Introductory Exercise – Naked Eye Night Sky Observations

Introduction

One of the goals of any Astronomy class is for the students to become more familiar with objects in the sky from here on out. Knowing how orient yourself with respect to the cardinal directions and use sky maps or star wheels is a valuable valuable skill. You never know when it may come in handy and you will be able to clear up misconceptions among your relatives and friends. You will be able to calm their fears about imminent alien attacks from space or Earth's catastrophic destruction by an incoming asteroid or comet on collision course by being able to identify that light in the sky.

It turns out that you can make awesome and meaningful observations of the sky just with your naked, unaided eyes. Neither telescope nor binoculars are necessary. The Crash Course Astronomy #2 "Naked Eye Observations"(https://www.youtube.com/watch?v=L-Wtlev6suc&t=23s) is a great primer on the variety of celestial objects you can observe just with eyes and how to go about it. Before you set out to make your own observations there are a few preparations you can make for the best experience: be aware of light pollution at your observing location, being able to estimate angular sizes and distances of objects in the sky, and having a sky map handy.

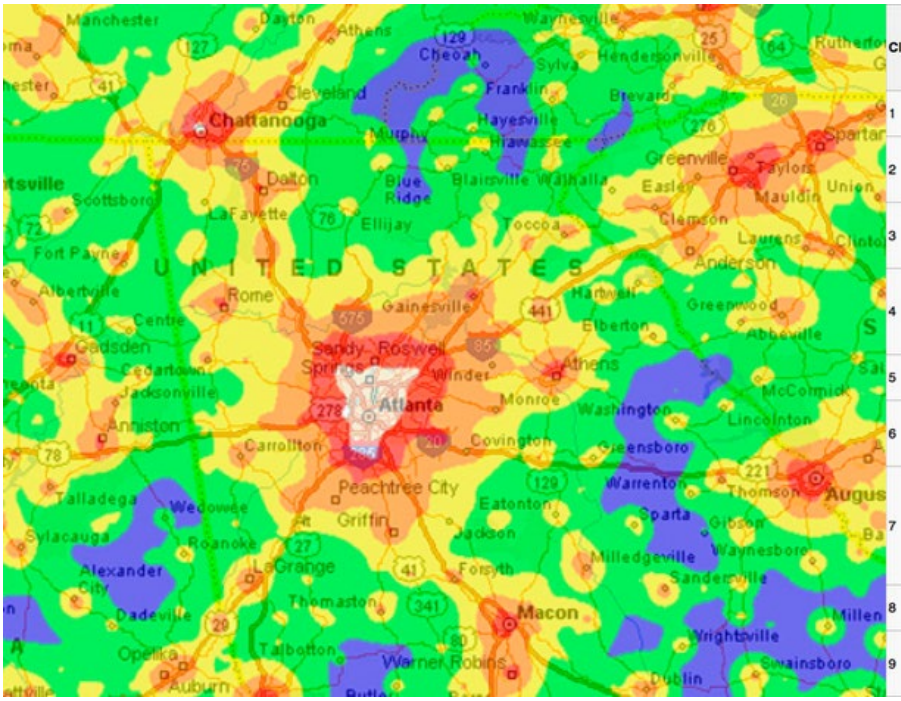
Light Pollution

Light pollution by manmade light sources is a big problem when observing the night sky. For example, here is an image by Jeremy Stanley showing part of the constellation of Orion seen with very little light pollution and with more severe light pollution.


by Jeremy Stanley

Depending on how populated an area you live in you will have to deal with some level of light pollution, any kind of stray light that leaves a light source in any other direction than the intended one. This stray light overpowers fainter objects that cannot be seen anymore at that level of light pollution. The International Dark Sky Society is devoted to reduce global light pollution and posts a lot of informational material on their website (http://darksky.org/).

