![A+ Indian Education Division, Montana Office of Public Instruction, opi.mt.gov]	**Mathematics Model Teaching Unit** **Seven Stars** Created by: Jessie Collins

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Grade 12—Approximate Duration: 50 minutes

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Stage 1 Desired Results

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Established Goals:

Algebraic and Functional Reasoning Mathematics Content Standard 4: A student, applying reasoning and problem solving, will use algebraic concepts and procedures to understand processes involving number, operation, and variables and will use procedures and function concepts to model the quantitative and functional relationships that describe change within a variety of relevant cultural contexts, including those of Montana American Indians.

- **4.3 Solving Systems of Equations and Inequalities**: Solve a variety of equations, inequalities and systems of equations and inequalities, justify the solution process, and interpret the solution in context.
- **4.5 Analyzing and Conjecturing with Models:** Given data or a problem situation, select and use an appropriate function model to analyze results or make a prediction with and without technology using cultural contexts, including those of Montana American Indians.

IEFA Essential Understanding 3: The ideologies of Native traditional beliefs and spirituality persist into modern day life as tribal cultures, traditions, and languages are still practiced by many American Indian people and are incorporated into how tribes govern and manage their affairs.
   Additionally, each tribe has its own oral histories, which are as valid as written histories. These histories pre-date the "discovery" of North America.

IEFA Essential Understanding 6: History is a story most often related through the subjective experience of the teller. With the inclusion of more and varied voices, histories are being rediscovered and revised. History told from an Indian perspective frequently conflicts with the stories mainstream historians tell.

Understandings:	Essential Questions:
Students will understand… - how the Crow star stories and constellations correspond to the Euro-American constellations. - how to use and manipulate logarithmic formulas to learn about individual stars' properties.	- How is the brightness of stars determined? - What is the brightest star we can see from earth? - How do the stars in the Seven Stars constellation compare to the sun?

| *Mathematics Grade 12 – Seven Stars* *(continued)*

 Students will be able to...
 • use known data to calculate unknown values.
 • use the properties of logarithms to simplify and solve problems.
 • compare very large and very small numbers.
 • manipulate formulas/derive own formulas. | *Students will know...*
 • the story of the Seven Stars as told by a Crow Elder from Lodge Grass.
 • the definitions of absolute magnitude, apparent magnitude, luminosity and parsec.
 • the names of the stars in the Big Dipper/Seven Stars constellation. |

Stage 2 Assessment Evidence

Performance Tasks: Worksheet with table containing star information, vocabulary, formulas, and star map. Worksheet with questions answered and turned in.

Other Evidence: Participation in classroom discussion. Observation of data calculation. Test over logarithms at the end of the unit/chapter. Individual questioning of students.

Stage 3 Learning Plan

Learning Activity

1. **State the "Understandings" for the lesson.**
2. **Read aloud the Seven Stars excerpt from <u>The Stars We Know</u> by Timothy P. McCleary, pgs 69-71.**
   - Discuss the names of the stars/planets/constellations, both the Crow as well as their commonly known names.
   - Site given in Resources
3. **Handout worksheet with star table, formulas, vocabulary, and star map.**
   - Read the stars' names (check online for proper pronunciation if necessary) and note that the first eight stars are from the Seven Stars story.
   - Go over the vocabulary with the class, making sure to stress the difference between apparent and absolute magnitudes.
   - Go over the formulas and variables making sure students understand when/why to use each one.
4. **Have students fill in the table, leaving Alioth blank (they will fill this in later).**
   - Go over values together as a class; make sure everyone has the correct values in the table. Use the last formula for filling in the "Brightness" column.
   - Look at the values for the sun, Polaris, and Sirius and note how distance has an effect of the magnitude and brightness—just because a star has a higher absolute magnitude, it's not necessarily brighter to viewers on Earth.
   - Discuss which stars seem to be the brightest—are any actually brighter than the sun? Polaris? Sirius? (Sample response: All of the stars in the table are many times brighter than the sun but much farther away so they don't appear as bright to us on Earth. Polaris is the brightest star, being 2271 times brighter than the sun but is the farthest away of the stars in the table by over 300 light years. Although Sirius is visually the brightest star, all but Alcor and the sun are brighter when distance is factored into the comparison.)
   - Are there any stars that appear brighter to us on Earth but are really not as bright as the others? (Sample response: Sirius is the third dimmest when comparing brightness but is the most visible in the night sky. Look for stars that have absolute magnitudes that are more than 1.5 units higher than their

apparent magnitudes. The sun is the most obvious, going from being the most visible from Earth to having the highest absolute magnitude.)

