UNIT 5:

PATTERNS IN ASTRONOMY ALMANACS

OVERVIEW FOR TEACHERS

Unit Outline

Introduction

The educational achievement is not to make the strange seem familiar, but to make the familiar seem strange. It is seeing the wonderful that lies hidden in what we take for granted that matters educationally.

---Kiernan Egan, ***Teaching as Story telling***

Nathaniel was thrilled with the challenges of mathematics. At the bright age of 14, Nat's brother introduced him to algebra. He couldn't sleep with excitement over the new world of using both letters and numbers to do his figuring. Soon Nathaniel was ready for navigation, a logical progression for someone indentured to the ship chandlery of Ropes and Hodges. It would only be a matter of time before Bowditch compiled a sailor's almanac, a summary of sun, moon, star and planet positions for each day of the year. An excerpt from ***Carry on Mr. Bowditch*** (p. 59) illustrates his passion:

He was sixteen the summer he figured how to make an almanac. He felt a tingle go up his backbone. Just to think! A man could sit right here and figure out when the moon would rise every night, next month - or next year - or ten years from now! He could figure out the way the sun would act: he could figure ...

Ben Meeker shuffled into the chandlery one day. "What's that you're figuring on?

"An almanac for the years from 1789 to 1823."

Ben sniffed. "Do tell. And what's your almanac going to have in it?"

"Just the regular things: the sun's rising, setting, declination, amplitude, place in the ecliptic--"

Nathaniel apparently wrote daily notes, much like a Captain's log, in a printed almanac dated 1789. The Bowditch family has preserved this almanac with its neatly printed inscriptions and drawings. Copies of a page with Nat's handwritten comments on the weather, sailing ships, and the comings and goings of Salem ship captains, are provided at the end of the Overview.

Even from the handwritten notes above, it is clear that the workings of the Universe were all a joyful matter of interest to Nathaniel Bowditch. Deciphering these workings were a matter of mathematics. The regularity of the sunrise and sunset, moonrise and moonset, as well as their ever changing placement in the night stars, were very much a part of every sailor's world. Sadly, these heavenly rhythms are lost to us in our fast-paced, modern lifestyles. The cyclic progression of constellations continue daily without our slightest appreciation or notice. Fortunately, students can become aware of these rhythms through many everyday sources. The daily newspaper, Farmer's Almanacs, and even the Internet offer daily almanacs for our diverse lifestyles.

In the following unit, entitled Student Almanacs, information is easily obtained by students to create individual almanacs. Students will rearrange and analyze data to uncover meaningful patterns from season to season. Students will also create graphs of changes over time, and summary tables for each of the almanac variables.

