
Using the Hands-On Astrophysics Manual

This manual addresses a wide range of grade levels (middle school through introductory college) and student abilities. It is flexible enough to meet the needs of the teachers and instructors of any of these grades. The following descriptions will tell you:

1. The conceptual framework around which the curriculum was built;
2. Information on each component within each chapter and the ancillary materials;
3. Several suggestions for presenting sequences of chapters and activities for specific student audiences.

The emphasis in this curriculum is on variable star observation, and so this manual is not intended to be a comprehensive astronomy textbook. There is, however, sufficient coverage here of most topics in elementary astronomy. ***You do not need any prior knowledge of astronomy or variable stars or physics to use this curriculum.***

1) CONCEPTUAL FRAMEWORK

This curriculum supports the *National Standards for Science and Math Education* by directly involving students in the scientific process. Students are taught the necessary skills to make observations, analyze their data with graphing and statistical techniques, make predictions, and compare predicted and observational values, as well as learn how to develop sophisticated mathematical models. Except for a few exercises in skill development, there are no “right” answers in this curriculum. The data obtained, and the results of the analysis of those data by students, is the “right” answer. In variable star astronomy, what you see is what you get. The amount of data and the mathematical refinement techniques will give reasonably accurate results. Students will understand that their observations can be reliable, and that their data can be useful enough to be used by professional astronomers.

Each unit contains a paragraph, which describes the specific *National Science Standards* and *Benchmarks* themes, concepts, and content addressed in its chapters.

This is a curriculum on variable star observation; it is neither an astronomy course nor a statistics course. The information within the chapters has this purpose: to inform students about variable stars and their importance to the professional astronomical community, and to give them the necessary information and skills to study variable star behavior or to become amateur variable star observers. Therefore only the astronomy, math, and skills directly associated with variable stars are contained within these pages. However, interdisciplinary connections exist within the chapter introductions, Space Talks, and Poster Pages (explained below), and historical aspects of variable star astronomy have also been included. Thus parts of this manual can be used in any science

computer, or math class, as well as in history and English classes. Besides being used as classroom material, the Hands-On Astrophysics (HOA) curriculum can be used for science fair projects, research projects in many disciplines, independent study, and enrichment activities.

Students will be able to access the American Association of Variable Star Observers (AAVSO) International Database, and share their investigations and observations with other students via the internet. Working together is an important aspect of the scientific enterprise, which is not usually understood within a traditional classroom setting. Sharing variable star observational activities with students in other geographical locations will enable data collection even when skies are cloudy.

One of the most powerful aspects of this curriculum is that it is intended to be interactive, both for students and instructors. Both will be able to access the AAVSO website and the Hands-On Astrophysics homepage. If you need answers to technical questions or assistance in locating data resources, you will be able to use the HOA website. Instructors can ask questions about any of the activities, or share their own activities with each other. You will be able to communicate with the authors of this curriculum and with professional astronomers and technicians.

If it is impossible for you to introduce your students to the night sky, the HOA curriculum is still of great value. Your students will be able to learn about variable stars by using the activities, software, and slide sets that come with the manual. So even if you are dealing with younger students or with city lights, the students can still study entire sequences of magnitude estimation, light curves, periodicity, phase diagrams, and prediction.

2) Chapter Components

THE MANUAL

There are two separate sections to this manual, one for teachers/instructors and one for students. The teacher pages give you suggestions for using the Activities, Poster Pages, and Investigations. These pages also contain suggestions for resources to enhance some of the activities. The student pages are set up so that Activities and Core Activities are on separate pages; in this way the instructors can easily photocopy only the activities they want to use. Except for the chapter entitled “The Nature of Light,” all materials required for the activities are either in this manual, or are easily and inexpensively attainable. **Teachers should read the student pages before reading the teacher pages.**

Misconceptions: Students typically have many misconceptions about astronomy and physical science. We have listed only the specific misconceptions, which are directly addressed within the activities of a particular chapter. Some chapters do not address any misconceptions—therefore none are listed.

Investigations: Most chapters have Investigations, and none of these have specific answers. Their purpose is to have students begin thinking about concepts which may be new to them, or about which they may have misconceptions. Investigations are meant to be a discovery process; the object is to have students think about and discuss the concept being presented.

Core Activities: The Core Activities are those that are necessary for acquiring skills and/or for understanding key concepts. However, if you have students who are already familiar with the material within some of the Core Activities, then you can leave that material out. For example, middle school students probably have not learned about the Kelvin temperature scale. They should, however, understand the basis of the scale, since it is used in stellar astronomy. If your students have had chemistry, they already have used this scale. Or, you may use the temperature conversion activity as a review classroom activity only. Perhaps some of your students have either had chemistry or physics, or learned the Kelvin scale in another class, and other students have not. Then only the students who need to learn about the Kelvin scale should do the temperature conversion activity.

Activities: Some activities are included which are not really necessary for understanding basic concepts or acquiring a necessary skill. Some are further treatments of concepts not easily acquired, and some are merely interesting related topics, such as the sky pollution activity.

