# Guidelines for Observing Eclipses Safely

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Submitted in Partial Fulfillment of the

Master of Science Teaching Degree

Rice University, April 2023

***Figure 1*** *Picture by Aubrey Gemignani, NASA, of the 2017 total eclipse as seen in Madras, Oregon https://solarsystem.nasa.gov/resources/2757/total-solar-eclipse-above-madras-oregon/?category=eclipse*

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## Abstract

The last solar eclipse to cast its shadow across most of the continental United States was in 2017. That event was viewed and enjoyed by millions. However, others who had planned and hoped to experience the event remotely were unable to because of poor Internet connectivity, or because the websites that were supplying the live feeds crashed. Another reason for some being unable to view the eclipse was that administrative decisions had been made preventing educators and their students from viewing the eclipse using safe, scientifically proven methods. The reasons for safe viewing are presented, including the types of harmful radiation received at Earth's surface during eclipse events and the few minutes it is safe to view the Sun without protection. Solar eclipses are significant celestial events that offer rare opportunities for awe-inspiring experiences. For millennia, astronomical scientists have taken advantage of these alignments as fleeting moments to learn about the positions and orbits of the Earth, Moon, and Sun. With two such events occurring over Texas within the near future, it is incumbent upon science educators to engage students and their communities where the eclipses can be observed, studied, and memorialized. Practical, safe, and proven methods are provided to educators wherever a solar eclipse may occur, from simple devices made from common classroom materials to using smartphone with suggested applications. Practical advice and suggestions for planning, recording, pitfalls to avoid, data collection, data comparison, and analyses of the data as it becomes meaningful information are included. A timeline for educators and those leading eclipse viewing events offers time-proven planning for success. Suggestions for engaging the community, including local libraries that participate in sanctioned eclipse events, are provided, along with many links to curated scientific websites.

## Acknowledgements

The author acknowledges the kind and generous support provided through NASA Heliophysics Education Activation Team (NASA HEAT), Grant Number 80NSSC21K1563.

Without the effective and wise guidance of Professor Patricia Reiff, without my fellow classmates during the MST program being as iron sharpens iron, and without my loving wife, Catalina Patricia Colmenares' unfailing urgings for me to proceed with this program, none of this would have happened. Thank you!

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***Figure 1*** *Crowd using handheld solar glasses to view an eclipse.* National Park Service, https://solarsystem.nasa.gov/eclipses/safety/

## 1. Purpose and Background

With two solar eclipses coming in 2023 and 2024, science educators in the USA, and particularly in Texas, have unique opportunities to engage students with in-person observations. Safe, inspiring, and enjoyable activities can be performed by students as citizen scientists under the guidance of their professional educators (science coordinators, department chairs, instructional coaches, and teachers) in K-12 and beyond. These rarely experienced eclipses will cover much of the USA, especially Texas. This paper's audience is primarily science educators, yet all are welcome to learn and use the techniques and resources. In areas along the pathways of **totality**, proven safe techniques can be applied for students to directly observe the Sun while taking quantitative and qualitative data for further analyses; safe, enjoyable, and scientific observations can be made by all. In 2017, during the partial solar eclipse experienced in Texas, some educators found themselves stymied. After months of careful planning and resource gathering, their districts issued memoranda warning against taking any students

outside to view the event.[1] School districts' concerns for the safety of their students are valid and reasonable.

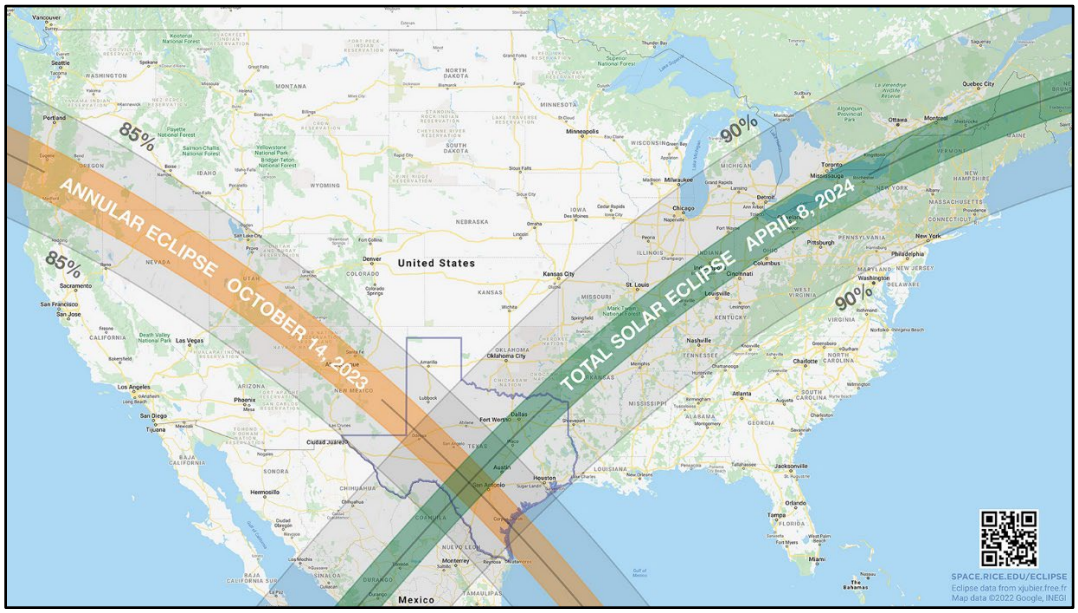


***Figure 2 Texas Nexus*** Map showing how the pathways of two spectacular solar eclipses have Texas in their crosshairs. Courtesy of Rice Space Institute, https://space.rice.edu/eclipse/

