away, people are shopping for equipment to view the night sky with. The purpose of this short article is to describe, in a very brief manner, what can be done on a very low budget (under $100) to what could be considered a moderate budget ($600-1000). This easily includes 120 mm refractors, 10" reflectors, or a pair of 80 mm binoculars. Today such formidable instruments can be had for well less than $1,000. For just over $1,000 you will find some very capable telescopes. The scope of this article is about equipment from the least expensive up to about $1,500.

Under $100

Here you will find a lot of "toy" telescopes. Most 50 mm refractors, some 60 mm refractors, and some 3" (76 mm) reflectors.

How can you tell if the telescope is a "toy"? First, the most telling feature will be the size of the eyepiece. The standard for small telescopes is 1.25". There are some telescopes with .965" eyepieces. These smaller eyepieces are a sure indication of a "toy" telescope that will provide little satisfaction. The other giveaway is the telescope's magnification is the major selling point. The numbers quoted will be very high. Magnifications of 375x, 525x and even 675x are not realistic for a telescope this size. There is a formula that can be used to determine your telescopes maximum practical magnification under excellent seeing conditions. Take the aperture of the telescope in millimeters and double it. For example, a 60 mm refractor is good to about 120x. An 8" (203 mm) reflector is good to about 400x. Telescopes with less than steady mounts or less than superb optics can't realistically be used at their maximum magnification. In reality, 400x is very ambitious for any telescope. Often our atmosphere is the reason for this. Some of the finest observatories in the world sit atop high mountains. There's a reason for this, less atmosphere to look through. The Hubble Space Telescope is in orbit high above our atmosphere. This is the reason it is capable of such magnificent images.

3" Newtonian

The fact is, few telescopes under $100 can satisfy even the most casual observer. If you own such a telescope already, you may want to invest in a better quality eyepiece or two to salvage the telescope. While most .965" eyepieces supplied with telescopes are of the two element variety, either Ramsden or Huygen, it is not impossible to find up a "step up" to three element eyepieces of the modified achromat or Kellner variety. At 25x to 75x these modest scopes perform at their best.

There is an alternative however. Some binoculars that are less than $100 can provide acceptable results. First, look for a pair with at least 50 mm objectives. When binoculars are described as 8x21, 10x25 7x35, 8x40, 7x50, 10x50, etc. The first number is magnification. The second number is the size of the objective. When you divide the magnification into the objective size, you get what is known as the exit pupil. This is how big the disk of light is coming from the eyepieces. At night, depending on how dark the location you are at and your age, your pupils open up to 4-7 mm. A young observer in a rural area might have pupils that open to about 7 mm. A middle-aged observer in a light-polluted suburb or small city may have pupils that only open to 5 mm. So, a pair of 10x50s with their 5 mm exit pupils, are perfect for my middle aged eyes in a small city with lots of street lights, in the outer suburbs of NYC. There are some good, though not great 50 mm binoculars for well under $100. There are some 8x56, 10x60, and 12x60 binoculars that are about $100 on the market. Again, I'd call them good, but certainly not great.

What are you going to see with say a 60 mm refractor? The easiest target would have to be the Moon. Depending on your eyepiece's field of view, 50-60x magnification will fill your eyepiece with the Moon. How do you figure the magnification a certain eyepiece yields? Take the focal length of the telescope, let's say it's 700 mm. Divide the focal length of the telescope by the focal length of the eyepiece, lets say it's 10 mm. 700 mm divided by 10 mm would therefore mean 70x magnification. At 50x you will see all the major craters, maria (seas) as well as mountains and other formations. Going up to a moderate magnification such as 100x brings significantly more craters into view, some perhaps as small as five miles across. The detail is staggering, even in a small telescope.

Other easy targets to find would be Jupiter, Saturn, Venus and Mars. Jupiter is often the brightest "star" in the night sky, only exceeded by the Moon and the Sun. With a small telescope at 100x, you will see the planet

has as many as four tiny points of light to either side of it. These are Jupiter's four largest moons. Looking at the planet, you will notice probably two parallel dark bands on it. Saturn, is a yellowish "star" that presently is found above and to the right of Jupiter. With a small telescope, the first thing you will see is the rings. Yes, at 100x the rings are very prominent! You might even detect the largest moon in our solar system as a tiny point near Saturn. There is a lot more texture and details to be seen in these two giant planets on larger telescopes. Next is Venus, which you will see fairly low in the sky near sunrise or sunset. Venus is the closest planet to Earth. It is very bright, most often as bright as Jupiter. Venus' thick clouds reveal little if any detail of the planet no matter what telescope. Venus will appear as a large thin crescent to a nearly full disk in a small telescope at 100x. It goes through phases just as our moon does, because it's between the Earth and the Sun. Last comes Mars. Mars, too, is very close to the Earth. Unfortunately, it's not such a large planet. In all small to moderate telescopes, Mars is an orange disk.

