How to Buy an Astronomical Telescope

Advice for the Beginner

Presented by

The York County Astronomical Society (YCAS)

Henry Hoffman

Introduction

This presentation is to introduce you to

optical telescopes

intended for amateur astronomer use

with the idea that you might be buying your first one in the near future.

What about BINOCULARS?

- For some people, binoculars are an easy and (relatively) inexpensive way into amateur astronomy.

- Why?
  - Buying binoculars **<u>may</u>** be a **cheaper** than buying a telescope.
  - Binoculars are more **portable** than most telescopes.
  - Powerful binoculars [7X50 or larger (i.e., 7 power with 50mm diameter objectives)] can see stars *<u>plus</u>* many bright, distant star clusters and nebulae and some galaxies (especially when using a tripod).

- But, binoculars are limited in power when compared to most telescopes. Why? Binoculars have:
  - Limited light gathering capability due to smaller objective lens size and
  - Fixed, low magnification compared to most telescopes, i.e. ≤ 10x.

- Also, big, heavy binoculars need a big, heavy tripod.

What Do Telescopes & Binoculars Actually Do?

- Most important telescope/binocular function is to **collect more light** than your eyes can!
  - Telescope/binocular diameter is larger than human eye pupil, so …
  - Telescopes/binoculars make *visible* what is otherwise invisible.
- Secondary function is to **magnify**.
- Note: Not all telescopes do everything well.
  - Larger apertures (= larger diameter) gather more light and enable seeing fainter objects than smaller apertures (= smaller diameter).
  - Longer focal lengths don't see fields of view as wide as shorter focal lengths.

Note 1: Focal length (FL) = roughly, the distance between where light enters the primary optical element and where it comes to focus to produce an image.

Note 2: Focal ratio (f/)= FL / diameter. This does not perform the same function as on photo cameras.

Types of Telescopes

- Refractor (uses a glass objective lens in front).

- Reflectors (use mirrors).
  - Newtonian. (Yes, named after Sir Isaac Newton, who invented it.)
  - Catadioptric. Two main types:
    - Schmidt-Cassegrain
    - Maksutov-Cassegrain (MAK)

- All of these are good designs when well-made!!!

How High Can Telescopes Magnify?

- **Basic formulas:**
  - Lens/Mirror width (in inches) x 50 = Maximum Magnification power.
  - Lens/Mirror width (in millimeters) x 2 = Maximum Magnification power.
  - **Example: 5” mirror x 50 = 250 power.**

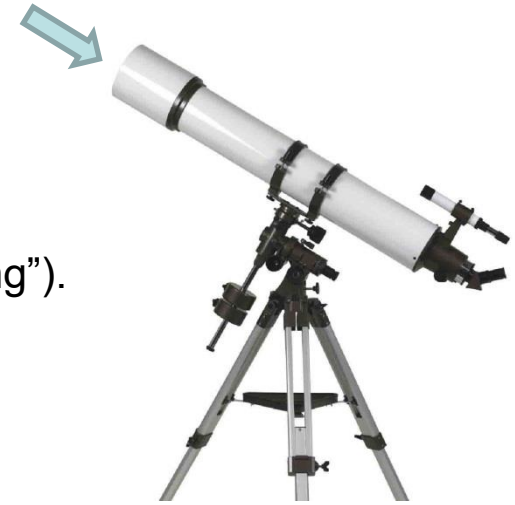
Note 1: Applies when environmental conditions are perfect.

Note 2: Attempting to magnify beyond this usually results in fuzzy views.

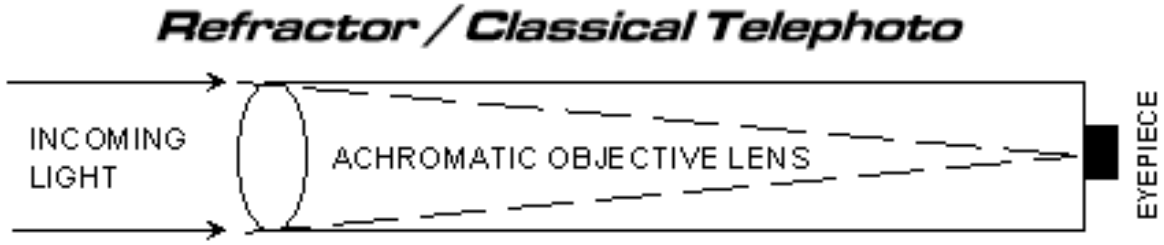
Note 3: Many inexpensive telescopes make outrageous claims on the box!