However, safe direct viewing techniques are proven and easily employed. In 2017, many attempts to log onto Internet-based links for remote viewing failed with frozen images and signal losses. An event that should have been a memorable time of "science in the moment" became a lesson in frustration. With preparation, and by addressing school districts' decision-maker's concerns, educators could provide their students safe, personal, and enjoyable celestial experiences for the two events referred to as the **Texas Nexus**.[2, 3] (A link to a comprehensive glossary of terms in bold is in the citations.[4])

2. **Addressing the Problems Associated with Observing an Eclipse**

The problems associated with directly viewing **solar eclipses** are real. This guide describes the dangers and provides safe, effective educational techniques and experiences as a clearing-house of curated resources. **NOTE: IT IS THE RESPONSIBILITY OF THOSE GUIDING STUDENTS DURING ECLIPSES TO ENSURE SAFE VIEWING PRACTICES.**

2.1. **The Fascinating Danger of Experiencing Solar Eclipses** Humans have had a fascination with many natural phenomena, including eclipses, as shown by depictions from ancient times. In some cultures, solar and lunar calendars anticipated celestial phenomena involving the Sun, Moon, and the planets. These events were known by those early astronomers and astrologers, and these events were believed to portend happenings on Earth.[5] The physical changes that occur during an eclipse are fascinating. As the Moon passes across the Sun's disc, the reduced sunlight, the drop in temperatures, and other natural responses may elicit primal reactions. Space.com described it this way:

> *When the … total solar eclipse descends on the U.S., skywatchers will be plunged into twilight at midday and will witness twisting streamers of light emanating from the edges of the obscured sun. While these features tend to dominate most people's total eclipse experience, there is much more to see if you know what to look for.*
>
> *A total solar eclipse changes the very air around you; the loss of sunlight can cause the temperature to drop 10 or more degrees. The change in lighting also makes shadows look sharper on the ground, so it's possible to see individual hairs on your head in your shadow. During a total solar eclipse, skywatchers might see stars become visible in the daytime or perhaps catch a glimpse of the planet Mercury, which is difficult to see on a normal day because of how close it orbits to the sun. "It's an assault on the senses," Rick Fienberg, press officer for the American*

*Astronomical Society (and a bit of an eclipse hunter), told Space.com. "But a good assault."* [6]

2.2. **Danger in the Sky** While eclipses are sensational, it is dangerous to look at the Sun during an eclipse. Human eyes respond to visible light by reducing the aperture, or opening, of the pupils as light intensity increases. Conversely, the pupils' sizes increase to allow more light into the eye under dim conditions. However, the Sun's emissions are more than visible light. Stars emit the full spectrum of **electromagnetic** (EM) **radiation**, from gamma rays to radio waves, and the visible light spectrum is a small portion of that radiation. The pupils do not respond to wavelengths of EM radiation outside visible light's frequencies, and despite Earth's **magnetosphere** and **ozone layer** blocking substantial portions of solar and cosmic radiation, some **ultraviolet** (UV) radiation is always present at Earth's surface during daytime. When light levels are reduced during a solar eclipse, the pupils respond by opening to let more light to enter the eye. This allows dangerous levels of EM

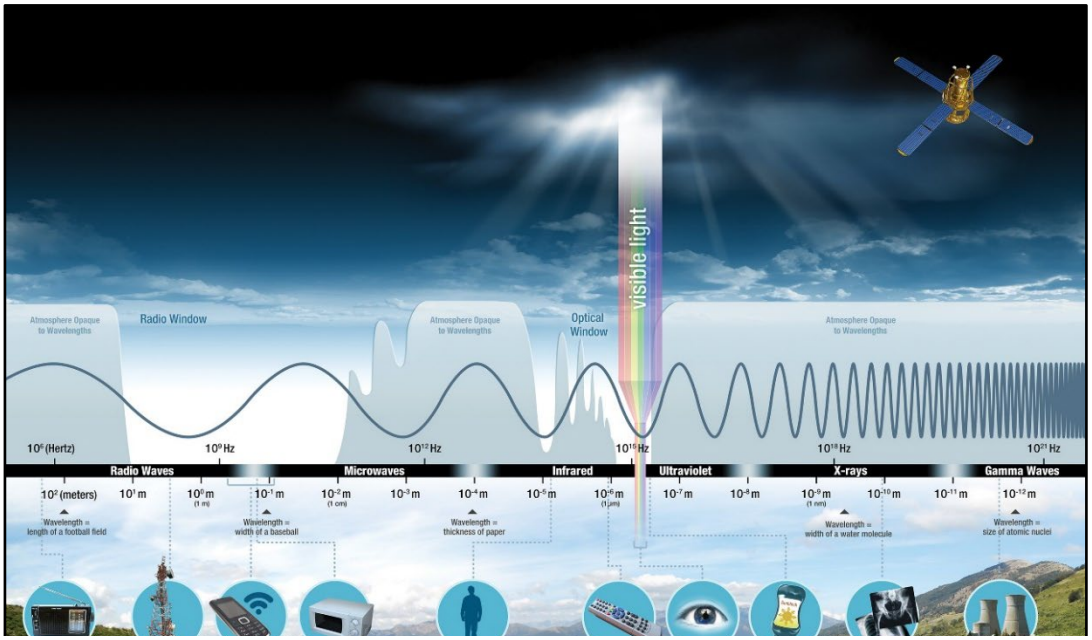


***Figure 3*** *Graphic depicting the range of electromagnetic radiation emitted by the Sun* Courtesy NASA, https://www.nasa.gov/analogs/nsrl/why-space-radiation-matters

radiation to enter the eye, causing permanent damage if one directly observes the dimmed Sun. (See "Solar Eclipse Eye Safety", a safe viewing document by the American Astronomical Society (AAS).[7]) UV radiation that survives Earth's natural filters are in wavelengths known as **UVB**, which can painfully damage the eyes' corneas, blurring vision, and **UVA**, that damages the lenses of the eyes and can burn the delicate retina and macula at the back of the eye. This irreparable damage can cause blindness. **It is imperative to use either a projection method or certified solar filters when directly observing a solar eclipse. It is only safe to directly view an eclipse when the observer is in the direct path of totality and only during totality as the Moon blocks the Sun's dangerous radiation.** The procedures discussed in this document are accepted safe methodologies as further described in NASA's "Solar Eclipse Safety" website.[8]

2.3. **Stages of a Solar Eclipse** As the Moon crosses the Sun's disc (the circle we see in the sky), there are special terms for each stage of the eclipse as it progresses.