Some of your deep sky subjects will be visible, but they will tend to faint gray blurs.

$100 to $200

So you've had the bad news. At less than $100 you're faced with some slim pickings. Here's the good news: At just over $100 can find a better 3" reflector or 60 mm refractor with a good 1.25" Kellner eyepiece. Such telescopes provide a bit more satisfaction. As you get close to $200, there are some 70mm refractors and even a few 4.5" reflectors, perhaps even with good 1.25" eyepieces. Now you'll start to see a noticeable improvement.

70mm refractor on Altizimuth mount

Likewise binoculars take a dramatic turn for the better when they are over $100. In a pair of 7x50s or 10x50s you should expect the superior BaK-4 prisms, as opposed to the cheaper BK-7 prisms. The optics should be multi coated, which will improve contrast and reduce glare.

Not only do binoculars get better, they get bigger as well. 9x63s, even some 11x70s or 15x70s are available within this price range.

What you see in a 70mm refractor or a 3" refractor is a little better than what you'd see in a 60mm refractor, as previously described, but not significantly.

The Catskills Astronomy Club doesn't endorse one brand or type of telescope over another.

Obviously, the cost of the equipment is going to have a large impact on what you'll be able to see, but what is the "perfect telescope" for your needs?

Only you can determine this for yourself. This guide is only just that, a guide. Some of the best chances to talk about and look through a variety of telescopes is at a star party, like the one's we host every month. We hope to see you at our next!

$200 to $400

Now things get easy. There are many telescopes in this price range that by all standards would be called "good." 4.5" Newtonians on a reasonably steady equatorial mount, 6" Dobsonian mount Newtonians, also 80 and 90 mm refractors. The ease of use and large aperture for the price makes Dobsonian mount Newtonians an excellent buy. In the past, there were 4.5" Newtonians on solid equatorial mounts. Today, unfortunately, most are on inadequate mounts with mediocre optics.

In this price range, you will see a lot of refractors and reflectors with short tubes, often referred to as "short tube", "rich field", "wide angle" and other names. While very compact and portable, there is a price to this. First, a short refractor is going to show a lot of false color, for example, the Moon will have a purple halo around it. Also, the short telescopes require a very short eyepiece to achieve even a moderate magnification. Short eyepieces require than you come uncomfortably close to them before you see the image.

Any telescope in this price range should have a 6x30 finder scope rather than a 5x24, but certainly there are some that don't. Likewise, the telescopes in this price range should have 1.25" eyepieces and certainly better than the Ramsden or Huygen variety, but some don't.

In this price range, and beyond, you now find many computerized telescopes that claim to give you a tour of the universe. The problem is while they have a database of more than 10,000 objects, many of these objects are not visible in modest sized telescopes. The ones that are visible , will leave you unimpressed. Also these telescopes often guarantee an accuracy of only one degree. Even at low magnifications, being off by one degree means the desired target may not

be in the eyepiece. The Moon is about one half degree, in other words, you could be off your mark by quite a bit. Rather than investing in "gimmicky" plastic telescopes of dubious quality, for the same money, one could invest in a much more substantial and capable telescope.

6" donsonian

With larger 6" reflectors you will see a great increase in detail of deep sky objects. For example, looking at M13, a globular cluster in Hercules, individual stars start to become visible. When looking at the Moon, smaller craters, perhaps 2 miles across, that aren't even identified in most lunar maps, are discernable. The cloud structure of Jupiter and Saturn becomes much more visible, as will details in Saturn's rings. While in a small telescope it's easy to see Jupiter's four largest moons, as well as Saturn's largest moon, with a 6" telescope one will notice some of Saturn's "medium sized" moons, Rhea and Iapetus. Uranus and Neptune start to look like a fuzzy disk and start to show color. Again in this price range are some excellent smaller binoculars, and good 70 and 80 mm giant binoculars. Keep in mind that these larger binoculars will need to mounted on a tripod or binocular mount to be most effective.