Refractor Telescopes

- Use a glass objective in the front.
  - Types:
    - "Achromatic".
      - Fairly well color corrected.
      - May show some chromatic aberration ("fringing").
    - "Apochromatic".
      - Very well color corrected.
      - Little to no observable "fringing".
      - More expensive!



- The objective lens focuses light through eyepiece.



Refractor Telescopes (cont'd)

Advantages:

- Easy to use and reliable (when well-made).
- Little or no maintenance.
- Objective lens is usually permanently mounted and aligned.
- Good for lunar and planetary observing.
- Some users claim the contrast is better than for reflectors.

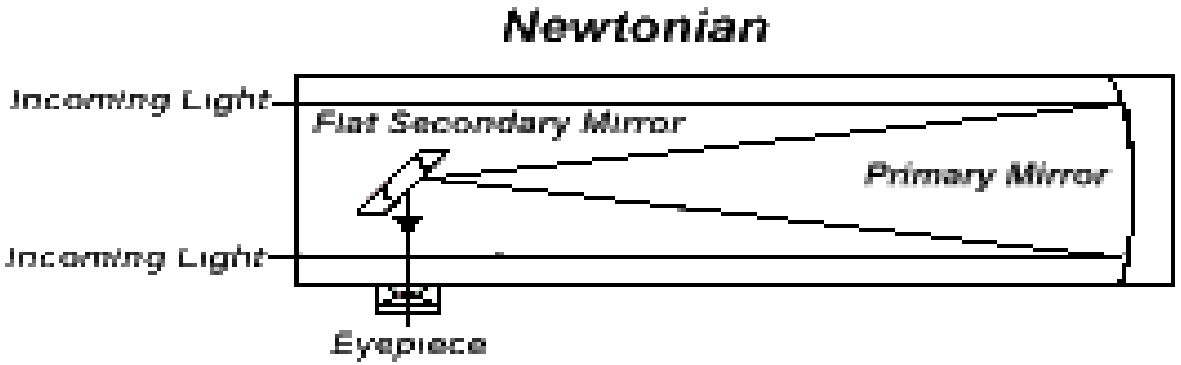
Disadvantages:

- More expensive per inch/mm of aperture than reflectors of the same size.
- Very expensive in larger sizes.
- Heavier, longer and bulkier than equivalent aperture reflector telescopes.
- Some color aberration in achromats (varies with quality of objective).
- Apochromats (little color aberration) can be very much more expensive than equivalent achromats.

Reflector Telescopes: Newtonian

- Open front end lets in light (and dust).
- "Primary" mirror at back of tube.
- "Secondary" mirror (45 degrees) in front reflects light out the side into eyepiece.

Note: Parabolic primary mirrors are better optically than spherical mirrors.
This is a point to consider when shopping.



Newtonian Telescopes (cont'd)

Advantages:

- Low cost per inch of aperture.
- Reasonably portable up to 8-inch diameter.
- Good for faint deep space objects (DSO) in larger sizes plus very good lunar and planetary observing .
- Low in optical aberrations (parabolic primary mirror).

Disadvantages

- Mirrors are exposed to dust and air, which can lead to mirror degradation over time (maybe, 20 years?).
- Requires periodic collimation (which you will need to learn to do yourself).

Note 1: Collimation is the process of aligning the mirrors precisely.

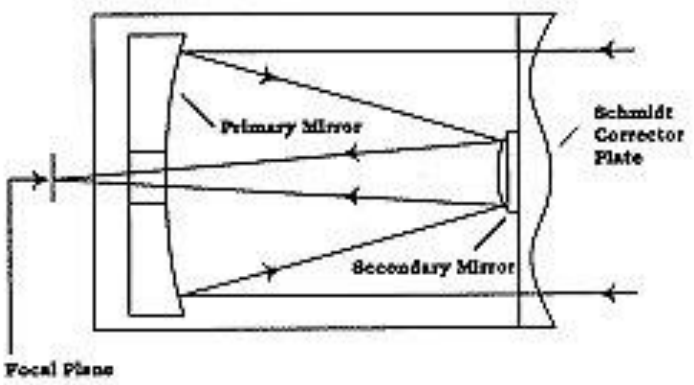
Note 2: Some new Newtonian telescopes need collimation right out of the box, but most are at least usable.

Catadioptric Telescopes

- Corrector plate or meniscus lens at front of tube.
- “Primary” mirror in back.
- “Secondary” mirror in front reflects light out the back.

