This is not so much an activity write-up as it is tips on how to safely observe the Sun.

Safely Observing the Sun

adapted from Observing the Sun for Yourself
Stanford Solar Center - http://solar-center.stanford.edu/observe/

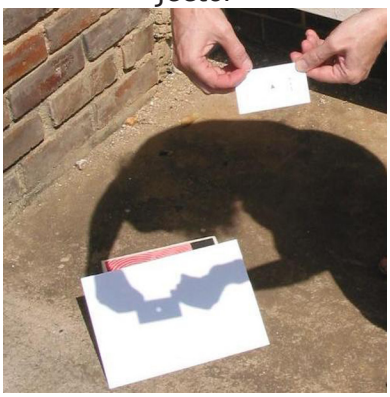
Warning

Don't ever look directly at the Sun through a telescope unless you have a proper filter covering the full aperture of the primary mirror or lens. Sunlight is very bright, and looking directly at the Sun with the naked eye for brief periods can be painful, but is generally not hazardous. Staring at the Sun is definitely hazardous but through binoculars or a telescope, even a small one, a brief glance of the Sun can cause permanent blindness. For more about safety, see http://en.wikipedia.org/wiki/Sun#Sun_observation_and_eye_damage

There are several ways you can observe the Sun safely:

- Projecting an Image of the Sun
- Specialized Solar Telescopes
- Your Own Telescope
- Remote Telescopes
- Solar Eclipses

The simplest pinhole projector



The simplest pinhole projector. Photos courtesy Hartebeesthoek Radio Astronomy Observatory, http://www.hartrao.ac.za

Projecting the Sun

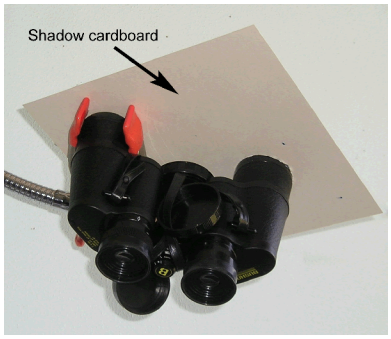
You can easily and safely observe the Sun by projecting it through a tiny hole onto a white sheet of paper. This simple device is called a "pinhole camera." The simplest technique is to use your hand to make a small "hole" for sunlight to shine through onto a piece of paper.

Almost as simple is to make a pinhole in a card or sheet of paper.

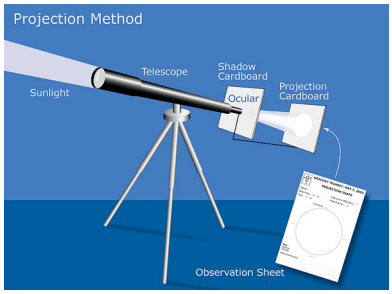
Move your hand or the paper with the hole back and forth until the Sun's image rests on the paper. Watch where the shadow of your hand is to get it lined up right. It is not just a dot of light coming through the hole, but an actual image of the Sun. Experiment with making your holes larger or smaller—an actual pinhole might not be best. Use the tip of a pencil or pen to enlarge the hole. What happens to the image? What happens when you punch 2 holes in the piece of paper? A bunch of holes?

You can also project an image of the Sun using a pair of binoculars or small telescope. Basically all you need is a "shadow cardboard" and a white cardboard screen to project the image onto. Do NOT under any circumstances look through the eyepiece! Instead, line up your telescope with the Sun by looking at its shadow, and hold a white cardboard screen (or sheet of white paper) behind the eyepiece. You'll see a solar image projected onto the paper. What happens when you move the paper farther back? Experiment with the paper for a sharp viewing contrast. You should be able to see the largest sunspots with this method. What's sometimes tricky is if you want to arrange a stand for the

projection screen to be positioned a certain distance away from the eyepiece of the telescope or binoculars. The shadow cardboard is important to get a dark background for the image of the Sun to form on and can actually be attached to either end of the telescope or binoculars. With binoculars, the shadow cardboard should have only one hole for one of the binocular lenses and the other binocular lens should be blocked off.



Projecting an image of the Sun through binoculars



Projecting an image of the Sun through a small telescope. Photo courtesy European Southern Observatory. http://www.vt-2004.org/mt-2003/

Specialized Solar Telescopes

There are a number of specialized solar telescopes available for purchase:

Sunspotter from Learning Technologies, Inc., is a wooden, folded-path, Keplerian telescope using a series of mirrors and lenses to project a bright 3.25-inch solar image onto a 5-inch white viewing screen. It's easily aligned to the Sun, totally safe, and excellent for tracking sunspots. They cost about $350 each.

Solarscope is similar to the Sunspotter, but available in versions made of less expensive materials. Options range from about $50–$300.

Coronado solar telescopes (http://www.telescopes.com) have special filters called Hydrogen Alpha filters that let only one wavelength of light through: the hydrogen alpha wavelength. These allow viewing of many solar features in addition to sunspots: granulation, flares, and prominences. They are also available with the Calcium K line filters that isolate a layer of the Sun that is below and slightly cooler than the layer viewed with a Coronado Hydrogen Alpha filter. Cost ranges from $500 to $10,000.