$400 to 800

In this price range, things are getting serious. You will find 8" reflectors on both dobsonian and equatorial mounts. You will find 10" reflectors on dobsonian mounts. Also you will find 4" and 4.7" refractors on equatorial mounts. Finally, you will find an interesting type of telescope not mentioned in previous sections, the catadioptric. Two popular types of catadioptrics are Schmidt-Cassegrains and Maksutov-Cassegrains, the most popular being Schmidt-Cassegrains commonly referred to as SCTs.

5" Schmidt-Cassegrain

One characteristic about SCTs to note is their small size relative to their aperture and the long focal length, which is often f/10. Here's another term you'll see describing focal length, or f/ number. What that number simply means is the relationship between the aperture and the focal length. A 125 mm f/10 SCT has a focal length of 1250 mm. A 6" (150mm) f/8 reflector has a focal length of 1200 mm, almost as much as the 5" SCT, but look at the two telescopes. The 5" SCT has a tube that's about one third the length of the of 6" reflector. This is because the design of the SCT "folds" light inside the tube. The result is a much smaller telescope. Many people choose these SCTs as their "travel scopes." Their light weight and small size allows them to be placed on smaller mounts and still remain steady. Some SCTs are computerized. They often suffer the same inadequacies that their smaller computerized relatives have. Fair accuracy in finding subjects and small aperture for their cost. We are not necessarily against computerized telescopes, but for your most important features, common to all telescopes, you should be looking for large aperture, quality optics, and most often overlooked, a steady mount. Without these basics, you will not enjoy the telescope.

Medium sized refractors for China, mainly the 102 mm (4") and 120 mm variety have stormed the market the past few years. In the past, a 102 mm refractor from Japan was nearly twice the price. From informal observations these new refractors are very good, not far off from their more costly predecessors. The one caveat to watch out for is the quality of the mount, which has suffered from this cost cutting. While in the past, wooden legs which dampen vibrations a bit quicker, have given way to aluminum legs. In some cases, the equatorial head is a little less substantial. If you look around, these refractors are sold under various brand names by several companies, but in some cases, the mount can differ. If you are good with tools, you could make your own wooden legs fairly inexpen-

120 mm refractor on eq. mount

sively, or for about $160 there is a company that makes wooden legs as a retrofit for these mounts.

Despite these telescopes moderate aperture and slight to moderate false color (a fault all refractors have that are shorter than f/10 or f/12, unless they are the much more costly APO variety) many people enjoy their very sharp lunar and planetary views.

As in other cases, the reflector type telescope is less costly per inch of aperture than any other type. With 10" dobsonian mounted telescopes, you will see an incredible amount of detail and structure in deep sky objects. The clouds of Jupiter and Saturn have "text book" detail. Now two more medium sized moons of Saturn can be seen, Dione and Tethys. Looking at our own moon, craters smaller than two miles across can be seen, atmospheric conditions permitting.

In this price range, you can find binoculars that are both large (70-80 mm objectives) and offer impressive quality. These large binoculars require a mount to hold them and can offer the user stunning views. They are an excellent complement to a telescope. Some people don't think about binoculars as useful tools for astronomy. Comet hunters prefer binoculars. The brilliant Comet Hyakutake (C/1996 B2) was discovered in a pair of large 25x150s by an amateur astronomer!

80 mm binoculars

$800 to $1500

This price range represents the "high end" for many amateur astronomers. Dobsonian mounted reflectors could be easily found in the 10" or 12.5" size in this price range. Some slightly larger dobs are at the very upper end of this range or just beyond it. While most reflectors in previous sections have good optics, many dob owners take extremely high quality optics over a larger size. For example, a 10" dob with what many consider the finest mirror found in amateur telescopes is about $1500. At the same price, a 14" with good optics can also be had. There's pro's and con's to either choice, far beyond the scope of this brief guide.

8" SCT on non computerized, heavy duty, motorized mount

With these large dobs tiny Mars finally begins to show a little surface detail. Jupiter and Saturn show an impressive amount of surface detail. Saturn reveals yet another moon, Enceladus which while not very large and fairly close to Saturn, it has the highest surface brightness of any moon in the solar system. Large telescopes such as these coupled with a keen eye and you have a chance of seeing the larger moons of Uranus Oberon and Titania, smaller and closer to Uranus are Umbriel and Ariel, these are a great challenge for amateur observers, as well as Neptune's Triton. Saturn's tiny Mimas and Hyperion might just be the limit of amateur telescopes.

Of course where these large telescopes really shine is in their ability to show you detail in deep space objects. I couldn't better describe it than with one word, "wow!"