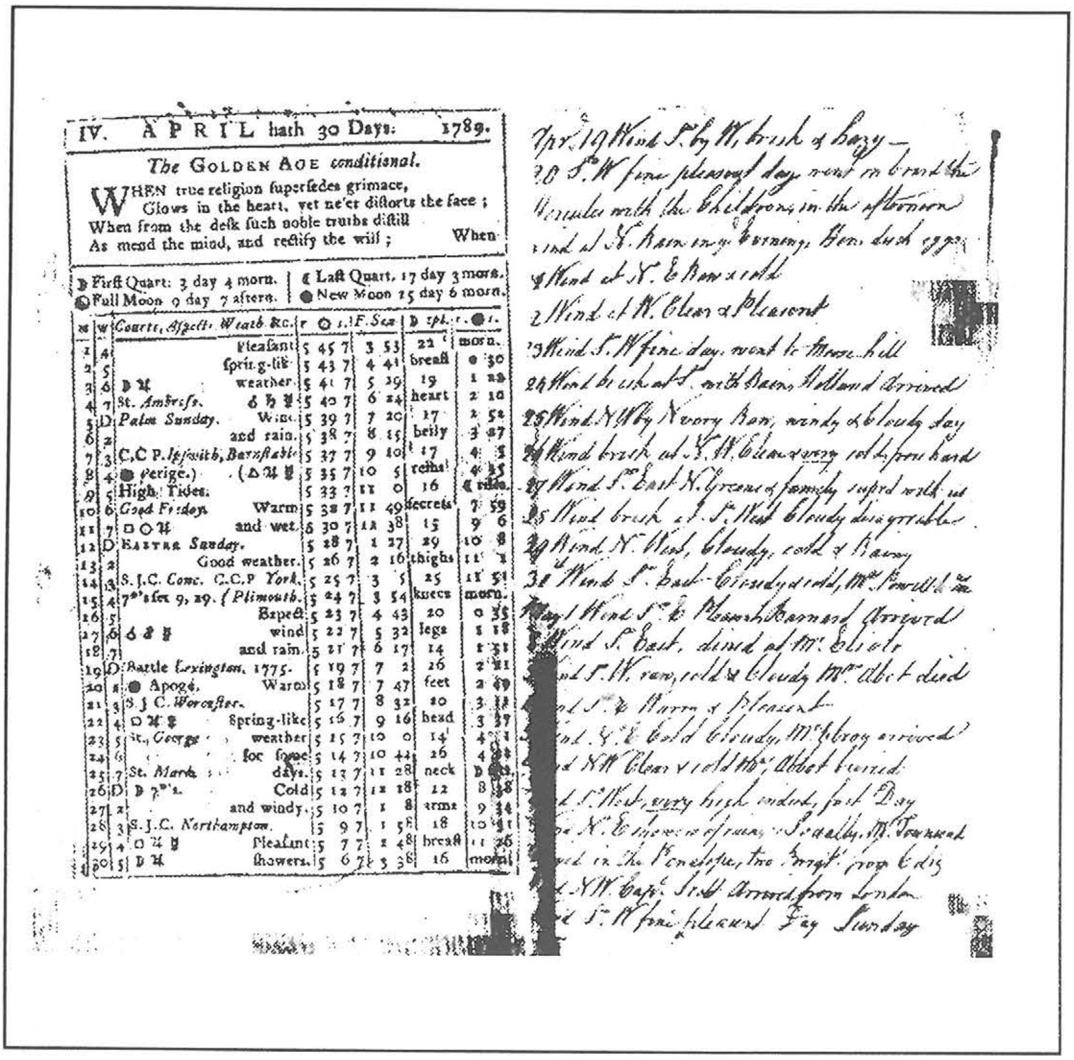
Students begin their discovery of the orderly movements of the sky through an investigation of sunrise and sunset data. To begin the journey, students graph the day-night cycle created by sunrise and sunset over a 7-day cycle. How predictable is the sunrise and the sunset? Students examine a large set of data over many days to discover changing trends in both sunrise and sunset times. Numerical patterns are easily discovered which allow students to predict future sunrises and sunset times. Students quickly and easily extend their almanacs to cover at least two weeks ahead of the date of their current data. Their mathematical predictions according to the data trends can be verified by consulting the original almanacs.

But why are these trends occurring in the sunrise and sunset data? Can they tell us anything about the Earth and its travels around the sun? To answer these questions, students are assigned a research project. What is the yearly path of the Earth around the Sun? How does the Earth's 23.5^0 tilt on its axis effect this annual cycle? How does this tilt effect our seasons? Can we locate the seasonal path of the Sun's position anywhere on our Earth? Where? And finally, Why?

New data is introduced to the student almanac, the declination, or angle, of the sun at noon. The sun's declination at noon changes as the seasons move from winter to spring to summer to fall. As students uncover and then comprehend the sun's seasonal path between the Tropic of Capricorn, the Equator and the Tropic of Cancer, they will discover an explanation for the trends in their sunrise/sunset data. The final conclusion from this exercise is that students now take notice of the changing sun positions throughout the year. The changes in sunrise and sunset times are now understood to represent an effective mathematical diary of the Sun's seasonal progress across the face of the earth. Sailors, navigators, and astronomers alike use this knowledge to build and interpret many more complex relationships found in the sky.

A final note: the Student Almanac can be useful for many more data explorations. Additional areas of investigations include the movements of the planets in relation to the stars, the monthly pattern in moonrise and moonset, the relationship between tidal cycles and moon phases, and an exploration of Newton's Law of Gravity in relation to the orbiting moon, planets, and tides.