Advantages:

- Schmidt-Cassegrain telescopes (SCT) & Maksutov-Cassegrain telescopes (MAK) = good optical designs.
- Excellent for deep space observing in larger sizes.
- Very good for lunar and planetary observing.
- Closed tube design helps keep dust out.
- Smaller ones are reasonably portable.
- Virtually maintenance free.



Disadvantages:

- More expensive than Newtonians of equal aperture.
- SCT requires periodic collimation; MAK does not.

Mounts

- Altitude/Azimuth (**Alt-Az**).
  - Does not track the way the sky moves.
  - Moves up and down & side to side by hand.

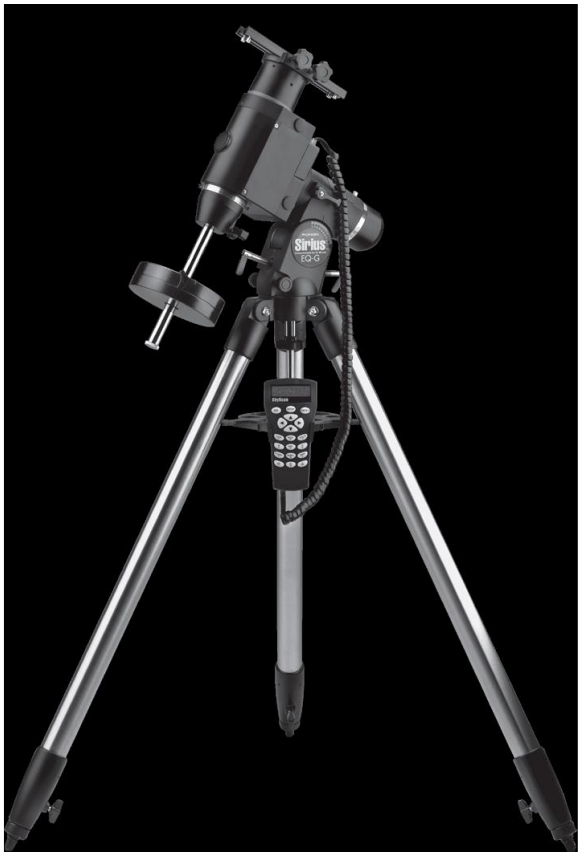
Note: requires learning the night sky thoroughly to find objects in the sky!

Mounts (cont'd)

- **Equatorial** (EQ):
  - Requires only one movement to follow objects, <u>when set up properly</u>.
  - Much more difficult than Alt-Az to set up.

Mounts (cont'd)

- **"Go-To" (computerized alt-az or equatorial):**
  - Computerized and motorized.
  - Finds objects *for* you <u>when aligned properly</u>.
  - Tracks objects automatically. More time looking **at** objects than **for** them.
  - Requires power source:
    - Batteries (e.g., AA), or
    - "Power tank"/large battery, or
    - AC to DC converter (+ an electrical socket).
    - Requires basic knowledge of sky to align.



Dobsonian (Dob)

- A **Newtonian reflector** optical tube on a **simple mount**.
  - Easy to transport in smaller sizes.
  - Easy to use.
  - Usually no tracking (“push-to” alt-az).
  - Basic models can be inexpensive.
  - Possibly the best first telescope for the rank beginner.
  - May have either spherical or parabolic mirror.

Dobsonian (Dob) (cont'd)

Advantages:

- Inexpensive compared to almost anything else (when on no-frills mount).
- Reasonably portable up to 8-inch diameter.
- OK for faint deep space objects in larger sizes.
- Reasonably good for lunar and planetary observing.

Disadvantages:

- No finding/tracking in basic model.
- Ability to magnify may be limited due to no tracking capability.
- Requires periodic collimation (which you will need to learn to do yourself).

Note: Some new Newtonian telescope tubes need collimation right out of the box, but most are at least usable.

Aperture vs. What You'll See
(Under Dark Skies)

- Up to **4" diameter**: stars, planets, the Moon, bright star clusters.

- Up to **8" diameter**: add larger, brighter deep space objects (DSO). Includes galaxies, nebulas, planetary nebulas, smaller star clusters.

- **Larger than 8" diameter**: fainter DSOs.

(Many amateur astronomers eventually develop "aperture fever".)

What kind of telescope do you need?

You need to answer and balance a lot of questions to determine this:

- **What do you want to look at?**
  - Wide field of view (e.g., to see Pleiades cluster or Andromeda galaxy) requires short focal length (e.g., f/5).
  - Faint deep space objects (DSO) require large apertures.