2.3.1. **First Contact** occurs as the Moon's disc first begins to "touch" the disc of the Sun. **THIS IS NOT SAFE TO VIEW DIRECTLY WITHOUT SPECIAL PROTECTION. FIRST CONTACT IS SAFE TO VIEW ONLY WITH INDIRECT VIEWING.**

2.3.2. **Second Contact** is when the Moon's trailing edge has reached the Sun's disc; the Moon now covers the disc of the Sun and totality begins. It is now safe to view without special protection. At this stage the Sun's corona may be observed, a phenomenal sight.

2.3.3. **Third Contact** happens as the Moon's disc allows the Sun's light to just begin to emerge. **RE-INSTALL SPECIAL PROTECTION OR VIEW INDIRECTLY.**

2.3.4. **Fourth Contact** signals the end of the eclipse experience as the Moon has now crossed away from the Sun. **SPECIAL PROTECTION MUST BE USED AS THE ECLIPSE ENDS AND THEREAFTER.**

2.3.5. **Eclipse Phenomena** have names, such as Baily's Beads and the Diamond Ring, and some physical features of the Sun are safely observable during totality. The Sun's corona should be seen without magnification, and, briefly, the chromosphere and prominences may be visible with magnification such as with binoculars or a telescope.

2.3.6. The American Astronomical Society website "The Solar Eclipse Experience" explains in further detail the progressive stages of an eclipse and expected observations.[9]

3. **What is an Eclipse?**

An eclipse occurs when a luminous celestial object is partially or completely blocked when another object passes between it and the observer. A solar eclipse requires the alignment of three celestial bodies: the source of light (the Sun in this case), Moon, and Earth. Since all objects in our solar system cast shadows from the Sun's light, a solar eclipse is when the shadow cast by the Moon aligns with and falls upon Earth, or during a lunar eclipse, when Earth's shadow aligns with and falls upon the Moon.[10]

3.1. **Lunar Eclipse** This event occurs when the Moon passes directly through the Earth's shadow in space; it is visible to anyone who can see the Moon at that time. Earth's shadow is large enough to cover the lunar surface partially or completely. Because the light is reflected from the Moon's surface and not directly by the Sun, no harmful EM radiation is emitted, and lunar eclipses are safe to view without eye protection. While not as dramatic

as solar eclipses, they can be enjoyed by all at nighttime simultaneously, they average three per year, they are longer in duration, and they are safe to view without special eye protection.

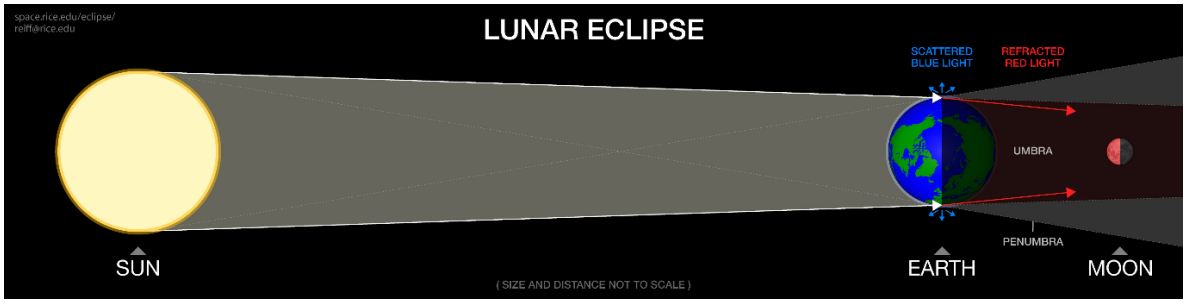


***Figure 4*** *Rice Space Institute graphic showing how a lunar eclipse occurs as Earth's shadow coincides with the Moon's orbital path.* https://space.rice.edu/eclipse/img/eclipse_diagram_lunar.jpg

3.2. **Solar eclipses** are rarer events. As many as three partial eclipses can occur per year with some years having no total eclipses. Because the Moon casts a shadow that is smaller than Earth's (the Moon being about ¼$^{th}$ Earth's diameter), only individuals who are in the path of the Moon's shadow will experience it. A quirk of astronomical nature is that the Moon's diameter is about 1/400$^{th}$ the Sun's, and the Sun is close to being 400-times the Moon's distance from Earth. This creates an unusual geometrical situation where the

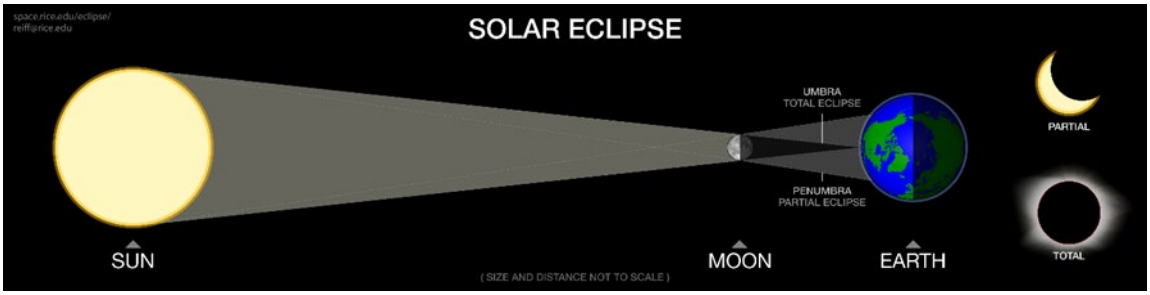


***Figure 5*** *Rice Space Institute graphic showing how the Sun aligns with the Moon, whose shadow crosses Earth's orbital path, creating a solar eclipse.* https://space.rice.edu/eclipse/img/eclipse_diagram_solar.jpg

Moon's "disc", its flat circle observed in the sky, covers the Sun's disc. Other factors imbue solar eclipses as rare events, such as orbital plane alignment and orbital eccentricity.

3.2.1. Moon's orbit around Earth is not in perfect alignment with Earth's orbit around Sun; it is inclined 5˚ to the plane of Earth's orbit around the Sun. If the two planes were in alignment, then the shadows would create lunar and solar eclipses each month.

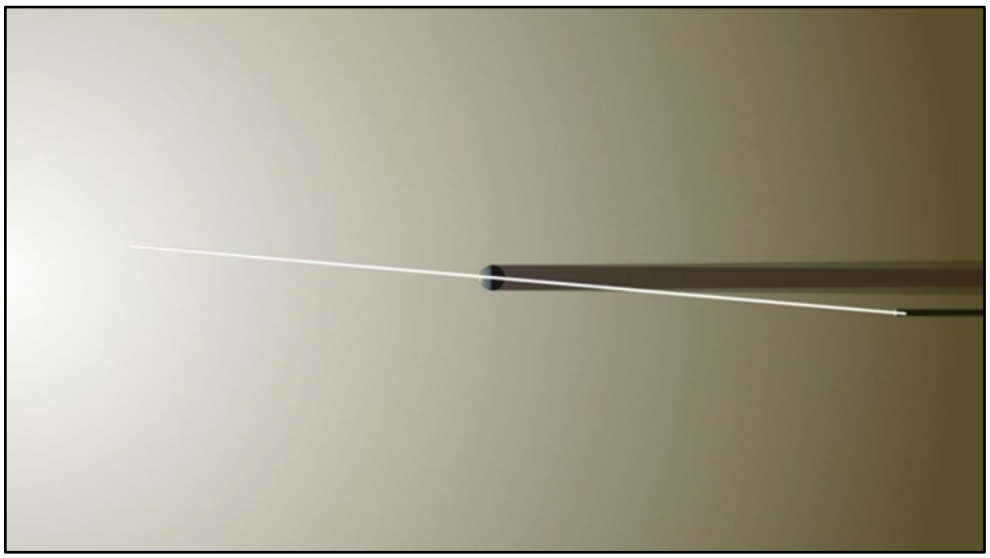

***Figure 6*** *Depiction showing Moon's orbit 5 degrees inclined to Earth's with their respective shadows trailing into space.* Courtesy, NASA https://solarsystem.nasa.gov/moons/earths-moon/lunar-phases-and-eclipses/

Moon's apparent size in the sky, about ½ of a degree of an arc, usually equals the size of the Sun, as noted above. Yet, Moon's orbit around Earth is not a perfect circle—it has a slight eccentricity to it. For this reason, the Moon can appear slightly larger when it is closer at orbital **perigee**. or smaller when it is farther during orbital **apogee**, than average. Earth observers may experience an **annular** solar eclipse if the Moon is farther from Earth when it aligns with the Sun (at apogee), or a total solar eclipse if it is closer to Earth in its orbit when aligned with the Sun (at perigee). The

timing of the alignment coinciding with Moon's slightly eccentric orbit determines whether the event is an annular or total solar eclipse.[11]

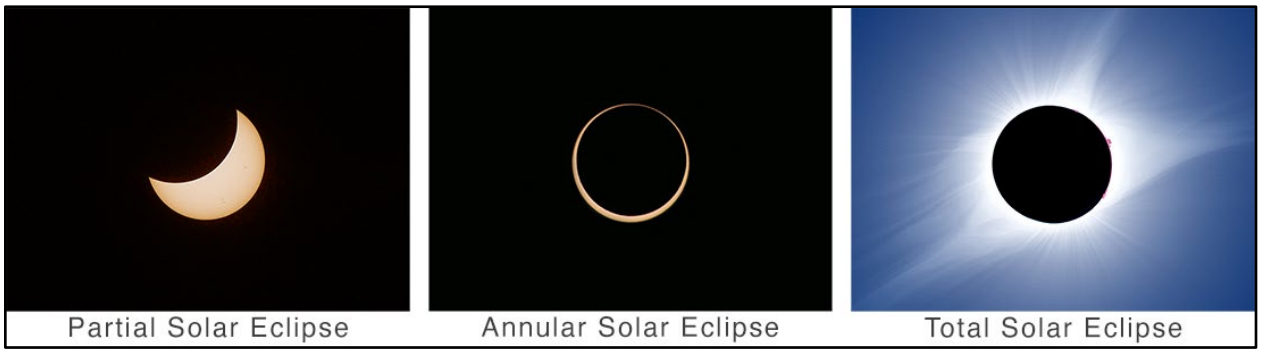


***Figure 7*** *Three images showing a partial, annular, and total solar eclipse. A partial eclipse appears as a yellow disc of the Sun with the smaller Moon's covering part of it. The annular eclipse shows the larger yellow disc of the Sun as a ring of light surrounding the smaller disc of the Moon. The total eclipse shows the moon's disc completely covering the Sun's with the Sun's corona emanating into a twilight sky.* AAS https://eclipse.aas.org/eclipse-america-2023-2024

3.2.2. A solar eclipse's duration is usually two to three hours, while totality is usually less than five minutes. The briefness of the event begs timely preparation as outlined below. A solar eclipse creates a tight pathway of totality with a larger pathway that is a partial eclipse. Those within the **centerline** of totality will experience the greatest duration of totality. The eclipse's effects are reduced the farther one is from the path of totality. Check your location for the percent coverage of the Sun and the duration. The US Naval Observatory has an interactive website where either GPS coordinates or location names may be input.[12] The **Texas Nexus** website lists useful information that includes the expected percent totality and duration for many locales across the state, including the Texas Education Agency's regions, museums, zoos, colleges and universities, and parks.[3] **Xavier M Jubier's** website has a comprehensive list of previous and upcoming eclipses. It links to his interactive map where detailed information can be found by clicking on the map for that location.[13]

3.2.3. During most lunar eclipses, Earth's shadow covers the entire Moon's diameter of 2,160 miles or 3,476 km. The width of totality from Moon's shadow on Earth's surface for the April 2024 solar eclipse is smaller, with a diameter of about 125 miles or 250 km. Comparatively, the annular eclipse of October 2023 covers 116 miles or 185 kilometers. Only those within the path of totality will have the full experience, though partial eclipses are noteworthy experiences. Fortunately for those in Texas, much of the state is close enough to the centerline for millions to enjoy. According to the American Astronomical Society, the pathways of the 2023 annular eclipse and the 2024 total eclipse offer millions of Texans and her visitors chances to experience rare celestial encounters.[14]


***Figure 8*** *Map of North America by the American Astronomical Society showing dates and paths of the 2023 and 2024 eclipses.* Courtesy, AAS https://eclipse.aas.org/eclipse-america-2023-2024

4. **Safe Viewing Methods**

Educators and students can employ safe, effective methods to experience eclipses. Some are inexpensive and can be made using readily available household items, while others require planning and ordering materials ahead of time.

4.1. **Indirect Viewing** These methods can be by purchased or classroom-made materials and will allow the Sun's image to be seen as a projection onto a surface. These are very safe methods as the viewer is not looking at the Sun. It is recommended to try different box sizes and to practice well beforehand to improve the methodology for successful viewing.

4.1.1. **Pinhole Methods** These use the projected image of the Sun onto a surface. Cleanly cut, round pinholes result in sharper images.

4.1.1.1. **Cereal Box or Shoebox Pinhole** The "shoebox method" uses a box that can be handheld, such as a cereal box. It should have a larger opening for viewing *into* the box, and a smaller opening covered with aluminum foil that has a pin-hole in it. The individual faces away from the Sun while a small image of the

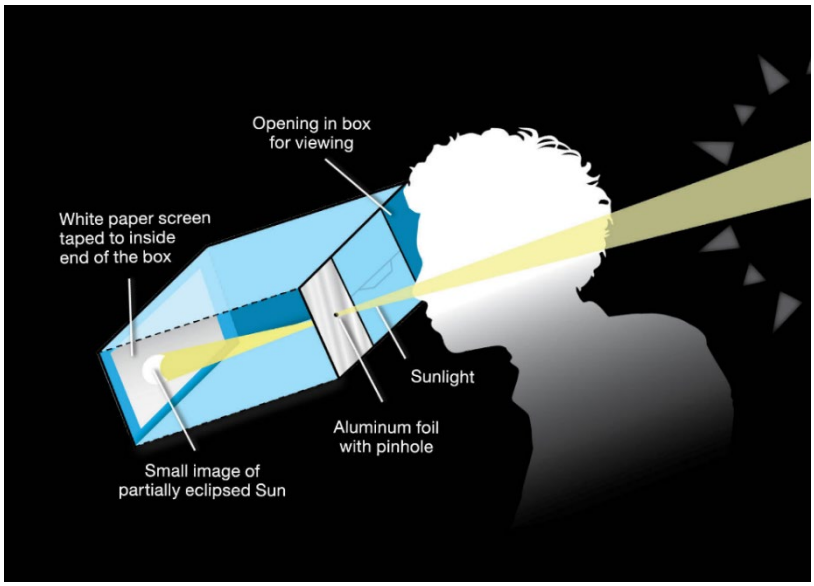


***Figure 9*** *Drawing that shows a person using a pinhole shoebox method to safely view an eclipse.* Courtesy, NASA https://solarsystem.nasa.gov/eclipses/safety/

Sun is projected through the pinhole onto the opposite inside box surface.[8,15]

4.1.1.2. **Large Box Pinhole** Similar to the shoebox, this uses a large box of (0.5m or more) in size. Set this on a stable surface with the pinhole side facing the Sun. The projected image will be cast on the opposite inside box wall. Having one side open allows observers to look inside. The advantage is a much larger image than the shoebox. Light-blocking drapery could cover the person and the opening, improving the image. Have a white surface for the projection to fall onto. Adding a lens over the pinhole can magnify the image.[16]


***Figure 10*** *A large, opened box on its side with a pinhole on the top surface allows viewers to see the projected Sun's image inside.* Courtesy, Rice Space Institute, https://space.rice.edu/eclipse/safe_eclipse_observing.html

4.1.1.3. **Similar Projection Methods** If a large box cannot be found, any object that casts a shadow can be used if a pinhole is made through it. Hands can be held to form apertures, a large piece of cardboard with a pinhole, even utensils with holes, such as colanders, and sunlight filtering through trees' leaves will project images of the Moon eclipsing the Sun.[8]

4.1.2. **Projection through Binoculars of a Telescope** If binoculars or a telescope are available, magnified images of the Sun can be seen as a projection through the device and onto a white screen, paper, or any light colored surface. No solar filter is needed with this method. Set the telescope (refracting is best) up on a tripod or set the binoculars on a stable surface. Find the Sun by creating the smallest shadow possible as the device's orientation is adjusted. **DO NOT LOOK INTO THE EYEPIECE WHEN VIEWING THE SUN—PERMANENT SCARRING AND BURNING OF THE EYE OR ANY TISSUE CAN OCCUR!** The image of the Sun will be magnified as is the strength of the energy it produces. The device should be placed so the image passing through it will be cast upon a white surface. If possible, install a simple sunshield around the device, such as a piece of cardboard cut to fit, or a dark cloth draped over it. The American Astronomical Society and Rice Space Institute have examples of these.[16,17] These methods allow several people to safely see the image at once without having to take turns with binoculars or bumping a telescope.

***Figure 11*** *A refracting telescope with a dark cloth projects the Sun's image onto white paper on the ground.* Courtesy, Rice Space Institute https://space.rice.edu/eclipse/safe_eclipse_observing.html

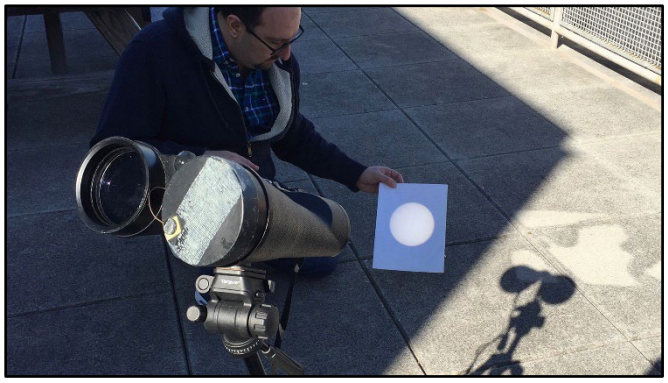

***Figure 12*** *Binoculars with one lends covered and the other allowing the Sun's image to be cast onto a white sheet of paper on the ground.* Courtesy, Rice Space Institute https://space.rice.edu/eclipse/safe_eclipse_observing.html

Other indirect devices and methods are available, such as a Sunspotter, Solarscope, and making a Sun Funnel. More information is on the AAS website.[17]

4.2. **Direct Viewing Methods** No other experience could match the moment when an individual has a direct observation of the Sun during an eclipse. To see the event happening with one's own eyes surpasses any projected image. However, these methods require stringent use of solar filters obtained from reputable dealers. Either solar eclipse glasses or filters for binoculars and telescopes will work if correctly used.

4.2.1. **Solar Eclipse Glasses** These glasses have specially coated lenses that will block dangerous UV radiation while allowing the observer to view the Sun. Be careful not to scratch them or harmful amounts of radiation could enter the eye; keep them in a protected sleeve. In 2017, the manufacturers exhausted their supply prior to that eclipse and irreputable vendors took advantage of the market demand.[18,19] Be sure

***Figure 13*** *A man, woman, and two children have amazed expressions as they look through solar eclipse glasses at an eclipse.* Courtesy, NASA https://svs.gsfc.nasa.gov/12200

to purchase these products only from dealers whose glasses meet ISO 12312-2 certification. A list of reputable dealers is on the AAS website here.[20] Obtain enough for everyone in your party to have their own to reduce the need to pass them around.

4.2.2. **Binoculars and Telescopes** To observe some of the finer details, such as **sunspots**, binoculars and telescopes must have solar filters attached in front of the objective lens. (**Do not place the filter over the eyepiece as the magnified sunlight will burn through the filter, ruining it and destroying its filtering capabilities.**)

***Figure 14*** *An image of a reflecting telescope with a solar filter attached over the objective lens.* Courtesy, NASA, credited to Carolyn Slivinski https://solarsystem.nasa.gov/eclipses/safety/#:~:text=When%20watching%20a%20partial%20or,safe%20for%20viewing%20the%20Sun.

***Figure 15*** *Three pictures showing solar filters correctly attached. Left-a pair of binoculars held by a man; middle-a telescope mounted on a tripod; right- a telescope held by a man. All three pictures show how the solar filters are placed over the objective lenses.* Courtesy, AAS https://eclipse.aas.org/eye-safety/optics-filters

Magnified viewing through binoculars and telescopes have benefits that solar eclipse glasses cannot provide. The details of the Sun's features, such as its sunspots and plages, are much improved with magnification. To see the corona during totality, as in the image on this document's title page, the observer only needs their eyes.

The downside is that only one individual can view it at a time. Having the device set up on an automatic tracker is very helpful so distracting adjustments do not need to be made every few minutes. A camera can be attached to the devices, or, with steady hands, images can be taken by hand-held cameras, even smartphones. Solar filters are also available for smartphones. (Pointing the smartphone's lens directly at the Sun without filters may damage the device.) Resources for filters for telescopes and smartphones are on the AAS website here.[20] Specialty H-*alpha* solar viewing telescopes are designed to be used for solar observations. Although costly, the results can be spectacular. In the image below, taken through such a telescope, note the prominence at ten o'clock streaming from the Sun's surface.

***Figure 16*** *Inset, a picture taken by a smartphone of a solar prominence taken by the author through an H-alpha telescope.* Photo by Carlton C. Colmenares.

***Figure 17*** *A deep red image of the Sun taken with a smartphone through an H-alpha solar telescope.* Photo by Carlton C. Colmenares.

4.3. **Remote Viewing** As mentioned earlier, access to websites that live-stream eclipses may crash or have connectivity issues. If the weather is a limiting factor for outdoor viewing, educators may have to log onto a website to view the eclipse. The greatest benefit is that an entire classroom or school body can view the event together without the need for safety measures. If the skies are not cooperative, of if decision-makers deem that any outdoor activities are not allowed, remote viewing may be the best option. As of this date, NASA has not published live-streaming website data for either the October 14, 2023, annular eclipse or the April 8, 2024, eclipse. The website timeanddate.com has a link for live viewing of a few eclipses. Educators can expect that all major news networks, NASA, and other institutions with interests in the eclipses, will have live streaming from various locations where the skies are expected to be clear. An estimation of the cloud cover expected at a location along the pathway of totality can be found at the AAS website.[21]

5. **Observable Phenomena**

Interesting changes can occur during an eclipse. Many are qualitative observations while others can be quantified. Bringing the measurable and testable phenomena into the experience can provide scientifically gathered data that should show students the effects of an eclipse. There are a number of activities and lessons that demonstrate how eclipses work, with models and activities suitable for various age groups and education levels. NASA has some listed here, and other resources are available at the Rice Space Institute website here.[22,23]

5.1. **Qualitative Effects** These can include the changes seen in shadows, the sounds of nature as birds or roosters change their vocalizations, the roosting or ceasing of flight of birds as

they anticipate nightfall, other animals bedding down, the thermal sensory changes by having "lunar shade", the changes to the color of the sky or clouds, among others. Students can record these experiences by video or audio recordings, or by writing them down. As a group, students may prompt each other to observe and recall events afterward that they otherwise may miss as individuals.[6]

**5.2. Quantitative Effects** Encourage students to record data prior, during, and following the eclipse event. These could include changes to air temperature, solar UV output, light intensity, the number and magnitude of visible celestial objects (Venus or other planets, stars, constellations), changes in wind speed and direction, and other measurable changes. Utilizing devices that do not need constant manipulation but can be set to record during the event will allow viewers to experience the eclipse themselves rather than having the distraction of tending to equipment.

5.2.1. **Equipment** The data collection will require some equipment such as thermometers, UV sensors, photometers, and star charts. Collectable data include wind speed, ambient temperature, and a smartphone's built-in photometer for light levels. Students may develop their own data set of recordable observations. Some data are accessible via the Internet and/or are downloadable applications for smartphones, including the following. Notification devices such as a whistle or bullhorn are useful for letting participants know when to remove and when to don safety equipment.

5.2.1.1. **Weather Underground** has live meteorological data from nearby stations accessible by smartphones. Tracking regional stations' data may show how meteorological data changes prior to, during, and after an eclipse.

5.2.1.2. **Stellarium**, a powerful application with versions for smartphones and laptops. Users can change the time to see how the Moon's future orbital path crosses the Sun's track across the sky on eclipse dates.

5.2.1.3. **Space Update** can be downloaded as a stand-alone program that periodically revises data with Internet access. It is a very useful tool but not for live viewing.

5.2.1.4. **Globe Observer** is an application that allows citizen scientists to connect and share data worldwide. There will be an eclipse release for direct collection of ambient environmental conditions during the eclipses.

5.2.1.5. **A video recorder** can be set up and stabilized (tripod) to record students' and other observers' reactions during the eclipse event, which may be quite remarkable. A nation-wide, citizen-scientist stitched video eclipse Megamovie project is in the works by Sonoma State University and University of California, Berkley, as they did for the 2017 eclipse.

5.3. **Local Resources** Educators are encouraged to use local scientific resources, including institutions of higher learning, museums, and natural science organizations. In southeastern Texas, the **Houston Museum of Natural Science** has a wide selection of eclipse events, Texas eclipse history, activities, shows at the Burke Baker Planetarium, and a Discovery Dome with eclipse programs for educators to rent.[24] **NOTE:** Smartphones are helpful but the personal experience of an eclipse should take priority over time spent trying to adjust a device or by taking readings. A logging probe, such as from Vernier can be useful as it records data (air temperature, UV, visible light readings, etc.) solar during the eclipse. These can be evaluated and analyzed afterward.

5.4. **Libraries** are local public resources that may have programs and activities for the eclipses. STAR Net's *SEAL* program (*Solar Eclipse Activities for Libraries*) is an extensive program of the Star Library Network based in Boulder, Colorado.

## 6. In Case of Clouds

What to do if the weather does not cooperate? If skies are not threatening with rain or severe weather, the eclipse can still be enjoyed as the Moon's shadow travels across the clouds. The eclipse may seem to be a lost event, but even with cloudy weather the effects of the eclipse can be experienced and measured. If access to a workable Internet-based website is available while students are outdoors under the cloudy skies, they would have the opportunity to experience the eclipse while watching what others experience under clear skies.

## 7. Local Site Scouting and Preparations

Have two or three sites as options in case of unavailability. Traffic and overwhelming crowds may be planned for, but unexpected interruptions can occur. Visiting the sites prior to the event is a wise action. Also, planning to be at the viewing location a year prior to the eclipse indicates the Sun's elevation and azimuth for that time and date. Are there trees, buildings, or other obstructions at that time? Check for mobility and accessibility, parking, shelter, a restroom, water, and other necessities for groups in the field. Set up your telescope or binoculars to practice viewing the Sun is good planning—not just for these eclipse events but for any solar observations. These recommendations may prevent troubles and woes as you manage a group in sites that otherwise would be unfamiliar.

## 8. Suggested Timeline

The American Astronomical Society has a detailed list for the eclipse experience. It is suggested that student participants, educators, and other leaders review these events in anticipation of the eclipses.[14]

8.1.1. **A month prior** visit the planned sites. Check the fit and function of filters, solar glasses, telescopes, binoculars, tools, equipment, etc., practice and repair equipment. Check for access by the disabled. If the skies will be favorable on eclipse day, consider the effect of being outdoors for several hours. Is there shade or a pavilion available, or is a popup canopy needed? Is there a restroom or portable potty? Potable water? Check for imported fire ants or other natural hazards. Check for Internet connectivity. Confirm your local time for first, second, third and last contacts, the duration and percentage for totality. Consider how students will store and share experiences, via a class website, blog, or social media to upload audio and visual experiences, data, analysis, and conclusions. Access to these can have limitations to those within the class, the school, or a wider audience per local policy.

8.1.2. **The week before** the event have all permission forms printed and detailed plans and maps sent to those who should know—administrators, parents, department chairs, etc. Download updated applications and practice using them. Collect notification devices such as a loud whistle or bullhorn.

8.1.3. **The day before** the event have the students bring their supplies such as straw hats and cereal boxes. They can practice putting on solar glasses, and cut out messages on cardboard, such as "My School Eclipse 2023". The cutout message will project the Sun as it appears during the eclipse and a picture taken to capture the moment.

***Figure 18*** *Picture of pin-hole projections of an eclipse shows the Moon's disc crossing over the Sun. The pinholes are cutout to form the words "Australia 2012" and the constellation of the Southern Cross.* Courtesy, Rice Space Institute https://space.rice.edu/eclipse/safe_eclipse

Prepare and have on hand needed materials (drinking cups, beverages, ice chests, snacks, permission forms). If the site is in the pathway of totality, practice with students so they know the whistle or horn is to notify them when and if it is safe to put on or take off solar glasses. Have a plan for collecting and disposing of trash and recyclables. Fully charge devices and check for operation. Check the weather forecast and have alternative plans for cloudy skies or inclement weather. Check websites and links for full function.

**NOTE: from first contact through last contact can take almost three hours.** According to Stellarium, in Hempstead, Texas (30˚ N, 96˚ W), the 8 April 2023 event is a partial solar eclipse. First contact occurs at 12:20 P.M. and last contact at 3:00 P.M., with maximum coverage of 96.7% at 1:40. P.M. *Solar eclipse events take time from*

*beginning to end*. Since the October 2023 and April 2024 eclipses occur at about midday in Texas, plan on daylong events.

8.1.4. **Two hours before** first contact check devices for Internet connectivity (if needed). Check weather conditions and the well-being of the participants, particularly during hot or threatening weather. Should the weather become threatening be sure everyone knows what to do and where to go. Expect traffic to be heavy, especially afterward.[25, 26]

8.1.5. **One hour before** first contact check devices' battery charge, make that last trip to the restroom. Check that participants have their protective eyewear, and that equipment is tracking the Sun. Begin observations, gather and record data, including sketches and observations. Set cameras to take pictures or record video.

8.1.6. **During <u>totality</u>** enjoy the moment! Announce with the whistle or bullhorn that it is safe to directly view the Sun. Be aware that some participants exhibit confusion during the eclipse. Be mindful of the duration of totality and prepared to announce to participation to put back on safety devices.

8.1.7. **During <u>partiality</u>** ensure the participants are NOT looking at the Sun without protection. If using a telescope or binoculars on a tripod, keep the participants moving through the viewing line as adjustments are made to track the Sun.

8.1.8. **After the eclipse** check data recording devices and save data. Collect all the materials and equipment and safely stow them. Remind participants to gather their belongings and to pick up all trash and recyclables. Be aware of the potential for heavy traffic leaving the area as everyone may try to leave at once; delays are not unusual. Lead

discussions of the experiences, asking participants to write down their experiences, or add narrations to their photographs.

8.1.9. **The following day** students can create charts or graphs from their data. Begin to interpret and draw conclusions from their data, including errors and activities that did not work as planned, or things they wish they had done. Have students compare and analyze their data to data collected by others in the region or other locations along the eclipse's path.

## 9. Conclusion

The Texas Nexus is a rare and significant astronomical, natural, and cultural event. For many individuals these are singular events in their lifetimes. Educators are encouraged to plan now with their campus and district principals, instructional coordinators, department chairs, and risk management teams to ensure safe, effective, and enjoyable experiences are had by all.

These events have the potential to attract students' interest in ways other events simply cannot match. By connecting the scientific aspects of the phenomena with student learning, educators may instill a lifelong journey into the sciences. From these two events, students' understandings of cultural, astronomical, and natural events should become enhanced as they experience them first-hand for themselves. Many safe and effective methods for viewing and experiencing these two phenomena are available; most can be done, or made, from readily available classroom or personal materials or devices, including smartphones.

Because the pathways of totality and partial totality for both events fall over and near major population centers within the State of Texas, planning should begin as soon as possible.

Communities may expect visitors from outside the area, even internationally, and these numbers are expected to be in the thousands. Especially for the April 2024 total eclipse, the skies across the state have a higher probability of being suitable for viewing than the other US states. Expect smaller communities along the pathway to have multiples of their usual population attending the skies, and the traffic to be beyond anything normally experienced. These events should be enjoyable, safe, memorable, and awe-inspiring. **Most of all, have fun!**

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**Other Websites that may be Useful for the Educator and Planner**

Of note are NSTA's eclipse website, and Andrew Fraknoi's list of resources.

- National Science Teaching Association (NSTA) Eclipse Website: https://www.nsta.org/eclipse
- Andrew Fraknoi's resource list: https://www.fraknoi.com/wp-content/uploads/2022/12/ECLIPSE-ACTIVITIES-for-Educators.pdf
- Sonoma State University and University of California, Berkley's Megamovie: https://eclipsemegamovie.org/
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- Interactive Eclipse Map with Duration Locations: https://www.timeanddate.com/eclipse/map/2024-april-8