Space Talks: The Space Talks address topics which give general information not included within the chapter activities or introductions. They cover a wide range of topics that are related in direct or indirect ways to the chapter content, except for Unit 5, which deals with mathematical analysis. Therefore the Space Talks in that unit are about more technical topics such as eclipsing binary star systems.

Terminology: The vocabulary words on the teacher pages are not necessarily the words that are the focus of the chapter; sometimes none of them are. The vocabulary words are the words that are either in bold type in the Space Talks or in italics within the student chapters. Sometimes the Space Talks contain words which are relevant to the activities within the chapter, or sometimes they involve extensions. All of the vocabulary words are defined in the glossary; a listing by chapter is also given in the Appendix.

Poster Pages: These pages can be utilized in several ways. They present important or interesting aspects of related topics, and are usually historical in nature. From Polynesian celestial navigation to Abraham Lincoln and the Almanac Trial, these pages contain interdisciplinary connections with stellar astronomy and celestial phenomena. The back of each Poster Page relates to the material given on the front. A substantial amount of this material asks a series of questions which can be used for classroom discussion, research topics for history and/or English classes, term papers, and classroom oral presentations. In the teacher pages, further information on the Poster Page topic is also given. The Poster

Pages are related to the chapters in which they are located, but can be used in any order and at any time, and can be posted on the board as either an introduction or conclusion to a chapter.

Resources: We have listed some suggestions for added reinforcement where appropriate. These are noted by a RESOURCE flag in the margin. The addresses, phone numbers, and other pertinent information for obtaining these items can be found in the Resource List in the appendix.

Appendix: This section includes the HOA web site information, a guide to observing eclipsing binary stars, a summary of variable star types, a list of HOA stars, the VSTAR, HOAENTER, and HOAFUN software documentation, the resource list, a reference list for further reading, and a two-part glossary. The glossary contains the bold-type terminology in the Space Talks and any italicized terms occurring in a chapter. Any other terminology is explained within the student chapters. Your students do not need to memorize these terms. The Space Talks are informational only and are not necessary for the activities.

ANCILLARY MATERIALS

HOAFUN, HOAENTER, and VSTAR: HOAFUN is a software program which introduces students to magnitude estimation and light curves. It is simple, non-threatening, and easy to understand, even for younger students. It is a good introduction to how variable stars produce light curves which can be analyzed for periodicity.

HOAENTER is a data-entry program which may be used to prepare data for loading into the VSTAR program or to prepare data to submit variable star observations to the AAVSO.

VSTAR is a dual-purpose software: 1) It will display a graph of the several dozen stars from the included AAVSO International Database, or from data provided by the students themselves; and 2) It is a sophisticated, powerful mathematical and statistical data analysis tool. Both teachers and students can use the VSTAR program to look at different types of variable stars, their light curves, and determine their periods, as well as analyze the periodicity by producing phase diagrams. A complete VSTAR manual is included in the appendix.

HOA Video: The video consists of four segments. The first is a four-minute introduction featuring teachers who have used this curriculum with their students. They discuss the valuable ways that variable star observation has helped their students acquire appreciation for and knowledge of the scientific enterprise. The video's three main segments are approximately 20 minutes each. They are entitled *Backyard Astronomy*, *Variable Stars*, and *How to Observe Variable Stars*.

Backyard Astronomy introduces the idea that you can observe and learn a great deal about the universe from your own backyard. *Variable Stars* gives a brief introduction to the nature of variable stars. *How to Observe Variable Stars* shows the process involved in

observing, data collecting, and analysis of variable stars. These videos can be shown in any sequence and at any time during the course of the curriculum. Two real high school students are prominently featured in the video. One has extensive experience observing variable stars, and the other is an interested amateur just starting to learn about variable stars.

Slides and Prints: There are a total of 31 slides. Of these, there are 18 constellation slides [2 for Auriga (Aur), 7 for Cygnus (Cyg), 1 for Ursa Major (UMa), 6 for Cepheus (Cep), and 2 for Cassiopeia (Cas)], as well as 7 slides for the variable star W Cyg. In addition, there are 6 finder slides, 1 for each constellation and 1 for W Cyg. Also included are photographic prints for each of the 7 Cyg constellation slides and the 7 W Cyg slides, for a total of 14 prints. The activities that go with these prints and slides give several suggestions as to how they can be used.

Charts: There are a total of 45 charts. Included are: a) 5 large-scale constellation finder charts to help locate the HOA constellations and the general location of variable stars; and b) a series of 11 a-scale, 2 aa-scale, 11 b-scale, 5 c-scale, 9 d-scale, 2 e-scale and 5 constellation charts which show the locations of the following 15 variable stars and give the locations and magnitudes of their comparison stars: R Aur, RT Aur, chi Cyg, W Cyg, X Cyg, U Cyg, R UMa, S UMa, Z UMa, T Cep, S Cep, delta Cep, U Cep, R Cas, and V Cas.