Nathaniel Bowditch's Original Notes in an Almanac Dated 1789



IV. APRIL hath 30 Days. 1789.

The GOLDEN AGE *conditional.*

WHEN true religion supersedes grimace,
Glows in the heart, yet ne'er distorts the face;
When from the desk such noble truths distill
As mend the mind, and rectify the will; When

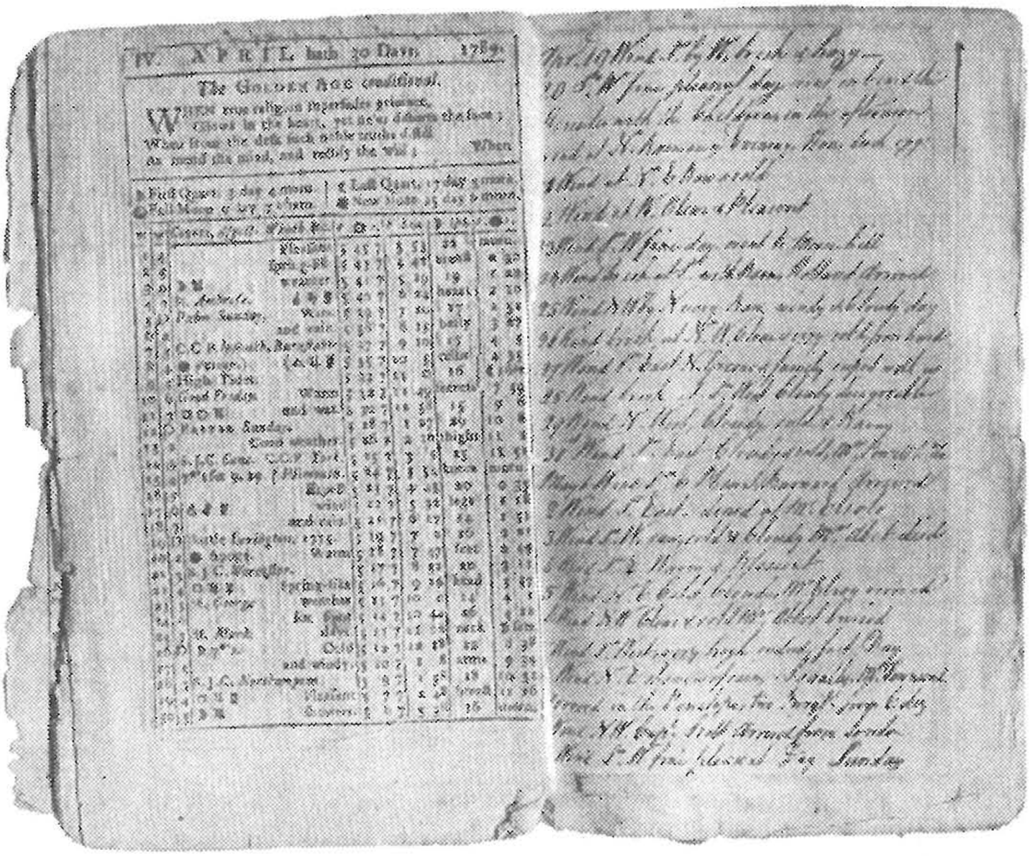
☽ First Quart. 3 day 4 morn. | ☾ Last Quart. 17 day 3 morn.
☉ Full Moon 9 day 7 aftern. | ● New Moon 25 day 6 morn.

