

Dark Skies Rangers Program

How Light Pollution Affects the Stars: Magnitude Reader

(This lesson was adapted from an activity by the International Dark-Sky Association: www.darksky.org.)

Grades: 5 – 12

Overview: Students each build a “Magnitude Reader”. They use the reader to determine how light pollution affects the visibility of stars and thereby learn the meaning of “limiting magnitude”. To do this they find a constellation like Orion in the night sky and view each star in the constellation through the Magnitude Reader. For each star in a drawing of the constellation (like the one of Orion in this activity), the students write down the number of the hole through which they can see the star the faintest. This illustrates the concept of magnitude. Note that for some of the stars on the drawing, the students will not be able to see due to light pollution. Using the faintest star they see (e.g., the limiting magnitude), the students can then estimate how many stars they have lost (e.g., they are unable to see) across their whole sky due to light pollution at their location.

Purpose: To help students determine how light pollution affects the visibility of stars and understand the meaning of “limiting magnitude” by using a Magnitude Reader. Students will apply scientific inquiry skills, ability, & attitudes associated with science.

Standards: This lesson has been developed and tested based on the U.S. National and Arizona State Standards. Science Inquiry is multi-faceted and correlates well with many other standards. Integration of science content, mathematics and research/language arts standards will enhance student achievement. Included are sample standards.

U.S. National Science Education Standards: Science Inquiry (selected standards not limited to the following)

- Understanding of scientific concepts
- An appreciation of "how we know" what we know in science
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world

Arizona State Standards: This lesson integrates well the introduction and design of “scientifically oriented questions” along with the design of the procedures in the scientific process. The generated questions may be most significant after the data collection. (Standards addressed in this activity include the following....

Grades 5-8

S1,C2,PO4. Perform measurements using appropriate scientific tools.

S1,C2,PO5. Keep a record of observations, notes, sketches, questions, and ideas using tools such as written and/or computer logs. (See W07-S3C2-01 and W07-S3C3-01)

S1,C3,PO1. Analyze data obtained in a scientific investigation to identify trends and form conclusions. (See M05-S2C1-03)

S3,C1,PO1. Analyze environmental risks (e.g., pollution, destruction of habitat) caused by human interaction with biological or geological systems.

S6,C3,PO5. (Gr7) Identify the following major constellations visible (seasonally) from the Northern Hemisphere.

Grades 9-12

S1,C1,PO1. Evaluate scientific information for relevance to a given problem. (See R09-S3C1, R10-S3C1, R11-S3C1)

S1,C2,PO5. Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs and computers.

S1,C3,PO1. Interpret data that show a variety of possible relationships between variables, including:

- positive relationship
- negative relationship
- no relationship

S3,C1,PO4. Evaluate the following factors that affect the quality of the environment:

- urban development



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Objectives: Science Inquiry National Objectives

- Ask a question about objects, organisms, & events in the environment
- Plan & conduct a simple investigation
- Employ simple equipment & tools to gather data & extend the senses
- Use data to construct a reasonable explanation
- Communicate investigations & explanations

Time: 20 minutes for students to make the Magnitude Readers. 20 minutes for students to use the Magnitude Reader to estimate the magnitude of the stars in the constellation. 20 minutes for the class discussion of students' results.

Materials and Tools:

- Inkjet transparencies (1 transparency makes 3 magnitude readers)
- Scissors (1 per student or they can share)
- Index cards (1 per student)
- Scotch tape
- Penny (optional) (1 per student)
- Templates for transparencies (1 template printout makes 3 templates)

Preparation/Prerequisites:

- Before making the Magnitude Reader in class, overlay the transparency on the printout of the template. Notice that the template printout repeats a pattern of rectangles labeled 1 through 5 three times. Cut the template printout and transparency into thirds preserving that pattern of rectangles. Make as many templates as there are students.
- Choose the constellation you will be using in the activity that is up in the early evening and find a picture of it as with Orion in this activity. Print out 1 constellation picture per student. (For the winter months in the northern hemisphere and the summer months in the southern hemisphere, Orion is the most easily recognized constellation in the early evening.)
- Before the students estimate the magnitudes of the stars, you may want to have a star party to teach the students how to find the constellation and how use their magnitude reader to estimate the magnitude of the stars in the chosen constellation.
- After the students have estimated the limiting magnitude at the location they took their measurements, you may want to get a map of the town and then ask the students to place on the map their measurements of limiting magnitudes and possibly the number of stars lost (see the Extension section below) and discuss the results.

Background Information: All materials for this lesson and other Dark Skies Rangers lessons are available at <http://www.globeatnight.org>. In particular you will find an interactive quiz on magnitudes, an explanation of magnitudes, an interactive activity on finding Orion in the night sky and mythology on Orion at the www.globeatnight.org website. See also the Constellation at Your Fingertips lesson (also part of the Dark Skies Rangers program).