- **Do you live near city lights?**
  - City lights will severely limit what you can see to bright objects.
  - You may need to travel to a (safe) dark site.

Note: A telescope that is too large or too heavy to move to the selected location (even in your own back yard) won't be used.

- If you **need portability** to go to a remote, dark site, how much weight can you lift?
  - Some telescopes are "portable" (i.e., pick it all up and walk away).
  - Some are "transportable" (i.e., you'll need a suitable vehicle for this).
  - Some are neither (i.e., it isn't moving from your observatory in your lifetime).

- **How much can you afford** (i.e., total, including *all* needed accessories)?

How much can it cost?

- Good entry-level Newtonians on Dobsonian mounts start around $280+.
- Large catadioptrics on Go-To mounts can cost up to $3000 or more.
- The good news: There is a vast array of good equipment between $500 - $1500.

What
Accessories
Do You Need?

Absolute rule:

The poorest piece of optical equipment in the light path between the objective lens/mirror and your eye will determine the quality of the image observed.

Eyepieces

- The focal length (FL) of the eyepiece (EP) determines the amount of telescope magnification. The smaller the EP FL, the *more* magnification. (See Note below.)

- Poor to mediocre eyepieces usually come with cheap to mediocre telescopes (so, plan to upgrade very soon).

- When upgrading, **buy "Plossl" eyepieces or better**. But:

  – Consider long eye relief EPs, especially if you must wear glasses.

  – It is better to buy 2 or 3 excellent eyepieces (and an excellent Barlow lens) than a lot of cheap eyepieces.

  – It may be cheaper to buy a set of good eyepieces to save $$$.

  – *Note: telescope FL / eyepiece FL = telescope magnification X.*

Barlow Lens

- Multiplies the magnification of an eyepiece.
- Available in different strengths (e.g., 2x, 3x, 5x).
- 5x only good with short focal length tubes.
- 2 – 3 good eyepieces plus a good Barlow lens will give you 4 – 6 possible magnifications – probably all you need with the right EPs.
- Cost can vary considerably with quality.
- Sometimes, a very poor Barlow lens comes with cheap telescopes (which can ruin a good view, so plan to upgrade very soon).

Star Diagonal

- Must-have for refractors and catadioptrics.

- Vary in greatly quality and cost.
- A poor to mediocre star diagonal comes with many new telescopes (so, plan to upgrade very soon).

Eyepiece Filters

- **Anti-Fringe filter (V-Block)** reduces color “fringing” in achromat refractors: usually optional, depending on the individual telescope. Essential in some telescopes.

- **Moon filter** useful for reducing blinding glare of Moon (especially with larger apertures): optional.

- **Narrow-band filter** makes nebulas more visible: good to have.

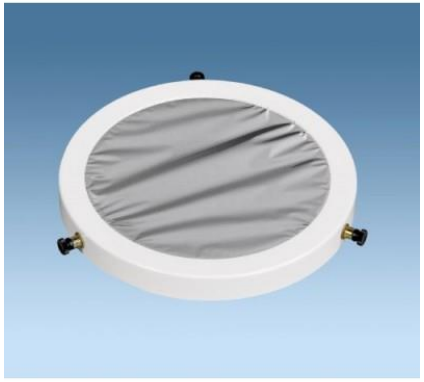
- **Color filters** for enhancing planet images: optional. Available in sets that might reduce cost.

Red Flashlight

- Necessary to see equipment and star maps & to avoid losing **night vision**. (It takes 30 minutes to regain night vision after exposure to a white flashlight's beam.)

- Not having one will make you *very* unpopular at star parties and public observing sessions.

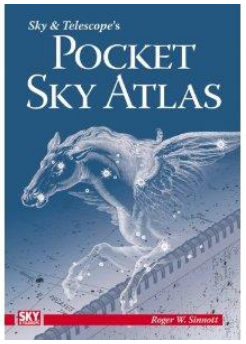
Solar Filter



- Allows for seeing sun spots.
- Absolute ***MUST*** for seeing the sun through your telescope. *(Don't look at the sun without this.)*
- Fits over front of telescope tube.
- Either polymer film material or glass in round frame fitted to telescope front end.
- Do **NOT** ***EVER*** use screw-in eyepiece "sun filters"!!!!!

(…unless you really want to go blind …)

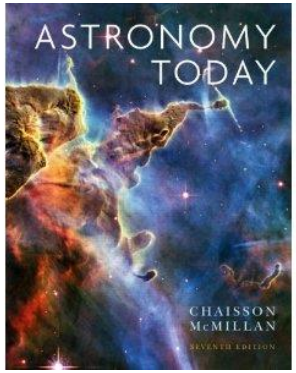
What else?



- **Star maps**: must have.
  - To learn the night sky and find objects during observing sessions.
  - Obtain from the Internet or purchase as books.
  - Free, simple ones from http://www.skymaps.com/downloads.html
- **Power source** for Go-To telescopes: must have.

- **Collimation** (or Cheshire) **Eyepiece**:
  - Must-have tool to collimate a Newtonian.
  - Usually used during day time.

- **Astronomy books**, to learn about what you'll see and how the Universe works. Recommend getting latest edition you can.



- **Computer software**: optional.
  - Commercial for sale in stores or on Internet.
  - Freeware from Internet; e.g., C2A, HNSKY, Stellarium.

How to decide what to buy

- **$$$:**
  - Buy the best equipment you can afford for long-lasting and pleasurable results.
  - Generally, you get what you pay for; however, *caveat emptor,* especially re: low-end/cheap telescopes.
- **Determine diameter** of the objective/aperture you need for your observing:
  - In order to see what you want.
  - To fit portability requirements. (Bigger = heavier.)
- **Determine telescope type:** refractor, Newtonian/Dobsonian, SCT, or MAK.
- **Determine which mount** you need (and make sure it is stable, not shaky).

How to decide what to buy (cont'd)

- **Determine accessories/upgrades** needed <u>at the start</u> before buying anything.

- **Look at telescopes & accessories** in specialty stores (if you can), at star parties/public observing sessions, or on the Internet; e.g.,
  - http://www.telescope.com/
  - http://www.optcorp.com/
  - http://www.celestron.com/
  - http://www.skiesunlimited.net/
  - http://astronomics.com/

  (Note: YCAS does not promote nor is affiliated with any commercial activity.)

- **Don't rush** your decision, and don't settle for something you don't really want.

- **Go shopping** for good brands (e.g., Celestron, Meade, Orion).

- A retail store within driving distance:
  - Skies Unlimited in Pottstown, PA

    (Note: YCAS does not promote nor is affiliated with any commercial activity.)

What To Be Wary Of:

- Any telescope with a flimsy, shaky mount.
- Any telescope with .96" diameter eyepieces. (Your telescope must take standard **1.25" diameter eyepieces**).
- Any telescope with Huygens or "H" eyepieces. (This not only indicates substandard eyepieces, but probably a substandard telescope and mount as well.) Be cautious about Kellner, Symmetrical Ramsden (SR) and Modified Achromat (MA) eyepieces, too. These are old and now inferior designs.
- Any refractor with plastic objective lens. (It must be glass.)
- Telescopes in department or discount stores (even if from a "good" manufacturer). There's usually some trade-off to make it cheaper.
- Any cheap, off-brand/no brand telescope (e.g., description = "white tube").

What To Be Wary Of: (cont'd)

- "Short-tube" Newtonians.
- *Any* telescope with a finder scope with plastic lenses or out-of-focus/cloudy view or that cannot be brought to focus.
- Sportsman's spotting scopes. (They are good for hunting and target spotting but not for astronomy.)

- ***Caveat emptor* on eBay!!!**

What to Do When You Get Your New Telescope Home:

- Open the box.
- Read ***all*** of the instruction manual & parts list first (yes, ***all*** of it!).
- Check that ***ALL*** the parts are there. (If not, stop and call the dealer/manufacturer right away. Either they fix it promptly or you take/send it back!!!)
- Gather all the tools needed; use only the right tools to not break anything.
- Assemble the telescope and mount carefully; do not over-tighten anything.
- Align the finder scope (best done in daylight).
- Read about astronomy to learn about what you see through your telescope; get appropriate maps, etc.
- Plan your first outings.
- Use your telescope (and have a lifetime of fun)!!!

- Join an astronomy club (like the York County Astronomical Society (YCAS)).

- **Last Word Of Advice:**

The best telescope you can buy is the one you will actually use!!!!!

(Hint: If it's too small to see anything, too large to handle, or too complicated to figure out, you won't use it.)

Binoculars to consider

- Orion Mini Giant 9x63 Astronomy Binoculars
  - Excellent for astronomical viewing.
  - 63mm objectives take in more light than 50mm objectives.
  - Only 2.6 lbs.
  - Long eye relief makes for comfort.
  - Cost: $236.89.