M	W	Courts, Aspects, Weath. &c.	☉ r.	☉ s.	F. Sea	☽ pl.	☽ r. s.
1	4	Pleasant	5 45	7	3 53	22	morn.
2	5	spring-like	5 43	7	4 41	breast	0 30
3	6	☽ ♃ weather.	5 41	7	5 29	19	1 22
4	7	St. Ambrose. ☌ ♄ ☿	5 40	7	6 24	heart	2 10
5	D	Palm Sunday. Wind	5 39	7	7 20	17	2 52
6	2	and rain.	5 38	7	8 15	belly	3 27
7	3	C.C.P. Ipswich, Barnstable	5 37	7	9 10	17	4 5
8	4	● perige.) (△ ♃ ☿	5 35	7	10 5	reins	4 35
9	5	High Tides.	5 33	7	11 0	16	☾ rises.
10	6	Good Friday. Warm	5 32	7	11 49	secrets	7 59
11	7	□ ☉ ♃ and wet.	5 30	7	12 38	15	9 6
12	D	EASTER Sunday.	5 28	7	1 27	29	10 8
13	2	Good weather.	5 26	7	2 16	thighs	11 1
14	3	S.J.C. Conc. C.C.P. York.	5 25	7	3 5	25	11 51
15	4	7*'s set 9, 29. (Plimouth.	5 24	7	3 54	knees	morn.
16	5	Expect	5 23	7	4 43	20	0 35
17	6	☌ ♂ ☿ wind	5 22	7	5 32	legs	1 18
18	7	and rain.	5 21	7	6 17	14	1 51
19	D	Battle Lexington, 1775.	5 19	7	7 2	26	2 21
20	2	● Apogé. Warm	5 18	7	7 47	feet	2 49
21	3	S.J.C. Worcester.	5 17	7	8 32	10	3 12
22	4	□ ♃ ☿ Spring-like	5 16	7	9 16	head	3 37
23	5	St. George weather	5 15	7	10 0	14	4 1
24	6	for some	5 14	7	10 44	26	4 [illegible]
25	7	St. Mark days.	5 13	7	11 28	neck	☽ [illegible]
26	D	☽ 7*'s. Cold	5 12	7	12 18	12	8 38
27	2	and windy.	5 10	7	1 8	arms	9 34
28	3	S.J.C. Northampton.	5 9	7	1 58	18	10 31
29	4	☌ ♃ ☿ Pleasant	5 7	7	2 48	breast	11 26
30	5	☽ ♃ showers.	5 6	7	3 38	16	morn.

Apr. 19 Wind S. by W. brisk & hazy—
20 S. W. fine pleasant day ...
22 Wind at W. Clear & Pleasant
23 Wind S. W. fine day ...
25 Wind N. W. by N. ...
29 Wind N. West, Cloudy, cold & Rainy

Courtesy of Anna H. Bowditch Family

Notes from a 1789 Almanac Containing Nathaniel Bowditch's Notes and Drawings.



Courtesy of Anna H. Bowditch Family

Objectives:

- Students will compile common astronomical data from everyday sources such as ***The Boston Globe*** and ***The Farmers Almanac***, and organize this data into tables entitled Student Almanac.
- The astronomical data in each almanac will include the following variables:
  - Sunrise time, sunset time
  - declination of sun
  - day of year
  - length of day
  - sun fast time

For future lessons:

  - moonrise, moonset
  - 1st and 2nd high tide
  - 1st and 2nd low tide
  - height of both high tides
  - height of both low tides
  - moon phase (8 phases)
  - planet rise and set (Mercury, Venus, Mars, Jupiter, and Saturn).

- Students will use their sunrise/sunset data to mathematically illustrate the 24 hour rotation period of the earth on its axis, demonstrating the creation of day and night.
- Students will make predictions of future sunrise and sunset times using mathematical patterns uncovered in their daily almanac data.
- Students will relate these sunrise and sunset patterns to the yearly journey of the Sun across the face of the Earth.

Additional objectives include:

- Students will analyze and describe mathematical seasonal changes in sun rise and sunset at the winter/summer solstices and the spring (vernal)/ fall (autumnal) equinoxes and will illustrate these seasonal differences using charts and graphs.
- Students will graph the changing positions of the planets as they move across a background of seasonal stars.
- Students will describe the regularly occurring patterns of Moon phases using both models of the Moon, Sun and Earth, as well as numerical illustrations (graphs, tables) of the changing pattern in moonrise, moonset, and changing phases of the moon.
- Students will use graphs to illustrate the relationship between the daily and seasonal tidal cycle and the phases of the Moon.
- Students will relate their understanding of the moon/tide cycles to the forces of gravity on the Earth's surface.
- Students will demonstrate their understanding of Sir Isaac Newton's Law of Gravity, by examining evidence that gravity is a force that produces an attraction between matter. Students will provide evidence that gravity pulls on or anywhere near the Earth toward the Earth's center and acts across space to hold the Moon in its orbit around the Earth and the planets in their orbits around the Sun.

Skills:

- Collecting data from outside sources.
- Organizing data into an appropriate table.
- Analyzing patterns and relationships between many variables.
- Illustrating scientific concepts using graphs.
- Summarizing trends and making mathematical predictions about future events from numerical patterns in the data.