5. Hand out worksheet with questions.
- Have students complete question 1 and 2—fill in the information for Alioth in the table. Go over answers.
  - o Do these new values change the answers to Learning Activity 4? (Sample: Not really but it does move from being the third most visible to having the 6th lowest absolute magnitude.)
- Have students complete #3 on worksheet (you may want to do this one together on the board or give them a hint to start out)
  - o Discuss answer—from earth, which star appears brighter? (Sirius appears brighter but Polaris is really much brighter when distances are equal)
- If time, have students complete #4 on the worksheet and check answers or assign as homework and discuss the next day.

Summary: You have learned how the story behind the Seven Stars in the Crow culture and how those stars compare to the brightest stars as seen from Earth. You should now be able to use logarithmic formulas to calculate and simplify data and apply those formulas to real world situations.

Materials/Resources Needed:
- Worksheets for each student.
- Copy of the Seven Stars story, available in <u>The Stars We Know</u> by Timothy P. McCleary, pgs. 69-71, or in PDF form. (Available for purchase at https://www.waveland.com/browse.php?t=570&pgtitle=Timothy%20P.%20McCleary)
- Scientific calculators for students.
- For more information about astronomy in general and sky maps, go to http://www.stargazing.net/david/index.html.

Extension: This lesson could be extended by have students research the actual size of different stars and determine if the size of a celestial body affects magnitude and luminosity, and if so, with what type of relationship (linear, exponential, logarithmic, etc.).

Also available on the OPI website: Search Montana Skies: Crow Astronomy
 at http://opi.mt.gov/Programs/IndianEd/Curricsearch.html.

STUDENT WORKSHEET #1

Star		Distance in Light Years	Distance in Parsecs	Apparent Magnitude	Absolute Magnitude	Brightness
Big Dipper or Seven Stars	Alioth					
	Alkaid	100		1.85		
	Dubhe	120		1.87		
	Mizar	78		2.27		
	Alcor	82		3.99		
	Merak	79		2.35		
	Phecda	84		2.43		
	Megrez	81		3.3		
Polaris		430		2.01		
Sirius		8.6		-1.47		
Sun		.000016		-26.73		

Formulas:

$$m = 6 - 2.5\log\frac{L}{L_0}$$

m—apparent magnitude
L—luminosity of star
L_0—luminosity of a sixth magnitude star (constant)

$$M = m + 5 - 5\log d$$

M—absolute magnitude

$$d = \frac{l}{3.262}$$

d—distance from earth, in parsecs
l—distance from earth, in light years

$$b = 2.512^{4.8-M}$$

b—brightness of a star as compared to the sun

Vocabulary:

apparent magnitude: The degree of brightness of a celestial body designated on a numerical scale, on which the brightest star (after the sun) has magnitude -1.4 and the faintest visible star has magnitude 6.
→ This rates how visible a celestial body is from Earth.

absolute magnitude: The magnitude of a star as it would appear to a hypothetical observer at a distance of 10 parsecs or 32.6 light-years.
→ This rates how visible celestial bodies are when they are all viewed from the same distance.

luminosity: The brightness of a star in comparison with that of the sun.

parsec: A unit of astronomical length based on the distance from Earth at which stellar parallax is 1 second of arc; equivalent to 3.262 light years.

light year: The distance that light travels in a vacuum in 1 year; 5.88 trillion miles or 9.46 trillion kilometers.

● Sirius/Bright Star/Morning Star

Big Dipper/Seven Stars

Dubhe   Merak
●   ●

Polaris/Star That
Does Not Move
●   Phecda
                                 ●

                    Megrez ●

                           ● Alioth

                        ● Mizar
                  Alcor ●

                           ● Alkaid

STUDENT WORKSHEET #2

1. The star Alioth is approximately 101 times brighter than the sun. What is its absolute magnitude?

2. If Alioth's apparent magnitude is 1.76, how far from Earth is it in terms of parsecs and light years?

3. Luminosity comparisons between other celestial bodies can be done by finding the difference in apparent magnitudes. Showing all steps, find how much brighter Polaris is than Sirius.

4. Using the formulas given, write one formula for finding apparent magnitude when given absolute magnitude and distance in light years.

TEACHER WORKSHEET #1

Star		Distance in Light Years	Distance in Parsecs	Apparent Magnitude	Absolute Magnitude	Brightness
Big Dipper or Seven Stars	Alioth	**82**	**25**	**1.76**	**-.21**	**101**
	Alkaid	100	**31**	1.85	**-.58**	**142**
	Dubhe	120	**37**	1.87	**-.96**	**201**
	Mizar	78	**24**	2.27	**.38**	**59**
	Alcor	82	**25**	3.99	**2**	**13**
	Merak	79	**24**	2.35	**.43**	**56**
	Phecda	84	**26**	2.43	**.38**	**59**
	Megrez	81	**25**	3.3	**1.33**	**24**
Polaris		430	**132**	2.01	**-3.59**	**2271**
Sirius		8.6	**3**	-1.47	**1.4**	**23**
Sun		.000016	**.00000494**	-26.73	**4.8**	**1**