A Telescope to Consider #1

Refractor on alt-az mount:

- Orion Observer 70mm Alt-Azimuth Refractor Telescope
- $119.95

Advantages:

- Inexpensive.
- Simple to operate.
- Light weight (6.5 lbs. fully assembled).

Disadvantages:

- Narrow fields of views.
- Small diameter limits light intake to viewing only bright objects: Moon, planets, stars, bright nebulae.
- So lightweight that it probably vibrates after any touch or in a breeze.
- User must learn enough about sky to find objects for maximum usefulness.
- In short, don't expect too much.

A Telescope to Consider #2

Dobsonian:

- Orion SkyQuest XT4.5 Classic Dobsonian Telescope.
- $279.95.

Advantages:

- Simple to operate.
- Affordable.
- Light weight: 17.6 lbs. fully assembled.

Disadvantages:

- User must learn enough about sky to find objects for maximum usefulness.
- Spherical primary mirror. (But, it still gets good views.)
- Can’t see very dim objects with 4.5” mirror.
- Low to the ground: great for kids, hard for adults to look through.
- Owner needs to learn collimation techniques.

A Telescope to Consider #3

Dobsonian:

- Orion SkyQuest XT6 Classic Dobsonian Telescope.
- $309.99.

Advantages:

- Simple to operate.
- Affordable.
- Better, larger 6” primary mirror (parabolic).
- Higher off the ground for comfortable viewing.
- Light weight: 34.4 lbs. fully assembled.

Disadvantages:

- Heavier than 4.5 inch version.
- User must learn enough about sky to find objects for maximum usefulness.
- Owner needs to learn collimation techniques.

A Telescope to Consider #4

Refractor on go-to mount:

- Celestron NexStar 102SLT Computerized, Go-To Telescope.
- $499.95.

Advantages:

- Relatively affordable for go-to telescope.
- Reliable go-to system. Firmware is flash upgradeable.
- Quality optical tube.
- 102mm is large enough to see some bright DSOs (but can't see very dim objects with 4" diameter objective).
- Will run from external power supply as well as 8-AA alkaline batteries (which may drain fast).

Disadvantage:

- Go-to is usually limited to 70 degrees altitude to avoid collision between tripod and telescope.
- Light weight makes the mount somewhat subject to vibration in breezes.

A Telescope to Consider #5

Maksutov-Cassegrain on go-to mount:

- Meade ETX-90 MAK.
- 90mm f/13.8 Maksutov-Cassegrain optics
  - 1250mm focal length
- $399.00.

Advantages:

- Uses well-established Autostar go-to system.
- Will run from external power supply as well as AA batteries.

Disadvantages:

- 90mm diameter MAK design is the absolute minimum for seeing much. Any DSOs will require dark, ideal conditions.
- Very long focal length limits view to narrow views.

A Telescope to Consider #6

Celestron NexStar 8SE go-to:

- 8" Schmidt-Cassegrain telescope
- $999.00

- **Advantages:**
  - Quick release fork arm mount, optical tube and accessory tray for no-tool setup.
  - Sturdy alt-az go-to mount with steel tripod.
  - Flash upgradeable hand control software and motor control units.
  - Large enough for many DSOs, but compact enough to go almost anywhere.
  - Considered a real work-horse by many.

- **Disadvantage:**
  - Not good for astrophotography.

If you want to go high end:

- **Celestron CGEM - 1100**:
  - 11" Schmidt-Cassegrain telescope.
  - CGEM go-to equatorial mount.
  - Ultra sturdy steel tripod.
  - Large 9x50 finder scope.
  - 40,000 object database.
  - Flash upgradeable hand control software and motor control units for downloading updates over the Internet.

- Includes NexRemote telescope control software for control of telescope by laptop computer.

- GPS compatible with optional SkySync GPS Accessory.

- Requires external power supply.

- **Price: a mere $3999.00.**
  Remember, Christmas is coming…

Thank you!!!

QUESTIONS???

The York County Astronomical Society, York, Pennsylvania

Backup Slides

Glossary

This very informal glossary of terms is provided to help understand the charts in the YCAS presentation "How to Buy an Astronomical Telescope" and is placed here so that it can be referred to. These definitions are not necessarily scientific, but are provided as an aid to easy and basic understanding.

- **Achromatic:** Literally, "free from color". In amateur refractor telescopes, the use of a doublet objective lens to provide moderate correction for chromatic (color) aberrations in the refracted light (because all colors do not refract at the same angle).
- **Altitude/Azimuth (Alt-Az):** a type of telescope mount that permits movement straight up and down and side to side – usually by hand power.
- **Aperture:** the effective diameter (expressed in either millimeters or inches) of a telescope's objective lens or primary mirror. This serves as an indicator of a telescope's light gathering ability. The larger the aperture, the more light that is gathered. The area of the lens or primary mirror determines the light gathering capability (and the area increases as the square of the radius for a circle), so light gathering quadruples with doubling of the aperture; e.g., an 8" diameter telescope gathers four times as much light as a 4" diameter telescope.

- **“Aperture Fever”:** A notional disease that strikes enthusiastic amateur astronomers, forcing them (almost against their will and often against their better judgment and/or their spouse’s patience) to purchase bigger and bigger diameter (i.e., more and more expensive) optical tubes (with appropriately heavy-duty mounts) in the hopes of seeing to the dimmest ends of the universe.
- **Apochromatic:** Use of *more* than two elements (i.e., three or four) in a refractor objective lens to provide greater chromatic aberration than in achromatic objectives. Helps to reduce objectionable “fringing”.
- **Barlow lens:** The Barlow lens effectively increases the focal ratio of the optical system and therefore serves as a magnification multiplier. It fits between the eyepiece and the focuser tube. These lenses are available in strengths between 2x and 5x. They are essential for short focal ratio (e.g., f/5) optical tubes to achieve maximum magnification.
- **Binocular:** two optical tube assemblies rigidly mounted in parallel so that both eyes can receive the same image at the same magnification.
- **Catadioptric:** a type of optical tube assembly that uses both a primary mirror and a glass “corrector” lens to gather and focus light.
- ***Caveat emptor*:** Latin for “Let the buyer beware.”
- **Celestial sphere:** an imaginary sphere in the sky rotating upon the same axis as the Earth. All objects in the sky can be thought of as being projected on the celestial sphere (as was believed by many ancient cultures).

- **Collimation:** in a reflector telescope, the mechanical process of aligning the secondary mirror, the primary mirror, and the focuser tube (where the eyepiece is inserted) to ensure the best focused and resolved image. This is usually required periodically (and sometimes right out of the box) with Newtonians and occasionally with Schmidt-Cassegrain telescopes. It is almost never required on Maksutov-Cassegrain telescopes. In refractors, collimation is the process of aligning the objective lens with the focuser. It is usually not required unless the optical tube left the factory misaligned or the optical tube receives a sharp blow that knocks the optics out of line.
- **Collimation (Cheshire) Eyepiece:** a device that is used in the telescope's focuser tube during collimation to help align the secondary and primary mirrors with the focuser tube. It is usually used with Newtonian optical tubes.
- **Contrast:** in astronomical viewed images, the difference in light and dark between light astronomical objects being viewed and the dark background of the night sky. Note: In light polluted areas contrast is usually very poor, making objects difficult to see.
- **Cool down time:** the time needed to allow the optical tube assembly to reach the same temperature as the air outside. Until this is done, air currents swirling inside the OTA or flexing of the optical elements can disrupt the view. This process generally takes longer for OTAs closed at both ends (e.g., Cassegrain OTAs) than for open-ended Newtonian OTAs and can take between 15 to 60 minutes, depending on the type and size of the telescope.
- **Declination:** the celestial equivalent to geographic latitude as projected on the celestial sphere. It is measured 0 - +90 degrees north and 0 – 90 degrees south of the celestial equator.

- **Deep space object (DSO):** an astronomical object outside of the Earth's solar system.
- **Dawes (or Rayleigh) limit:** Calculations that permit determining the ability of a telescope to resolve two nearby objects into two separate images (rather than having them merge into one fuzzy mess). Exceeding Dawes limit explains why magnification beyond a certain point makes images appear fuzzier and fuzzier.
- **Dobsonian (DOB) mount:** a simple alt-az mount invented by John Dobson that allows for pushes and pulls by the user's hand to move a Newtonian optical tube to desired celestial targets. This basic version represents one of the cheapest ways into amateur astronomy. Some sophisticated Dobsonian mounts now are available with electronic indictors that tell where the optical tube is pointed (in RA and Dec) or, with the aid of motors, move the tube to the target. These latter versions can be very expensive.
- **Equatorial (EQ):** The equatorial coordinate system is a widely-used method of mapping celestial objects that functions by projecting the Earth's geographic poles and equator onto the celestial sphere. An equatorial telescope mount is adjusted to align with this system, allowing the telescope to track objects accurately by moving only in right ascension (once the declination is properly set).
- **Eyepiece:** A lens inserted into an optical tube assembly's focuser tube or star diagonal to focus light images into the human eye. There are many types and designs that have been used over past years. The basic size is currently 1.25 inches in diameter, though some amateur astronomers use 2" diameter eyepieces (which require 2" focusers to use them – limiting the telescopes with which they can be used).
- **Filter:** a translucent glass disk that is colored and mounted to be able to be screwed into the bottom of an eyepiece to help bring out details in objects (such as planets) or restrict certain bands of light to enhance certain types of deep space objects (e.g., nebulae).