Vocabulary:

- Sunrise time, sunset time
- declination of sun
- day of year
- length of day
- sun fast time
- Tropic of Cancer
- Tropic of Capricorn
- Solstice
- Equinox

Frameworks connections:

Science and Technology:

Strand 1: Inquiry, p. 28

- Note/describe relevant details, patterns and relationships.
- Differentiate between questions that can be answered throughout direct investigation and those that cannot.
- Apply personal experience/knowledge to make predictions.
- Describe trends in data when patterns are not exact.
- Represent data and findings using tables, models, demonstrations and graphs.

Strand 2: Domains of Science, pp. 77-78

- Demonstrate an understanding that, like all planets and stars, the Earth is approximately spherical in shape. Use models to demonstrate how the rotation of the earth on its axis every 24 hours produces the night-and-day cycle.
- Observe and illustrate that planets change their positions against the background of stars.
- Observe and explain that the Earth has a natural satellite, the Moon, that circles the planet approximately every 29 days.
- Use models to describe how the motion of the Moon about Earth and the location of the Sun relative to Earth and its Moon are responsible for the regularly occurring patterns of Moon phases, eclipses and tides.
- Give evidence that gravity is a force that produces an attraction between matter. Gravity pulls on or anywhere near the Earth toward the Earth's center and acts across space to hold the Moon in its orbit around the Earth and the planets in their orbits around the Sun.

Unit 5 Lesson Plans

Lesson 1. What is an Almanac?

Objectives:

- Students will compile useful astronomical data from everyday sources such as the Boston Globe and the Farmers Almanac and organize this data into a personal almanac.

Skills:

- Collecting data from outside sources.

Vocabulary:

- sunrise, sunset
- declination of sun
- day of year
- length of day
- sun fast time

For future lessons:

- moonrise, moonset
- 1st and 2nd low tide
- height of both low tides
- 1st and 2nd high tide
- height of both high tides
- moon phases (8)
- planet rise and set (Mercury, Venus, Mars, Jupiter, and Saturn)

Materials:

- *The Old Farmers Almanac*, by Robert B. Thomas, Dublin, NH 03444 - class set of 25 - 30 (1801 edition replicated)
- Other almanacs for further comparison
- Current *Boston Globe* Weather page - class set of 25 - 30
- What is an Almanac? - handout
- Creating Your Student Almanac - handout
- notebook
- paper for almanac title page
- colored pencils/markers
- ruler

Procedure:

Class Challenge: (on board or overhead)

- What is an almanac? Brainstorm ideas, show several examples, etc.
- Distribute class copies of the Farmers Almanac.

- Title page (p. 1): What does it contain? When was it originally printed? What number is it? What else is on the cover?
- Contents (p. 2): What are the 2 major categories of articles? Which article would you like to read?
- Weather: What types of forecasts are in this almanac? What is the forecast for your region? Were the editors right in their forecast?
- Contents (p. 4): Review the Charts, Tables, and Miscellany: Which pages relate to your study of astronomy? What is the difference between astrology and astronomy?
- Astronomical Data (p. 4): Do you know all of these terms? What page contains information on how to use the almanac?

Individual Activity:

- It's time to define a "true" almanac and to begin your own! What does your almanac state as a definition of a "true" almanac?
- Your personal almanac will need astronomical data from the left hand calendar pages. To simplify your search, we will begin with only a few variables at a time. Our first almanac chart will need only information about the sun. Which columns should you select?
- Rises, Sets, Length of Day, Sun Fast, Declination of Sun: All of these relate to the sun. Review the explanations of these terms before we go on.
- You will also need to know the information in the first column, Day of the Year. Create your own column format for Date (ex: 12/10/00, or Dec. 3, 2000)
- Find today's date and enter all of the data you selected for the sun.
- What units are these variables? This is very important to know!
- Copy 7 days of sun data into your almanac. We will begin searching for patterns tomorrow.

Homework Suggestion:

- Create your own colorful almanac cover at home.

UNIT 5 STUDENT HANDOUT

WHAT IS AN ALMANAC?