Remote Telescopes

Using Mike Rushford's robotic solar observatory in Livermore, California, you can actually control your realtime view of the Sun by controlling this telescope from your web browser. The site is called Eyes on the Skies (http://www.eyes-on-the-skies.org/).

Sunspotter® from Learning Technologies, Inc., http://www.starlab.com/prodsunspotter.html

Solarscope. http://www.solarscope.com/en/index.en.html

Coronado hydrogen alpha filter telescope

While you can't actually control the telescopes through the Internet, as with Eyes on the Skies, there are a number of solar observatories where you can obtain recently acquired images of the Sun. Here are a few Solar Observatories:

Amateur Solar Observatory http://home.worldonline.nl/~slooten

Big Bear http://www.bbso.njit.edu

Birmingham Solar Oscillations Network http://bison.ph.bham.ac.uk

High Altitude Observatory (HAO), http://www.hao.ucar.edu/

Mees Solar Observatory http://www.solar.ifa.hawaii.edu/mees.html

Mt. Wilson Observatory 150-ft Solar Tower http://www.astro.ucla.edu/~obs/intro.html

National Solar Observatory http://www.nso.edu

Sacramento Peak http://nsosp.nso.edu/

SOHO (NASA-European Space Agency Solar Heliospheric Observatory) - http://sohowww.nascom.nasa.gov/ or http://lasco-www.nrl.navy.mil/lasco.htmlhttp://sci.esa.int

Swedish 1-meter Solar Telescope (SST) http://www.astro.su.se/groups/solar/solar.html

Then there are the satellite missions that provide Sun images:

TRACE (Transition Region and Coronal Explorer) - http://vestige.lmsal.com/TRACE/
SOHO (Solar & Heliospheric Observatory) - http://sohowww.nascom.nasa.gov/

HESSI (High Energy Solar Spectroscopic Imager) http://hesperia.gsfc.nasa.gov/hessi/ or http://hessi.ssl.berkeley.edu/

Your Own Telescope

The safest way to look at the Sun through your own telescope is NOT to! It only takes an instant of concentrated sunlight to destroy an eye. Not only could you damage your eye, but you can also damage the lenses in the telescope. It is possible to view the Sun directly through a telescope if it is properly fitted with a solar filter. If you own an inexpensive telescope that came with a sun filter that fits on the eyepiece, please be advised that there is no such inexpensive filter that is safe. If you should have such a filter, smash it to pieces with a hammer or rock, and toss it in the trash. The safest telescope is one specifically designed for solar observations and they use such tricks as having uncoated mirrors or partially reflecting optical surfaces. These are inherently safe.

The use of filters is less safe but if extra care taken, they can give good views of the Sun in relatively safe fashion. Most importantly, do not cover the eyepiece end of the telescope (the small end) with filter. The filter must cover the top end of the telescope and cover the full aperture (diameter) of the telescope. Coated metallic filters all suffer from the possibility of pinholes in the coating. For this reason, mylar filters usually consist of more than one layer of material. Coated glass filters are higher quality and produce less optical distortion than a flexible mylar filter, but mylar is far less expensive. Mylar filters have a tendency to produce a blue solar image. Always check any filter before you use it, and each time you use it. They are delicate and can be ruined by the slightest mishandling.

Don't use a filter you think may be damaged. Your eyesight is too valuable. For more information see http://eo.nso.edu/MrSunspot/answerbook/telescope.html

For some Internet links on where to get filters for telescopes, see the "Filters" section on http://lhs.berkeley.edu/sii/URLs/NASAsunearth.html

The very best, and most expensive filters are hydrogen alpha filters, like those used in the Coronado telescopes mentioned previously. For more information on H-alpha filters, see http://www.novac.com/resources/solar/ or http://www.icstars.com/HTML/SolarSection/HAlpha/OBSERVINGTHESUNHAlpha1.html

Solar Eclipses

A solar eclipse occurs when the Moon happens to exactly line up between the Earth and the Sun. The glory of a solar eclipse comes from the dramatic view of the Sun's corona, or outer atmosphere, which we can see only when the brilliant solar disk is blocked by the Moon. The corona is not just light shining from around the disk. It is actually the outermost layer of the solar atmosphere. Although the gas is very sparse, it is extraordinarily hot (800,000 to 3,000,000 K), even hotter than the surface of the Sun! The corona shows up as pearly white streamers, and their shape is dependent upon the Sun's current magnetic fields. Thus every eclipse will be unique and glorious in its own way.

When there is a solar eclipse, it is only visible from a small area of the Earth. It's unlikely that, during your lifetime, you will ever have a total solar eclipse right where you live. However, many people travel long ways to experience a total solar eclipse. Or, if you're lucky, you might be able to see a partial solar eclipse (one where the Moon doesn't quite cover all the Sun's disk) nearby someday. It is NOT safe to look directly at a partial solar eclipse without proper eye protection or safe viewing technique. However, you can safely observe a TOTALLY eclipsed Sun with your unprotected eyes. Just make sure that for observing the beginning and ending of an eclipse, or for a partial eclipse, you use a pinhole camera, an appropriate type of welder's glass (grade 14 or higher), or special Mylar filters/glasses to observe the Sun safely.

Binoculars with solar filters fitted over the front end(s)