There are different levels of light pollution with the highest level occurring in heavily urbanized areas and the lowest level in remote, rural areas. This map for the North Georgia region by the Deer Lick Astronomy Village (http://www.deerlickgroup.com/) shows the following colors indicating the levels, or classes, of light pollution from highest to lowest: white, red, orange, yellow, green, and blue (go to the Deer Lick website for the colored version). Areas with absolutely no light pollution would appear black but there are none in North Georgia. The corresponding Bortle Dark Sky Scale that classifies the levels of light pollution is shown on the right. An excellent dark sky site without any light pollution is classified as level 1 whereas the most light polluted inner city sky reaches level 9.



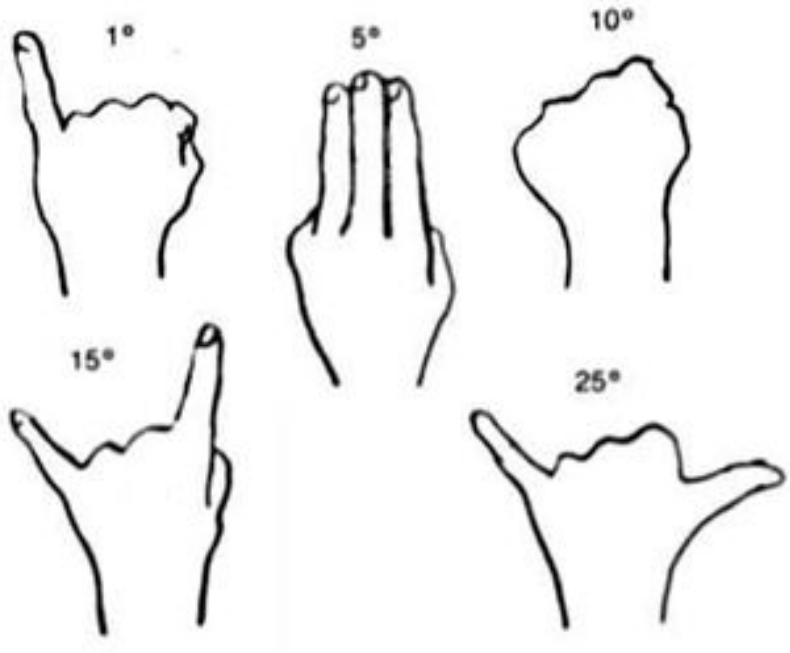
Class	Title	Color key	Naked-eye limiting magnitude	Stellar limiting magnitude (with 12.5" reflector)
1	Excellent dark-sky site	black	7.6–8.0	19 at best
2	Typical truly dark site	gray	7.1–7.5	17 at best
3	Rural sky	blue	6.6–7.0	16 at best
4	Rural/suburban transition	green / yellow	6.1–6.5	15.5 at best
5	Suburban sky	orange	5.6–6.0	15 at best
6	Bright suburban sky	red	5.1–5.5	14.5 at best
7	Suburban/urban transition or Full Moon	red	4.6–5.0	14 at best
8	City sky	white	4.1–4.5	13.5 at best
9	Inner-city sky	white	4.0 at best	13 at best

For your observations in this activity you will need to look up the level of light pollution at your observing location. You can use the Global Map from Dark Site Finder (http://darksitefinder.com/map/) and allow the site to see your location either by locating the IP address of your computer or the location service on your cell phone. The instructions are short, straight forward, and easy to follow

1. **Work out the Bortle Scale Light Pollution Practice on the worksheet below.**

Estimating Angles

You can easily estimate the position and size of an object in the sky by using your hand on your outstretched arm. Even though people come in all shapes and sizes, this works because for each person the size of the hand and the length of the arm are proportional to each other as long as you keep your arm fully extended. The diagram below by One Minute Astronomer (http://oneminuteastronomer.com/860/measuring-sky/) shows how which hand position corresponds to which angular measurement.



The YouTube video by Eyes On The Sky – Stargazing Basics 3, https://www.youtube.com/watch?v=YMu5k3Ik7JU&t=25s, explains in simple terms how to estimate angular distances between stars with your hands using the hand positions above.