Class Challenge:

1. What is an almanac? First, brainstorm ideas with your classmates.

2. Let's investigate by looking at a copy of ***The Old Farmers Almanac***

Title page:

- What does it contain?
- When was it originally printed?
- What number is it?
- What else is on the cover?

Contents:

- What are the major categories of articles?
- Which articles would you find interesting to read?

Weather:

- What types of forecasts are in this almanac?
- What is the forecast for your region?
- Were the editors right in their forecast?

© Historic Salem, Inc. Permission to copy for classroom use.

Contents:

- Charts, Tables, and Miscellany:

- Do any pages relate to your study of astronomy?

- What is the difference between astrology and astronomy?

Astronomical Data:

- Do you know all of these terms?

- List the terms that you do not know:

- What page contains information on how to use this almanac?

© Historic Salem, Inc. Permission to copy for classroom use.

UNIT 5 STUDENT HANDOUT

CREATING YOUR STUDENT ALMANAC

Individual Activity:

1. It's time to define a "true" almanac and to begin your own!

   - In the section titled, "How to Use This Almanac" or "Explanation of the Calendar Pages", what pages are the heart of the almanac?
   - Describe the contents of a "true almanac".

2. Your personal, student almanac will need astronomical data from the calendar pages, the left-hand side. To simplify your search, we will begin with only a few variables at a time.

   - Our first almanac chart will need only information about the sun. Find the calendar page for November. Which columns refer to the sun?
   - Use the almanac's Glossary and the explanations on the page titled Left-Hand Calendar Pages to define the following terms:

     Sunrise/Sunset

     Length of Day

     Sun Fast

     Declination of Sun

© Historic Salem, Inc. Permission to copy for classroom use.

- All of these terms relate to the sun.

  Skim the Glossary pages for other terms you might know.

3. Create a table for your almanac of the sun:
   - Place a title at the top, along with your name and class period.

   Enter:
   - Column 1: Day of the Year
   - Column 2: Day of Month:
   - Column 3: Day of Week
   - Column 4: Rises (h. m.)
   - Column 5: Sets (h. m.)
   - Column 6: Length of Day (h. m.)
   - Column 7: Sun Fast (m.)
   - Column 8: Declination of Sun (degrees minutes)

4. If you are handy with creating spreadsheets using EXCEL or other software, this is an excellent opportunity to practice your skills!

5. Copy 7 days of data, starting with today, into your almanac. We will begin searching for patterns in the next activity.

6. Homework suggestion: Create a colorful almanac cover at home.

© Historic Salem, Inc. Permission to copy for classroom use.

Lesson 2. What Can We Do With All of These Numbers?

Objectives:

- Students will use their sun data to mathematically illustrate the 24 hour rotation period of the earth on its axis, demonstrating the creation of day and night.
- Students will make predictions of future sunrise and sunset times using mathematical patterns uncovered in their daily almanac data.

Skills:

- Collecting data from outside sources.
- Analyzing patterns and relationships between many variables.
- Illustrating scientific concepts using graphs and tables.
- Summarizing trends and making predictions about future events from patterns in the data.

Vocabulary:

- sunrise time
- sunset time
- day length
- declination of sun
- day of year
- sun fast time

Materials:

- Student almanac cover
- centimeter graph paper
- ruler
- The Mathematics of the Sun - handout
- pencil

Procedure:

Class Challenge:

- How long is 1 day on our Earth?
- Mathematically define one Earth day for your classmates. Illustrate your definition with a chart and a graph.
- Why do we have a "day" and a "night"?
- Mathematically demonstrate the creation of day and night. Illustrate your proof with a chart and a graph.

Activity:

- Can you predict the sunrise without consulting your almanac?
- First, is there a pattern in the daily changes in sunrise for the 5 to 7 days you copied into your almanac?
- Subtract each day's sunrise time from the previous day to see if the changes are consistent from one day to the next.
- How can this information help you predict the sunrise for the next day you do not have data for?
- Without consulting *The Farmer's Almanac*, calculate the sun rise times for the 7 days after your own almanac data.
- Now, recheck *The Farmer's Almanac* for your predicted dates. How accurate were you? Explain your results.
- Now, repeat this exercise for sunset times. Determine the difference in daily times and use this difference to predict the 7 days after your own data.
- Recheck *The Farmer's Almanac* for your predicted sunset times. How accurate were you? Explain your results.