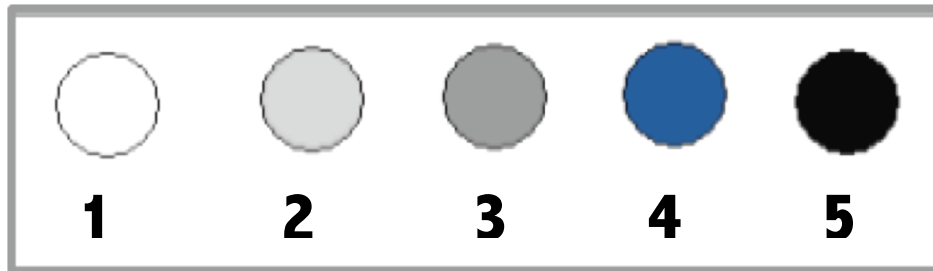
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Lesson Sequence:

Making the Magnitude Reader:

- Have the students cut out the 5 rectangles (labeled 1 through 5) with each transparency still overlaid on top of each template. From this point on, the students do the following.
- Use a penny to trace and cut out 5 circles on the index card as shown in the picture below **or**, instead, slightly bend the card lengthwise in half and cut 5 “V”s to create 5 diamond shaped cutouts. Make sure the cutout holes are all slightly spaced in a row across the widest portion of the index card.
- Label the 5 cutout holes #1 through 5 from left to right across the index card as shown in the picture below.
- Tape the transparency piece #1 across the hole #1, making sure that the transparency piece covers that hole. In all these steps, when you tape the transparency piece to the index card, the tape should not cover the holes. In any of these steps, it does not matter if the rough side of the transparency is face up or down.
- Tape the transparency piece #2 across the holes #1-2, making sure that the transparency piece covers those holes.
- Tape the transparency piece #3 across the holes #1-3, making sure that the transparency piece covers those holes.
- Tape the transparency piece #4 across the holes #1-4, making sure that the transparency piece covers those holes.
- Tape the transparency piece #5 across the length of the index card.
- The 1st hole should have 5 layers of transparency and the 5th hole should have only 1 layer of transparency.



Estimating the Magnitudes of the Stars

- During winter months in the Northern Hemisphere and the summer months in the Southern Hemisphere, the constellation Orion is visible in the first half of the evening. You can choose to use the drawing of Orion used in this activity or a drawing of another constellation that is up in the evening at another time of year.
- Have the students go out on a moonless, cloudless night in their backyard for a few minutes with the drawing of the constellation and a pencil and find the constellation in the night sky. Backyard lights should be off. The students should allow at least 5 minutes outside for their eyes to become adapted to the dark before beginning the activity.
- The students view each star in the constellation through the Magnitude Reader. For each star in the drawing of the constellation, the students write down the smallest number of the hole through which they can see the star. This is an estimate of the magnitude or brightness of the star. For instance, a star that really has a magnitude of 3 will be seen through holes #3, 4 and 5. But the student would record only hole #3.
- Note that some of the stars on the drawing the students will not be able to see due to light pollution. Once they have recorded for all of the stars shown on the drawing of Orion, the highest number for the magnitude that they record will be the limiting magnitude (the faintest star) that can be seen in their night sky.
- The students should also record the lighting situation where their data was recorded. Are the outdoor lights bright or dim? Are they as bright as a full Moon? How many are they? How far away are they?
- Have the students bring their results to class. As a class, compare the results. Remember that the lower the magnitudes are the brighter stars and the higher the magnitudes are the dimmer or fainter stars. How did each star compare to the other students' data in each of their lighting situations? In situations with brighter light were the same stars dimmer or brighter? How accurate is this data?
- The students can then estimate how many stars they have lost (e.g., they are unable to see) across their whole sky due to light pollution at their location. See the Extensions section below.

5

3

4

2

1

5

3

4

2

1

5

3

4

2

1

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Extension: *Estimating How Many Stars are Lost*

(Based on “Calculating Stars Lost” by Fred Schaaf in *Seeing the Sky*, John Wiley & Sons, 1990)

In order to complete this activity you will need to determine your local limiting magnitude using your results from the “Estimating the Magnitudes of the Stars” activity described in the previous pages.

By now you know that the number of stars visible is affected by the quality of the night sky. The Moon, atmospheric conditions, and light pollution can make it hard or impossible to see the fainter stars. You have also probably discovered that astronomers use the **magnitude scale** to measure the brightness of stars. Remember that magnitude 1 stars are brighter than magnitude 2 stars, which are bright than magnitude 3 stars, and so on.

Through the “Estimating the Magnitudes of Stars” activity you have learned to measure the **limiting magnitude** of your night sky, that is, what are the dimmest stars that can be seen. Under perfect conditions—no Moon, clear skies, and far, far away from any lights, the human eye can see stars down to about 6th or 7th magnitude. According to the table below, a limiting magnitude of 7 is about 14,000 stars!

Limiting Magnitude	Approximate Number of Stars Visible
1	6
2	45
3	150
4	540
5	1,700
6	4,900
7	14,000

Now you are ready to calculate how many stars you are missing at your location. All you have to do is subtract the approximate number of stars visible from your location from 14,000. For example, if you measured your limiting magnitude to be 3, you can see about 150 stars with the naked eye, but you are missing around 13,850 stars ($14,000 - 150 = 13,850$)!

Questions:

- Place your limiting magnitude and number of stars lost on a map of your town at the location where you took your measurements. Invite the other students to do the same and talk about the results.
- What do you think the result would be (e.g., how many stars are lost) if you took a measurement closer to the nearest town or city? How about farther away?
- Tonight at home, try taking a measurement as soon as stepping outside, followed by another in 15 minutes— using the table above, how many more stars can you see after your eyes adapt to the dark?

Teacher Resources:

- On Light Pollution: http://en.wikipedia.org/wiki/Light_pollution and http://www.globeatnight.org/learn_light.html
- On Light Pollution Interactive Game: http://www.globeatnight.org/learn_orionsky.html
- On Apparent Magnitude: http://en.wikipedia.org/wiki/Apparent_magnitude
- On Stellar Magnitude System: http://www.skyandtelescope.com/howto/basics/Stellar_Magnitude_System.html
- On Limiting Magnitude: http://en.wikipedia.org/wiki/Limiting_magnitude
- On Sky Brightness: http://en.wikipedia.org/wiki/Sky_brightness
- On Skyglow: <http://en.wikipedia.org/wiki/Skyglow>