Formulas:

$$m = 6 - 2.5\log\frac{L}{L_0}$$

m—apparent magnitude
L—luminosity of star
L_0—luminosity of a sixth magnitude star (constant)

$$M = m + 5 - 5\log d$$

M—absolute magnitude

$$d = \frac{l}{3.262}$$

d—distance from earth, in parsecs
l—distance from earth, in light years

$$b = 2.512^{4.8-M}$$

b—brightness of a star as compared to the sun

Vocabulary:

apparent magnitude: The degree of brightness of a celestial body designated on a numerical scale, on which the brightest star (after the sun) has magnitude -1.4 and the faintest visible star has magnitude 6.
→ This rates how visible a celestial body is from Earth.

absolute magnitude: The magnitude of a star as it would appear to a hypothetical observer at a distance of 10 parsecs or 32.6 light-years.
→ This rates how visible celestial bodies are when they are all viewed from the same distance.

luminosity: The brightness of a star in comparison with that of the sun.

parsec: A unit of astronomical length based on the distance from Earth at which stellar parallax is 1 second of arc; equivalent to 3.262 light years.

light year: The distance that light travels in a vacuum in 1 year; 5.88 trillion miles or 9.46 trillion kilometers.

TEACHER WORKSHEET #2

1. The star Alioth is approximately 101 times brighter than the sun. What is its absolute magnitude?

$$b = 2.512^{4.8-M}$$
$$101 = 2.512^{4.8-M}$$
$$\log(101) = \log(2.512^{4.8-M})$$
$$2 = (4.8 - M) * \log(2.512)$$
$$2 = (4.8 - M) * 0.4$$
$$5 = 4.8 - M$$
$$-0.2 = M$$

2. If Alioth's apparent magnitude is 1.76, how far from Earth is it in terms of parsecs and light years? Round final answers to the nearest whole number.

$$M = m + 5 - 5\log d$$
$$-0.2 = 1.76 + 5 - 5\log d$$
$$-6.96 = -5\log d$$
$$1.392 = \log d$$
$$10^{1.392} = 10^{\log d}$$
$$25 = d$$

$$d = \frac{l}{3.262}$$
$$25 = \frac{l}{3.262}$$
$$82 = l$$

3. Luminosity comparisons between other celestial bodies can be done by finding the difference in apparent magnitudes. Showing all steps, find how much brighter Polaris is than Sirius. Round final answer to the nearest whole number.

METHOD 1

$$m_P - m_S = \left(6 - 2.5\log\frac{L_p}{L_0}\right) - \left(6 - 2.5\log\frac{L_S}{L_0}\right)$$

$$m_P - m_S = -2.5\log\frac{L_p}{L_0} + 2.5\log\frac{L_S}{L_0}$$

$$m_P - m_S = -2.5\left(\log\frac{L_p}{L_0} - \log\frac{L_S}{L_0}\right)$$

$$m_P - m_S = -2.5\left(\log\frac{L_P/L_0}{L_S/L_0}\right) = -2.5\log\frac{L_P}{L_S}$$

$$2.01 - (-1.47) = -2.5\log\frac{L_P}{L_S}$$

$$3.48 = -2.5\log\frac{L_P}{L_S}$$

$$1.392 = \log\frac{L_P}{L_S} \quad (drop\ the\ negative)$$

$$10^{1.392} = 10^{\log\frac{L_P}{L_S}}$$

$$25 = \frac{L_P}{L_S}$$

<div align="center">METHOD 2</div>

$$m = 6 - 2.5\log\frac{L}{L_0}$$

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POLARIS   *SIRIUS*

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$$2.01 = 6 - 2.5\log\frac{L_P}{L_0} \qquad\qquad -1.47 = 6 - 2.5\log\frac{L_S}{L_0}$$

$$-3.99 = -2.5\log\frac{L_P}{L_0} \qquad\qquad -7.47 = -2.5\log\frac{L_S}{L_0}$$

$$1.596 = \log\frac{L_P}{L_0} \qquad\qquad 2.988 = \log\frac{L_S}{L_0}$$

$$10^{1.596} = 10^{\log\frac{L_P}{L_0}} \qquad\qquad 10^{2.988} = 10^{\log\frac{L_S}{L_0}}$$

$$39 = \frac{L_P}{L_0} \qquad\qquad 973 = \frac{L_S}{L_0}$$

$$ratio = 973 \div 39 = 25$$

4. Using the formulas given, write one formula for finding apparent magnitude when given absolute magnitude and distance in light years.

$$M = m + 5 - 5\log d$$
$$-m = -M + 5 - 5\log d$$
$$m = M - 5 + 5\log d$$
$$m = M - 5 + 5\log \frac{l}{3.262}$$
$$m = M - 5 + 5(\log l - \log 3.262)$$
$$m = M - 5 + 5\log l - 5\log 3.262$$
$$m = M - 7.567 + 5\log l$$