Analysis:

- What is a prediction in science or mathematics?
- Why are you able to predict sunrise and sunset times?
- What can these daily changes in sunrise and sunset tell us about our Sun and our Earth?
- Does the Earth's tilt, moving to different locations in the yearly revolution around the Sun, determine our different seasons?

Independent Research:

- To answer these questions you must research the relationship between the Earth's yearly revolution around the Sun and the Earth's constant 23.5° tilt on its axis.
- Use as many resources as you can find to help you illustrate:
  - the tilt of the Earth on its axis as the Earth revolves around the sun.
  - the position of the Earth and the Sun at each of the four seasons of the year

- find both on a globe and then draw, the location of the Tropic of Capricorn, the Equator, and the Tropic of Cancer.
- find both on a globe and then draw, the location of the Sun at the winter solstice, spring equinox, summer solstice, and fall equinox.

UNIT 5 STUDENT HANDOUT

THE MATHEMATICS OF THE SUN

Class Challenge:

1. How long is 1 day/night cycle on our Earth?

    - Is it the same length of time for every complete cycle or does it change with the seasons? Does it change from one year to the next?

    - Use your almanac to research the questions above, then mathematically define one complete Earth day/night cycle. Illustrate the class definition with a chart and a graph.

2. Why do we have a "day" (daylight) and a "night" (darkness)?

    - Use your almanac to research the question, then mathematically demonstrate the creation of day and night. Illustrate your class proof with a chart and a graph.

    - Is the amount of daylight and darkness the same throughout the year? Why?

© Historic Salem, Inc. Permission to copy for classroom use.

Individual Activity:

- Can you predict the sunrise time without consulting your almanac?

- First, determine if there is a pattern in the daily sunrise times you entered into your almanac:

- If you see a pattern, check your hunch by subtracting the sun rise time from each previous day to see if the changes are consistent from one day to the next. Show your work in a table below:

- Can this information help you predict the sunrise time for the 8th day?

- Without consulting ***The Farmer's Almanac***, calculate the sunrise times for the next 7 days following your own almanac data. Show your work in a table below:

- Now, recheck *The Farmer's Almanac* for your predicted dates. How accurate were you? Explain your results.

© Historic Salem, Inc. Permission to copy for classroom use.

- Repeat this exercise for sunset times. Determine the difference in daily times and use this difference to predict the 7 days after your own data. Show your work in a table below:

- Recheck *The Farmer's Almanac* for your predicted sunset times. How accurate were you? Explain your results.

Analysis:

- What is a prediction in science or mathematics?

- Why are you able to predict sunrise and sunset times?

- Did the length of day change with changing sunrise and sunset? Using your original 7 days of sun data, create a graph of length of day (vertical axis) versus date (horizontal axis). Explain your results below:

- Select a week that is 4 months ahead of your current date. Did the same patterns in sunrise and sunset, and in length of day, occur? Create tables and graphs to illustrate your results. Explain your results below:

© Historic Salem, Inc. Permission to copy for classroom use.

Questions to think about:

- What can these daily changes in sunrise and sunset tell us about the location of our Sun in respect to the Earth?

- Does the Earth's tilt, moving to different locations in the yearly revolution around the Sun, have an effect on your sunrise, sun set, and length of day results?

Independent Research:

- To answer these questions you must research the relationship between the Earth's yearly revolution around the Sun and the Earth's constant 23.5° tilt on its axis.

- Use as many resources as you can find to help you illustrate:

  - the tilt of the Earth on its axis as the Earth revolves around the sun.

  - the position of the Earth and the Sun at each of the four seasons of the year

  - find both on a globe and then draw, the location of the Tropic of Capricorn, the Equator, and the Tropic of Cancer.

  - find both on a globe and then draw, the location of the Sun at the winter solstice, spring equinox, summer solstice, and fall equinox.

© Historic Salem, Inc. Permission to copy for classroom use.

Lesson 3: A Diary of the Sun.

Objectives:

- Students will relate the sunrise and sunset patterns in their almanac data to the seasonal journey of the Sun across the face of the Earth.

Skills:

- Illustrating scientific concepts using graphs, tables, and models.