2. **Work out the Hand Position Angle Practice in the worksheet below.**

Sky Map: Building Star Wheel

Now that we know how to use our eyes and hands to locate celestial objects we need some sort of a sky map that puts our observations into their proper context. There are many smartphone apps, a lot of them free such as Google Sky, for example, that show a celestial map of that section of the sky that you are pointing your phone camera to. It shows star names, constellations, the Sun, the Moon, the planets, etc. It can be very helpful to figure out what this light is in the sky that you are wondering about. You are welcome to use a suitable smart phone app for this activity but it will give you more practice and reinforcement of Astronomy concepts

that are important in class if you work with a traditional star wheel. Unlike a smartphone app, a star wheel only shows celestial objects that stay put in the sky, kind of like mountains, lakes, or towns on a geographical map. A star wheel or planisphere cannot show you objects that move with respect to the stars such as the Sun, the Moon, the planets, asteroids, etc., however, it will show a map of all fixed objects in the entire night sky for any given date and time of the year which would be hard to see on a cellphone screen.

You can easily print out and assemble the Star Wheel shown below from the Sky & Telescope Magazine's website: http://www.skyandtelescope.com/observing/make-a-star-wheel/. Your instructor may let you print one out and have you practice how to use it properly. Instructions are posted below the image.

Assembled Star Wheel, Sky & Telescope Magazine, http://www.skyandtelescope.com/observing/make-a-star-wheel/.

First, display (left mouse click) or download (right mouse click) the two parts for the Star Wheel. Your computer needs to be able to display PDF files (download and install the free *Adobe Reader*.) Part 1 of the star wheel from the website is the circular sky map, Part 2 is the star wheel's outer sleeve. Each part for the Star Wheel will fit on a single sheet of letter-size (8 ½ by 11 inches) paper. You may want to use a thicker type of paper such as card stock. Print and cut out both parts as follows. For the sky map (Part 1), cut off the gray corners so you get a circle 8 inches across. For the outer sleeve (Part 2), KEEP the large white rectangle at the bottom but cut out the white oval in the middle. The assembled star wheel is shown below. To finish the star

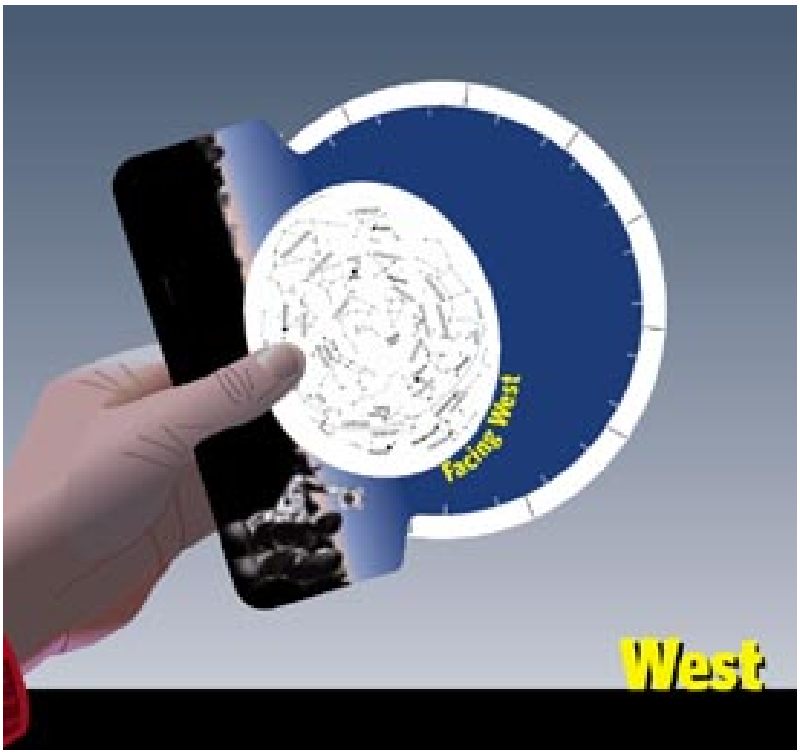
wheel, fold the white rectangle at the bottom of the outer sleeve so it will be underneath the front. Then staple the rectangle to the front at the locations marked by short white lines to either side of the oval. This creates a sleeve in the back. Finally, slide the circular sky map into the sleeve so it shows through the oval cut out.

