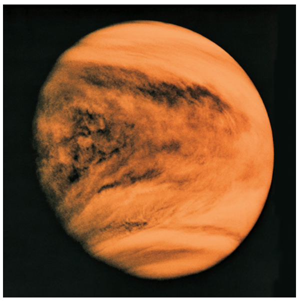
TELESCOPES

INTRODUCTION TO TELESCOPES



Optical design: Activities such as astronomy, nature studies and viewing sports must often be done at a distance. For various reasons we cannot get close enough to the subjects to view them in the detail that is needed. Our eyes are general purpose tools and their resolution is limited, their magnifying properties are minimal and they are limited in how much light that they can gather. We must use optical devices such as telescopes to increase our visual range. A telescope is an optical device which makes far objects appear closer. It samples a small area of view, a field, and then magnifies it so that distant objects appear larger. Parallel light rays entering the telescope are focussed to a single point, called the focus or focal point. These focussed rays are then magnified with a very powerful lens, or more commonly a set of lenses, called an eyepiece, to give enlarged views of distant objects. The eyepiece acts in the reverse direction to the telescope lens, taking the focussed rays and sending them to the eye as parallel rays. The diameter of the observed circle depends on the field of view of the eyepiece.

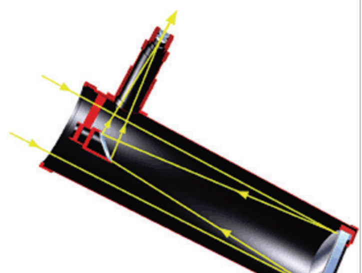
Refractors: There are two basic ways to bring light rays to a focal point. The earliest method used by telescope makers, was to bend the rays by passing them through one or more pieces of glass which had curved, polished surfaces. This method produces a type of telescope called a refractor.

Refractors

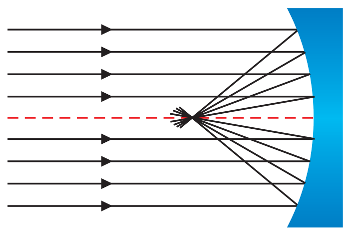
Refractors have several advantages over other designs. They are enclosed so that dust and moisture doesn't enter the optical tube. They have fixed optics so that they don't require routine collimation, which means that the optics don't have to be adjusted by the user. They do not have a central obstruction, which reduces the amount of light entering the tube and causes an alteration of the diffraction pattern. The resulting high-contrast, fine-resolution images produced are considered ideal for planetary viewing. A problem with refractors is that since many wavelengths of light are passing through glass, the uneven bending of the rays causes false colour around bright objects. This must be counteracted with additional lenses and special glass. Since at least four lens surfaces usually have to be very accurately shaped, polished and coated, they are more expensive to produce than other telescope designs.

Reflectors: The second method of focussing light is to reflect the rays off of the surface of a curved mirror, producing a type of telescope called a reflector. The most common reflectors in use today are called Newtonians because this design was invented by Isaac Newton.

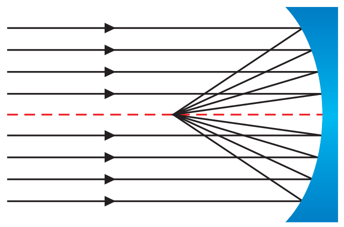
A mirror is made by coating the front surface of a concave piece of glass with a reflecting material. Light rays entering the telescope reflect off the mirror and since they never pass through the glass no false colour is produced. The surface of the mirror of a high focal ratio reflector can be shaped or figured to that of the surface of a sphere. This works for small reflectors and those with focal ratios of f/9 or higher. However, with large reflectors and those with focal ratios of f/8 or lower, these spherical mirrors do not bring all of the light rays to the same focal point. The rays from the mirror's perimeter are focussed at a different point from it's centre, resulting in an image which lacks contrast due to spherical aberration.



Reflectors



Spherical mirrors bring the light rays to different focal points, resulting in blurry images



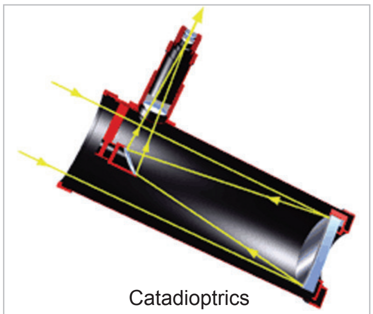
Paraboloidal mirrors bring all the light rays to the same focal point

To overcome this defect, mirror surfaces are shaped during polishing to a paraboloidal shape which focusses all of the light rays to the same point.