- **Finder Scope:** a small refractor telescope of low magnification (e.g., between 5x and 9x) mounted on the main telescope to aid finding celestial objects.
- **Focal length:** roughly, the distance between where light enters the primary optical element and where it comes to focus to produce an image. Applies to both optical tube assemblies and eyepieces. Usually expressed in millimeters for both optical tubes and eyepieces.
- **Focal ratio:** the ratio between the focal length of an optical tube and its diameter (aperture). Symbol = f/. Example: 1000mm focal length / 200mm aperture = f/5.
- **Fringing:** the effect of chromatic aberration that produces a visible red and/or blue/purple "fringe" around very bright objects – particularly bright planets. This is a problem especially in achromatic refractors, but can be controlled somewhat by an "anti-fringe" filter (e.g., Orion V-Block filter). Fringing is seen much less in apochromatic refractors.
- **Go-to:** a type of telescope mount (powered by several small batteries, a 12 volt power supply, or an AC adapter) that, once properly aligned, will find celestial objects with the aid of a computerized hand controller and track them fairly reliably without further adjustment. Controllers often allow for interface with a laptop computer, which then allows for using software programs to select desired target objects and command the telescope to move to them.
- **Lunar:** applying to the Earth's Moon.
- **Maksutov-Cassegrain (MAK) telescope:** a Catadioptric telescope design that combines a spherical mirror with a weakly negative meniscus lens at the front.
- **Newtonian telescope:** an optical tube open on one end that uses a primary mirror and a flat, 45-degree secondary mirror to gather and focus the light into an eyepiece mounted at the open end on the side of the optical tube.
- **Optical tube assembly (OTA):** The optical apparatus and tube of the telescope, including front lenses, tube material, and/or mirrors but without eyepieces.

- **Planetary:** in our solar system, relating to the other planets.
- **Primary mirror:** in a reflector telescope, the mirror that collects and focuses the light, then reflects that light off the secondary mirror to the eyepiece (sometimes with a mirror diagonal in between). The mirror may be either "spherical" or "parabolic" in shape, but the parabolic type produces better images in Newtonians.
- **Right ascension (RA):** the celestial equivalent of terrestrial longitude as projected on the celestial sphere.
- **Schmidt-Cassegrain telescope (SCT):** a Catadioptric telescope that combines a Cassegrain reflector's optical path with a Schmidt corrector plate.
- **Secondary mirror:** a mirror that reflects the light from the primary mirror into the eyepiece. Angled 45° in a Newtonian; not angled in a Catadioptric.
- **Spotting scope:** a small refractor telescope of limited magnification and restricted aperture viewed usually either straight through or at a 45 degree angle that is intended primarily to assist sportsmen/women in the field or at a target range. Due to the limitations of its design, it is not generally considered suitable for amateur astronomy (unless there is absolutely nothing else available).
- **Star diagonal:** a device containing a 45 degree mirror (or a prism) that fits between the focuser tube and the eyepiece on refractor and Catadioptric telescopes causing the light path to change direction 90 degrees. This permits viewing comfort and avoids contorted positions required when viewing straight through a (usually Catadioptric) telescope. Star diagonals are not used on Newtonians; they are not needed and also can produce problems with insufficient back focus. Catadioptric telescopes require 90-degree star diagonals for astronomy. The 45-degree star diagonals (used for terrestrial viewing only) that come with some Catadioptric tubes will not allow seeing virtually straight up in the sky, and are, hence, worthless for astronomy and must be replaced.

- **Telescope:** For this presentation, an optical instrument that gathers light (primarily) and magnifies images (secondarily). There are principally two types: refractors (using a glass objective lens(es) at the front of the tube to refract the entering light to focus) and reflectors (using a curved primary and a curved or flat secondary mirror to reflect and focus the light).
- **York County Astronomical Society:** an astronomy club in York County, PA.