This star wheel is usable for northern latitudes between 30° and 50°, basically all of the continental U.S., southern Canada, and Europe. It includes the names of the brightest stars and the most prominent constellations. Depending on how dark or cloudy the sky is in your area, you may see more or fewer stars than are shown on the map. Also, keep in mind that your eyes will take a few minutes to adjust going from a lighted environment to the darkness of the night outside. If you bring a flashlight with you, make sure it is fairly dim or has a red filter so that your eyes will remain adjusted to the darkness.

When you are ready to make an observation align your current date with your current time by turning the movable part of the Star Wheel. The example below is set for 10 p.m. daylight-saving time (yellow) or 9 pm standard time (white) on June 15th. Now the part of the circular disk showing through the oval cut out represents the whole sky you are seeing at the aligned date and time. The oval's curved edge represents your horizon all around you.

Sky & Telescope Magazine, http://www.skyandtelescope.com/observing/make-a-star-wheel/.

After aligning the date and time of your observation, the last step in properly orienting the Star Wheel is to align it with the cardinal directions. Once outside figure out the direction you are facing by using an old-fashioned magnetic compass, a smartphone app, or your knowledge of the location where the Sun usually rises (roughly East) and sets (roughly West). Hold the star wheel out in front of you and look at the yellow "Facing" labels around the oval, as shown below. Turn the entire wheel so that the yellow label for the direction you are facing is on the bottom, with the lettering right-side up as shown in the following image.



Sky & Telescope Magazine, http://www.skyandtelescope.com/observing/make-a-star-wheel/.

Now the stars above the map's horizon should match the real stars in front and above of you. Remember that star patterns (constellations) will look much larger in the sky than they do on the map. The farther away from the edge of the oval the stars appear, the higher up they will be in your sky. Stars in the center of the oval will appear directly overhead. Here is a sequence of YouTube videos that show how to use a Star Wheel ("Using a Star Wheel Planisphere 1, 2, 3"):

- Introduction: https://www.youtube.com/watch?v=1lUKskSsSEw
- Finding Constellations: https://www.youtube.com/watch?v=PVXJMOjhPAQ
- Locations in The Sky: https://www.youtube.com/watch?v=bkoR8RtA67g

3. **Work out the Star Wheel Practice in the worksheet below.**

Moving Celestial Objects

We found out in the previous section that the Star Wheel can only show celestial objects that are "fixed" to the sky which means that their positions with respect to each other always stay the same so the patterns they make always stay the same. They rise together, pass across the sky, and set together as Earth spins on its axis. Some of the brightest celestial objects such as the Sun, Moon, and planets visible with the naked eye are NOT "fixed" to the sky because they are part of our solar system and so nearby that we can see them change their position with respect to the "fixed" objects due to the combined effect of their motion and our motion as we observe them throughout the year. You can identify what these moving objects are by consulting print or online sources that post their up-to-date locations and viewing conditions. Sky & Telescope magazine (print and online) is a popular and accurate resource. There are a number of planet finder or planet locator apps for smartphones that you can use.

A fairly straight forward website that also includes an intuitive night sky simulator that shows planets, asteroids, and other moving objects in the constellations they are currently passing through is TheSkyLive.com (https://theskylive.com/guide). Finding a planet that is visible from your location at the date and time of your observation will be part of this lab so you want to familiarize yourself with how you can look up in which constellation the visible planets will be. Right after you have opened this website, go to the box showing the information of location, longitude, latitude, and time zone. Click on the link labeled "change" right next to the location and adjust it to your actual location. The website will then list the moving objects that are visible at your location on your current date according to three categories: close to sunset, most of the night, close to sunrise. One of the entries for each object is its set time. Pick a planet with a set time that is later than your current time at which you observe and that has a visibility listed as "naked eye". The last entry for each object is a link to its sky map which will show its current position with respect to the fixed objects in the sky, i.e. where it is located in the constellation it is passing through. This visual information may help you find it in the sky with your own eyes.