Since the light rays are reflected back up the optical tube by the primary mirror, they must be redirected in order to be viewed. A secondary mirror, which has a flat surface is mounted at a 45 degree angle in the centre of the tube to reflect the rays to the focal point. The secondary is usually oval in shape because this presents a circular shape when viewed from a 45 degree angle. Obstructions, such as secondary mirrors, have a limited visual effect when placed in the path of the light entering the telescope. They modify the diffraction patterns, which can cause a slight loss of contrast, and they reduce the amount of light reaching the focal point. However, they are not seen in the focussed image presented through the eyepiece.

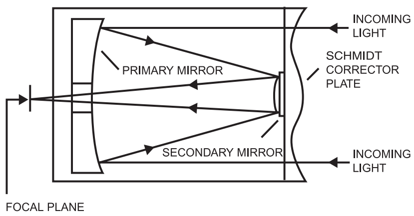
Since the eyepiece is near the front of the tube, reflectors can be mounted lower to the ground giving more convenient viewing and greater stability. Only two surfaces need to be shaped, polished and coated and these can be tested separately. This makes them less expensive to produce than other telescope designs. On the negative side, a long optical tube Newtonian on a German equatorial mount can be more susceptible to wind vibrations than shorter designs. Collimation of both mirrors is part of the regular maintenance for reflectors.

Catadioptrics: A third group of telescopes, called catadioptrics, are hybrids of the two previous methods. A catadioptric, which means mirror-lens, uses a combination of both mirrors and lenses to manipulate and focus the light rays. Examples of these are the Catadioptric-Newtonian, the Schmidt-Cassegrain, and the Maksutov-Cassegrain.



Catadioptrics

Catadioptric-Newtonian telescopes are Newtonian reflectors which are enhanced by placing a correcting lens in the light path before the focal point. The resulting Newtonian has a short physical length while its focal length is increased by the magnification of the correcting lens. In other words, if the correcting lens produces a 2x magnification and the physical length of the system is 500mm, the focal length becomes 1000mm. This design is very portable, being lighter and more compact than a normal Newtonian of the same focal length. It is easy to set up and aim and is much less subject to wind vibration. The correcting lens is factory aligned and the mirrors are user collimated like a regular Newtonian.



Schmidt-Cassegrain

Schmidt-Cassegrain telescopes: use a thin aspherical corrector plate, which is a lens carefully matched to the primary concave mirror to correct for spherical aberration. Parallel light rays enter the telescope through the corrector plate.The secondary mirror reflects the rays back down the tube and through a hole in the centre of the primary. The eyepiece can be placed directly behind the primary mirror or a diagonal can be used to change the angle at which the image is viewed. Focussing may be gained by moving the primary mirror or by moving the eyepiece. The main advan-

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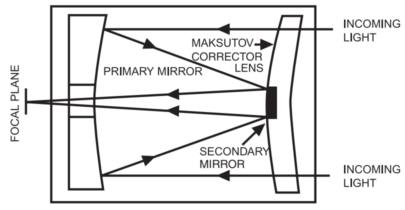
tage of this design is that, because the light path is folded back on itself, it provides a very portable, short physical length telescope with a long focal length. The main disadvantage of the design is the fairly large secondary mirror which reduces the amount of light collected and which may cause some loss of contrast.

Maksutov-Cassegrain telescopes: are similar to the Schmidt-Cassegrains. They also have a corrector plate to remove spherical aberration, but instead,they use a thick, meniscus lens other than the Schmidt lens. Light gets through the concave side of the corrector plate and the primary mirror reflects it back up the tube to the secondary which is often a mirrored spot on the convex side of the corrector plate. As with the Schmidt-Cassegrain, the light rays are reflected through a hole in the primary to reach the eyepiece. This design is easier to produce than the Schmidt-Cassegrain, it may be heavier due to the thicker corrector plate.



Maksutov-Cassegrain

IMPORTANT FEATURES TO LOOK FOR IN A TELESCOPE


Focuser

Focuser: The focus assembly is a device to bring the image into sharp focus. It usually moves the eyepiece back and forth with a rack-and-pinion or with a screw-in assembly. It should move smoothly and the image should not jump around as it is adjusted. Standard focusers accommodate eyepieces with 1.25 inch diameter barrels although 2 inch are also becoming more common.

Coatings: Coatings are thin lays applied to lenses and mirrors to enhance light transmission, protect mirror surfaces and suppress flare and colour aberrations.

Finderscope

Finderscope: A finderscope is a small auxiliary telescope, attached to and aligned with the main telescope. It has low power magnification, a wide field of view and a crosshair to aid in centre. It can help you in finding and aiming at objects which you are intended to observe through the main telescope. Most finderscopes give an upside down or left-right reverse image.

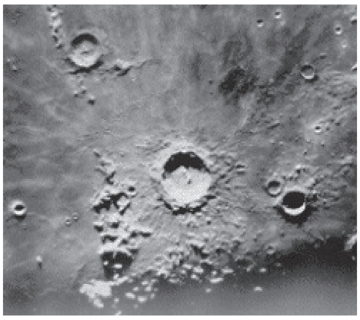
Aperture (diameter): The clear aperture of a telescope is the diameter of the objective lenses or primary mirror specified either in inches or millimetres.
The larger the aperture the more light it collects and the brighter (and sharper) the image will be. Greater detail and image clarity are observed as aperture increases.

Focal length: This is the distance (usually in millimetres) of an optical system from the lens (or primary mirror) to the point where the telescope is in focus (focal point). The longer the focal length of the telescope, generally the more magnifying power it would have and the larger the image and the smaller the field of view.

Focal ratio: This is the ratio of the focal length of the telescope to its aperture in the same units of measurement. For example, the f/ratio of a telescope with a 200mm aperture and a focal length of 1000mm is: 1000/200=5, or f/5. Telescopes of f/4 to f/6 are called “fast” systems. They offer lower magnifying power and wider fields of view than slow f/8 to f/15 systems.

IMPORTANT FEATURES TO LOOK FOR IN A TELESCOPE

Magnification: If you think the telescopes are rate by their magnifing power, then you are wrong. The fact is, telescopes are rated by their aperture of light gathering capability. It is the aperture of the telescope that determines the telescope's ability to resolve small or distant objects.



CHOOSING A TELESCOPE

There are lot different kinds of telescopes available on the market, and for the beginner, selecting one can be a very challenge experience. Before buying a telescope it is important to ask yourself the following questions:

What kind of observing do you want to do? astronomical? terrestrial? both?

Selecting a telescope for both astronomy and land viewing sounds attractive, but there are quite different requirements for each, and your choice will usually be a compromise. However, once you have decided on the telescope's main purpose, choosing one can become much easier.

If you have decided that your telescope will be used primarily for observing the night sky, the instrument you want to get does not necessarily need to give a right side up image and is not required to focus on nearby objects. With the exception of the moon, planets and close star clusters, interesting night sky objects are faint, in fact most are very faint. As a new observer you may be mainly interested in viewing the moon and planets, and if this is the case, a telescope with a small objective (primary mirror or lens) may be more suitable for you. However, most observers may quickly try to view galaxies, nebulae, globular clusters, open clusters etc. To view these objects you will require a telescope with the largest aperture that is possible for your circumstances, which will include things like cost, weight, portability, etc.

Newtonian reflector telescopes are a popular choice for astronomical use because they have the lowest cost per inch of aperture. Observation of faint deep sky objects, such as nebulae and galaxies, can be achieved at a relatively reasonable cost by reflectors having mirror diameters of 150 to 200mm (6 to 8 inches).

Refractor telescopes are good for obtaining high power and contrast when viewing the planets and the Moon. They have a reputation of providing crisp, sharp images. Since they are virtually maintenance free, they are easy to operate, but due to high costs for the large aperture scopes, most beginners will choose a Newtonian reflector as a first scope for all round astronomy. Short-tube refractors are now another low cost option for beginners. Their smaller size makes them an excellent choice for a portable telescope, and the beautiful widefield star vistas which they provide are great for learning our way around the night sky.

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CHOOSING A TELESCOPE

Terrestrial viewing can easily be achieved with both short and long optical tube refractors, but shorter refractors with apertures of 70mm to 150mm, and focal lengths of 400mm to 800mm are preferred. Shorter scopes have wider fields of view than longer scopes and for land as well as night viewing, gathering more light gives better resolution which is more important than magnification. When choosing a scope for this purpose keep in mind that you will also be trying to look through the air in front of you, and at higher magnifications the image will shimmer, especially on hot, windy days. Newtonian reflectors are not suitable for terrestrial viewing because observing is done through the side of the tube and you therefore have to turn sideways to the target. Since there is no reasonable way to compensate for this, refractors make better terrestrial scopes. For dual purpose viewing, the refractor is a better choice but with larger apertures you do not have to magnify as much to achieve the same resolution. When using your refractor for daytime viewing, a 45 degree erect image diagonal is required to turn the image right side up. For night sky use, a 90 degree star diagonal is almost a necessity to avoid a strained neck.

Where will the telescope be used?

When astronomical viewing in urban areas, using a longer tube will increase the contrast, but it will give you a smaller field of view. If you do want to use larger aperture scopes in the city, just remember to use lower power. All telescopes will perform far better in darker sky areas.

Important considerations include convenience of use, portability, ease of storage and ease of transportation to dark sites. Short tube Catadioptric-Newtonians (1141EQ1, 1301EQ2, 1501EQ3, 15014EQ3) and short tube refractors (705AZ3, 804EQ, 1025AZ3, M9012EQ) are good choices if there are any restrictions.

Purpose		Recommended Telescopes
First-time user	For the serious beginner, a few Saxon telescopes have always been our most popular, for their portability and ability to reveal a wide range of astronomical objects	F1149EQMS, F1309EQMS, F15014EQ3, 15012EQ3, 705AZ3, 709EQ1, 709AZ3, 909EQ2, 13065AUTO TRACKING
Children	Most children have fewer expectations than adults. Not expensive and yet offer gorgeous views of the night sky and planets	606R, 607AZ, 608AZ, F763AZ, 707AZ2, F767AZ, F709EQ,1149EQE
Urban (poor sky conditions)	If you live in urban areas where the light pollution problem is severe, a quality medium refractor for planetary study may be a practical goal for your circumstances	1021EQ3, 1206AZ3, 1201EQ3, 1206EQ5, 12012EQ5, 15012EQ5
Lunar/planetary observing	If serious Lunar/Planetary study is your interest, these instruments give the best performance of all commercially made telescopes in their class	1201EQ5, 15012EQ5, M1302EQ, F20012EQ5, M15019EQ3, F25412HEQ
Deep-sky observing	Perfect instruments for deep-sky observing. The impressive light gathering power of these scopes is ideal for capturing a vast array of galaxies and nebulae	Dob-10, F20012EQ5, 1201EQ5, 15012EQ5, M15019EQ3, M20325EQ5, P25412HEQ, Dob-12
Daytime nature study	Your major interest is terrestrial viewing or daytime nature study .These well-proven performers provide sharp images with very little chromatic aberration	7035TP, 705AZ3, 804EQ7, 804AZ3, M9012EQ1, 1025AZ3, 1206AZ3, 70mm DIGITAL SCOPE
General astronomical observation	The telescopes provide enough light gathering power to display gorgeous images of solar system landmarks	F1309EQ2, F1141EQ1, F1149EQ1 M9012EQ1, 15014EQ3, 15012EQ3, M1302EQ3,13065 AUTO TRACKING, Dob-8, Dob-10, Dob-12
Easy transportation	Compact telescopes will be your best choice if you are looking for astronomical and terrestrial viewing telescope that is light weight, easy to handle and easy assemble	M65835, 7035TP, 804TP, F1141EQ1, 804EQ7, 804AZ3, M9012EQ1, M10014EQ7 70mm DIGITAL SCOPE
Budget	If you are looking for an all-purpose telescope that allows the sky to come alive in front of your eyes, but you don't want to spend a fortune	709EQ1, F1149EQ1, F1141EQ1, F1309EQ2, F15014EQ3, 15012EQ3, 13065 AUTO TRACKING, M9012EQ, Dob-6, Dob-8
Astrophotography	Selecting a telescope for astrophotography, the most important feature is a solid EQ mount. Dual-axis motor drives are an essential accessory	1206EQ5, 15012EQ5, M1302EQ, M15019EQ3, 2001EQ5, F25412HEQ5, M20325EQ5, 70mm DIGITAL SCOPE