Materials:

- Sunrise/sunset predictions
- Research results from Lesson 2
- The Sun's Diary - handout
- Map of the world with latitude and longitude clearly marked
- centimeter graph paper
- pencil
- ruler

Procedure:

1. Class Challenge(on board or overhead):

Answer the following questions from your research:

- How does the Earth's 23.5° tilt, moving to different locations in the yearly revolution around the Sun, determine our different seasons?

- Where are the Sun's rays shining directly overhead at the winter solstice? spring equinox? summer solstice? fall equinox?

- Is your variable, Declination of Sun, related to this changing position of the Sun through the seasons?

- Can you use this variable and your research knowledge to explain why your sunrise data and your sunset data are changing daily?

2. Activity:

- Create a graph with the variables Day of Year (corresponding to your 14 sunrise dates) on the horizontal axis and Declination of the Sun (degrees and minutes) on the vertical axis.

- Graph these points for each day of your almanac data.

- Next, on your globe, point to the degrees latitude that match as closely as possible the same degrees as your Declination of the Sun on your graph.

- Explain the relationship, now, between your changing sunrise and sunset times with the change in the Sun's declination over the same time period.

3. Group Analysis:

- Find the dates of the two solstices and the two equinoxes. Examine the changing Declination of the Sun for each of these dates.
- Each group member should now create a graph of the Day of Year and Declination of the Sun for one week before and one week after his/her assigned equinox or solstice.
- Compare the graphs within the group.

4. Class Analysis (on board or overhead)

- Describe the seasons according to your graphs of the Declination of the Sun.
- Relate these graphs to the location of the Earth as well as the tilt of the Earth in its journey around the Sun.
- Can you create a mathematical description of the sun's angled rays as they travel seasonally from the Tropic of Capricorn to the Tropic of Cancer?
- Summarize the reason for the seasons. Include the revolution of the Earth around the Sun, the Earth's 23.5° tilt on its axis, and the changing declination of the Sun.

UNIT 5 STUDENT HANDOUT

THE SUN'S DIARY

1. Class Challenge:

Answer the following questions from your research in Lesson 2:

- How does the Earth's 23.5° tilt, moving to different locations in the yearly revolution around the Sun, determine our different seasons? Illustrate and explain below:

- Illustrate and explain where the Sun's rays are shining directly overhead at noon on the winter solstice, the spring equinox, the summer solstice, and the fall equinox:

2. New Challenge:

Is your almanac variable, Declination of Sun, related to the changing position of the Sun through the seasons? Explain below:

© Historic Salem, Inc. Permission to copy for classroom use.

3. Activity:

- Use the variable, Declination of the Sun, and your research knowledge, to explain why your sunrise data and your sunset data are changing daily:

- Create a graph with the variables, Day of Year, (corresponding to your 14 sunrise dates) on the horizontal axis and Declination of the Sun (degrees and minutes) on the vertical axis.

- Graph these points for each day of your almanac data.

- Next, on your globe, locate the degrees latitude that match as closely as possible the same degrees as your Declination of the Sun on your graph.

- Explain the relationship, now, between your changing sunrise and sunset times with the change in the Sun's declination over the same time period:

4. Group Analysis:

- Open your almanacs to the dates of the two solstices and the two equinoxes. Examine the changing Declination of the Sun for each of these dates.

- Each group member should be assigned one of these dates. Create a graph of the Day of Year and Declination of the Sun beginning one week before and ending one week after your assigned equinox or solstice.

- Compare/contrast the graphs within the group:

© Historic Salem, Inc. Permission to copy for classroom use.

Winter solstice declination-

Compare

Contrast

Spring equinox declination-

Compare

Contrast

Summer solstice declination

Compare

Contrast

© Historic Salem, Inc. Permission to copy for classroom use.

Fall equinox declination:

Compare

Contrast

5. Class Analysis:

- Describe the seasons according to your new graphs of the Declination of the Sun at different dates:

- Relate these graphs to the location and tilt of the Earth in its seasonal journey around the Sun.

- Create a mathematical description or diary of the sun's angled rays as they travel seasonally from the Tropic of Capricorn to the Tropic of Cancer and back again. Use your almanac data (sunrise, sunset, declination of sun, length of day) in your description.

© Historic Salem, Inc. Permission to copy for classroom use.