4. **Work out the Planet Finding Practice in the worksheet below.**

Star Wheel Worksheet

Name: _____ Date: _____

1. ***Bortle Scale Light Pollution Practice.*** Go to the Dark Site Finder website (http://darksitefinder.com/maps/world.html) and look up the the Bortle Scale light pollution class, number, and title for your current location. Use the search box at the upper left to enter the name of your town.

Class: _____ Color: _____ Title: _____ Loc.: _____

2. ***Hand Position Angle Practice.*** From where you sit or stand find three objects around the room or outside the window that have the same angular length or width as three different hand positions from the diagram above. Enter your answers into the worksheet below. (On-campus students: have the instructor verify your measurements. Online students: take a cellphone picture of the object with your outstretched hand in the appropriate position while holding the camera lens as close to your eye as possible. That way, your camera is nearly the same distance away from the object as your eye. Send these images to your instructor using their preferred way of submission.)

	1	**2**	**3**
Object			
Angle			

3. ***Star Wheel Practice:*** Once you have fully assembled, set the current time & date, and properly aligned your Star Wheel with the cardinal directions at your present location record the named star that is nearest each of the cardinal directions.

Date: _____ Time: _____ Daylight Savings? Yes / No

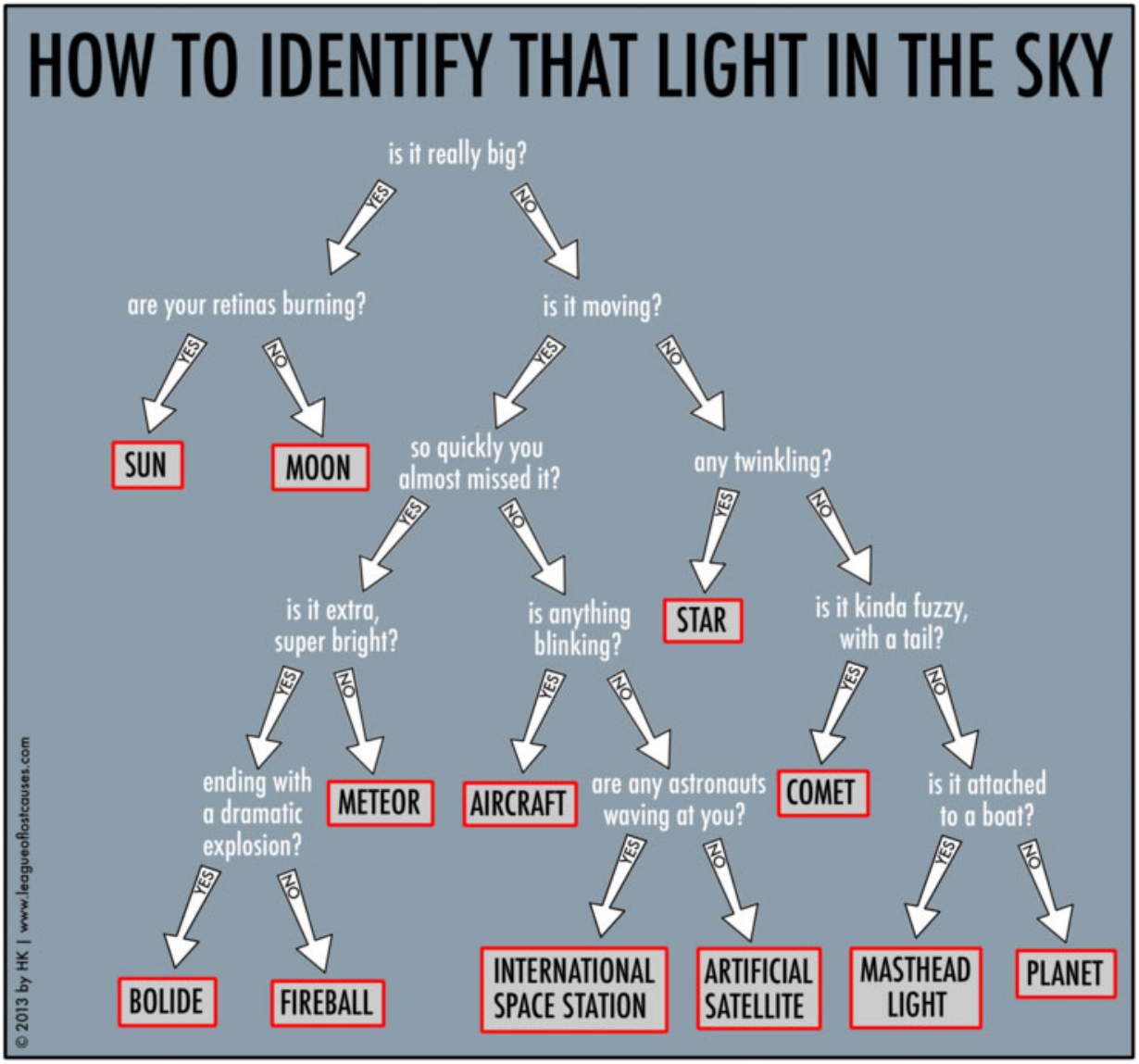
North: _____ East: _____ South: _____ West: _____