3) POSSIBLE SEQUENCES

The material within this curriculum is laid out in sequence, from easiest to most difficult. However, using the complete sequence is only one of many options available. If you have a full or half-year astronomy course at the middle or high school level you may use this option. If you have students with some science and math background at the college or high school level, you may want to leave out the first two units and start with Unit 3. Even though the sequence presented has a specific direction and relationship, the units or chapters can also be used independently. ***The chapters are related to each other, but do not depend upon one another.*** Even though you may not have an astronomy, physical science, or math class in which to use this curriculum, you may decide to select certain parts of it to include within an English, history, or biology class. A few of the many options are as follows:

If your interest is solely in variable star observations and data analysis, or you have college or high school students:

1. Core Activity 6.5: Collecting Your Own Data
2. Chapter 7: Observing Variable Stars in the Sky
3. Unit 5: Analysis of Variable Stars

Chapter 10: Statistical Concepts

Chapter 11: Variable Stars, Light Curves, and Periodicity

Chapter 12: Variable Stars and Phase Diagrams

Chapter 13: Variable Stars and O-C Diagrams

If you have middle school students:

1. Unit 1: Planets and Stars

Chapter 1: The Solar System and Beyond

Chapter 2: The Nature of Stars

2. Unit 2: Introducing the Sky

Chapter 3: Familiarizing Yourself with the Night Sky

3. Unit 3: Observing Variable Stars

Chapter 5: Introducing the Hands-On Astrophysics Constellations

Chapter 6: Measuring Variable Stars Visually

Chapter 7: Observing Variable Stars in the Real Sky

(OMIT if your students are unable to observe at night)

4. Unit 5: Analysis of Variable Stars

Chapter 10: Statistical Concepts

Chapter 11: Variable Stars, Light Curves, and Periodicity

If you have a computer or statistics class:

1. Core Activity 6.5: Collecting Your Own Data

2. Unit 5: Analysis of Variable Stars

Chapter 10: Statistical Concepts

Chapter 11: Variable Stars, Light Curves, and Periodicity

Chapter 12: Variable Stars and Phase Diagrams

Chapter 13: Variable Stars and O-C Diagrams

If you have a physics or physical science class:

1. Unit 4: The Message of Light

Chapter 8: The Nature of Light

Chapter 9: The Life of a Star

4) HOA WEBSITE

There is a schematic of the *Hands-On Astrophysics* Website in the Appendix. The website is accessible through the AAVSO website (<http://www.aavso.org>), and includes the following sections:

1. About *Hands-On Astrophysics*

This section gives information about variable stars, and background information about the American Association of Variable Star Observers (AAVSO). A brief history of the HOA project, the AAVSO's International Database on variable stars, who accesses the database and why are all explained here, along with an introduction to AAVSO director Janet Mattei, the AAVSO technical staff, and project co-director John Percy. HOA newsletters will be included as well as links to other astronomical and science education websites.

2. *Hands-On Astrophysics* Materials

This section introduces and provides samples of the HOA curriculum and ancillary materials, including the Manual and its table of contents, the AAVSO International Database, star charts, slides and prints, HOA videos, and other resources which would be useful in using the *Hands-On Astrophysics* materials.

3. Talk To Us!

This section has the HOA e-mail interface, a direct link to the HOA webmaster (an experienced teacher) for teachers and students who have questions or ideas, or who need assistance with projects, etc. An evaluation form is located here so teachers may evaluate any part of the materials being used. Students also may wish to comment on the use of the manual and other materials. Feedback will be posted, so if you find better methods of completing some of the activities, or would like to see a particular activity included, or a poster page developed on a specific topic, this is the place!

4. *Hands-On Astrophysics* Activities

This section includes sample investigations, activities, and poster pages from the manual, along with previously-developed HOA observing activities. The samples will be representative of the entire manual and available for downloading.

5. What's New with *Hands-On Astrophysics*

This section includes news updates about HOA and/or the AAVSO, as well as new HOA materials, including ideas culled from the HOA e-mail link. Relevant news items about variable star research, and results of student projects will also be posted. For teachers, notices about upcoming workshops, conferences, presentations, etc., will be posted here, as well as reports on past workshop activities.

6. Order Forms

Information and order forms will be available for the *Hands-On Astrophysics* materials, AAVSO publications, AAVSO star charts, AAVSO membership, and the *Hands-On Astrophysics* and AAVSO stellar gifts (T-shirts, sweatshirts, mugs, keychains with red light, hats, etc.). There will also be links to other astronomical gift websites.

SUMMARY

- ✓ The *Hands-On Astrophysics* (HOA) curriculum can be a complete course of study, or you can use individual chapters or any combination of chapters.
- ✓ The content is useful in astronomy, physical science, mathematics, and computer classes, and has interdisciplinary connections that make it appropriate for history or English classes, or public education programs.
- ✓ The material is appropriate for middle school through introductory college level, depending upon the chapters selected.
- ✓ The curriculum is self-contained: no prior knowledge of astronomy, variable star astronomy, or physics is necessary.
- ✓ HOA actively involves students in the scientific process through observation, data collection, graphical and computer analysis, mathematical models, prediction, and assessment of prediction and further observation.
- ✓ HOA participants can access the AAVSO International Database and talk directly with others engaged in variable star observing. They can also communicate with the AAVSO headquarters staff via the AAVSO website.