So you want to take photos? You may have noticed no mention of photographic ability in previous sections. The reason is simple, inexpensive telescopes have only a marginal ability to take photos at best. In this price range you just begin to see telescopes who's mounts are steady enough and motors are accurate enough to make an exposure longer than one second. Optically, lesser telescopes may be up to the task, but the mount is not.

Premium quality 10" dob with plywood construction

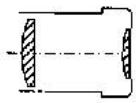
There are some 8" SCTs on solid, non computerized mounts for about $1,500. To many this is the entry level point to astrophotography.

There is a 6" refractor that came to the market within the last year. Depending on the vendor, it goes for $900 to 1,200. Never before has such a large refractor cost so little. It has caused quite a stir. It is only an f/8, so a fair amount of false color can be detected. The mount is marginal, but the image is very sharp.

There are certainly telescopes that are more than $1,500. They are more advanced than the scope of this article.

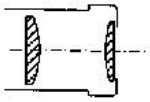
Eyepieces

Telescopes are only 1/2 of the equation. Just as important is the eyepieces you choose. Here is a brief description of several common eyepieces.



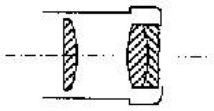
Huygens

Huygens date from the 17th century. They are a simple design named after their creator, Christiaan Huygens. He was a Dutch astronomer who was the first to desribe the nature of Saturn's rings. He also discovered Saturn's largest moon, Titan. While his contribution to astronomy was significant, these eyepieces would be best left to the history books. The can be identified by being marked "H" and are popular with cheap department store telescopes.



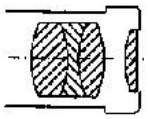
Ramsden

Ramsden eyepieces date back to the 18th and very early 19th century. They are named for their English designer Jesse Ramsden. In his time, he was considered the maker of the finest telescopes and optics. Alas, the time of these eyepieces has also gone. They two are simple two element designs marked "R" "SR" and "F" and are popular with cheap department store telescopes.



Kellner

Kellner eyepieces and their variations, Modified Achromats and RKEs are three element eyepieces also with roots in the 19th century. A modern version with coated optics is the entry level point into what is a good eyepiece. They tend to be fairly sharp, offer a moderate field of view (40° to 50°) and good color correction. There tended to be a little problem with internal reflections, but most modern coated versions do not exhibit this. They can be identified by the marking "K", "MA", "SMA" and "RKE".

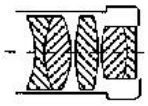


Orthoscopic

Orthoscopic or Ortho for short are four element eyepieces. They are very sharp. They tend to have a moderate field of view, 45°. They were wildly popular until the late 80's when Plossls became popular and offered a wider field of view. Some people still prefer Orthos over Plossls.

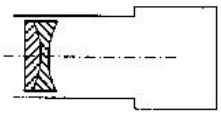
Plossl

Plossls are a design that predates Orthoscopics. For a long time manufacturing techniques prevented them from being practical and affordable. Then a company called Tele Vue offered a line of excellent Plossls at a reasonable cost. They were very successful and many other manufacturers scrambled to get their own line of Plossls on the market. The reasons were simple. Plossls offer outstanding sharpness, color correction and a somewhat wide 50° to 52° distortion free field of view. Today there are many Plossls that are about $30. There are also premium Plossls and 5 element "Super Plossls" that cost a bit more but offer performance worthy of the finest telescopes made.



Erfle

Erfles and other wide and super-wide eyepieces offer extremely wide fields of view. Anywhere from 65° to about 84° field of view. This becomes important with telescopes with long (1200mm+) focal lengths. These long telescopes can't achieve a low magnification. With the expansive field of view, this type of eyepiece, even these large telescopes can achieve a a fairly wide field of view. Many come in 2" barrels as the standard 1.25" barrel would restrict their field of view. These eyepieces tend to be large and costly, but well worth it to those with large telescopes.



Barlow

Barlows are not used on their own. They are placed between the eyepiece and the focuser and achieve a higher magnification than just an eyepiece does on it's own. For example a 1000mm focal length telescope with a 10mm eyepiece gives you a magnification of 100x. Add a 2x barlow and now the magnification is 200x. You could get the same result by using a 5mm eyepiece, but there is a drawback to that. As the focal length of eyepieces gets shorter, the eye relief gets closer as well. With most 5mm eyepieces your eye will be uncomfortably close to see into it. On the other hand, with most 10mm eyepieces you will find they eyepiece to be much further away. Barlows come in a variety of magnifications, but the most popular are 2x and 3x. Some less expensive Barlows have two elements, better ones have three. If you have high end eyepieces and an excellent telescope, you would be wise to seek out one of these three element Barlows.