4. ***Planet Finding Practice.*** Use the TheSkyLive.com (https://theskylive.com/guide) website to find a planet that is above the horizon right now regardless of whether or not it is daytime and record your current date, time, location, light pollution class (from 1. Above), and constellation the planet is passing through on the worksheet below.

Planet:	Constellation:
Date:	Your Location:
Time:	Light Pollution Class:

Procedure

The objective of this activity is for you to make observations this week when sky conditions are suitable (clear or mostly clear skies). Using the "How To Identify That Light In The Sky" flow chart below with your star wheel, and record your observations of **at least three objects *including at least one star and one planet*** in all required data fields of the Observing Log below. You can double check your observations with a smartphone app of the night sky (i.e. GoogleSky), or use the interactive sky map provided by Sky & Telescope on their website: http://www.skyandtelescope.com/login/?redirect_to=http%3A%2F%2Fwww.skyandtelescope.com%2Fobserving%2Finteractive-sky-chart%2F.



Astronomy Picture of the Day, June 9, 2014 (https://apod.nasa.gov/apod/ap140609.html), NASA

Observation Log – Student Name: _____

For at least three celestial objects including at least one star and one planet, record the following information required in the data tables below.

Use the "How To Identify That Light In The Sky" Flow chart above (https://apod.nasa.gov/apod/ap140609.html) to track your decision making process while identifying the three objects. Write down the guiding questions and answers of the path you follow in the provided space underneath the data table for the respective object.

For each of your three objects you need to record the following items in the respective data table: observation date, prevailing weather conditions, the time (and whether or not it is daylight saving time), your location, your estimate of the level of light pollution based on the Bortle Scale above, the compass direction (use your local knowledge, a cell phone app, or a magnetic compass), the height in the sky using your hand as explained above, the name and type (if name not available then just type) of the object, and the constellation it is in. Treat the constellation as the entire area that contains the connect-the-dots patterns of the brightest stars. Think of the stars as the towns and the area taken up by the entire constellation as the state.

Object 1

Describe the object's appearance in the sky:

Flow chart path (list all questions and answers you encountered while identifying this object):

Name & Type:	Constellation:
Date:	Location:
Time:	Daylight Savings: YES / NO
Weather:	Light Pollution Class:
Height:	Compass Direction:

Object 2

Describe the object's appearance in the sky:

Flow chart path (list all questions and answers you encountered while identifying this object):

Name & Type:	Constellation:
Date:	Location:
Time:	Daylight Savings: YES / NO
Weather:	Light Pollution Class:
Height:	Compass Direction:

Object 3

Describe the object's appearance in the sky:

Flow chart path (list all questions and answers you encountered while identifying this object):

Name & Type:	Constellation:
Date:	Location:
Time:	Daylight Savings: YES / NO
Weather:	Light Pollution Class:
Height:	Compass Direction: