Independent Study in Idaho

PHYS 1152

Descriptive Astronomy

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Course Guide

Independent Study in Idaho

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Physics 1152
Descriptive Astronomy

Idaho State University
3 Semester-Hour Credits

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Phys 1152: Descriptive Astronomy 3 Semester-Hour Credits: ISU

Welcome!

Whether you are a new or returning student, welcome to the Independent Study in Idaho (ISI) program. Below, you will find information pertinent to your course including the course description, course materials, course objectives, as well as information about assignments, exams, and grading. If you have any questions or concerns, please contact the ISI office for clarification before beginning your course.

Policies and Procedures

Refer to the ISI website at **www.uidaho.edu/isi** and select *Students* for the most current policies and procedures, including information on setting up accounts, student confidentiality, exams, proctors, transcripts, course exchanges, refunds, academic integrity, library resources, and disability support and other services.

Course Description

Survey of the historical and modern observation of the sky. Physical relationships in the solar system; planets, satellites, comets, etc., and theories of the creation of the universe and life in the universe.
ISU students: With Phys 1153, satisfies Goal 5 of the General Education Requirements.

Required: Internet access.
7 graded lessons, 2 self-study lessons, 1 research paper, 2 proctored exams.

Course Materials

Required Course Materials

Arny, Thomas T., and Stephen E. Schneider. *Explorations: An Introduction to Astronomy*. 6th ed. Boston: McGraw-Hill, 2010. MHID: 0-07351217-6. ISBN-13: 978-0073512174.

Recommended Course Materials

Astronomy Interactives:
http://highered.mcgraw-hill.com/sites/0073512176/student_view0/astronomy_interactives.html#

Course Delivery

This course is available online. An electronic course guide is accessible through Canvas at no additional cost. Refer to your *Registration Confirmation Email* for instructions on how to access Canvas.

Course Introduction

This course is designed for students who have little or no mathematical or scientific background. But, it can also be appreciated by those with more advanced technical educations. Astronomy is the oldest of all the sciences. Many modern fields of scientific endeavor have their roots in astronomy. Likewise, astronomy embraces these sciences, from geology in planetary formation, to chemistry with the nuclear properties of the atom, and to mathematics in the study of orbital mechanics. Astronomical research cannot, in fact, be separated from these and other fields of science. To fully understand astronomy is to appreciate many other areas of the physical and mathematical sciences.

Astronomy has developed significantly over thousands of years. Early astronomy was entangled in pseudoscience like astrology and in pagan religious rites. Modern astronomy has progressed far past these non-scientific beginnings. Your textbook uses astronomy as a tool whereby you, the student, can be made aware of the flow of scientific ideas from one mind to another. Of even greater significance, however, it shows the interdependence of the work of one person upon that of another.

This particular text has been chosen for several reasons. The text will lead you from a study of astronomical objects with which most of you are familiar, like the Moon and the Sun. Then it will guide you to a greater appreciation of the planets, then to a consideration of more distant objects such as stars, galaxies, and quasars. Finally, it gives a view of the **Universe** as a whole with a discussion of its origin and future. It does all of this in a most readable fashion. The authors are more educators than they are simply scientists; you'll find their style very simple, yet comprehensive.

One of the problems many students have with a course in astronomy is the visualization of planetary motions and the motions of other celestial objects. This problem becomes even more difficult in an Independent Study course such as this. For this reason the text has offered several ways to assist the serious student. The text has several special features such as "*Extending Our Reach"* boxes to analyze a few of the key concepts in more detail. To assist the student with comprehension, there are *"Planetarium Exercises" and "Projects*" at the end of some chapters that help to show students how to find things in the sky. These include observing exercises and links to the star maps that appear on the inside covers of the book. These will all give the student a broader view of the subject for study.

Finally, the author and publisher have set up a web site to assist the student. Throughout the text, icons are found in the text to identify important topics that are cross-referenced to their site on the World Wide Web. This includes simulations and interactive sites. Students who have Web access should consider this a boon to their education, using this site as another instructor or tutor. Please take advantage of these valuable resources.

Course Objectives

The objective of this course is two-fold. The first is to present, in a broad spectrum, the spirit of scientific investigation and to develop an understanding of the scientific method. Although we use the motif of astronomy, the methods we develop here can be applied to all sciences. While doing this, our second objective is to instill in you an appreciation for the observable Universe. Particularly, you will learn how astronomers are able to discover the nature of planets, stars, and galaxies by applying the laws of physics to faint glimmers of light coming from the stars. To accomplish these goals, concepts are developed with reference to everyday experiences.

Lessons

Overview

Each lesson includes the following components:

- lesson objectives
- reading assignments
- important terms
- lecture
- written assignment

Study Hints:

- Complete all reading assignments.
- Set a schedule allowing for course completion one month prior to your personal deadline. An *Assignment Submission Log* is provided for this purpose.
- Web pages and URL links in the World Wide Web are continuously changing. Contact your instructor if you find a broken Web page or URL.
- Use the **self-study** lessons to **focus your study;** this will help to identify your weaknesses **before** you

take the exam.

- You will be responsible for everything presented in the text and in this course guide. In a few cases what is presented in our discussion will conflict with the text. This should not worry you; we are only supplementing the text. Discoveries are being continually made. Where there are differences, our discussions will supersede the text.

Exams

- You must wait for grades and comments on lessons prior to taking subsequent exams.
- For your instructor's exam guidelines, refer to your *Registration Confirmation Email*.

Refer to *Grading* for specific information on lesson/exam points and percentages.

Proctor Selection/Scheduling Exams

All exams require a proctor.

Grading

The course grade will be based upon the following considerations:

There are seven graded lessons, two *self-study* lessons, a research paper, and two exams. Each lesson (except the *self-study*) will count as 5% of the grade (35% total). Each exam will count as 25% (50% total). The research paper will count as 15%.

Grades will be assigned according to the following schedule:

93 – 100% = **A**
90 – 92.9% = **A-**
87 – 89.9% = **B+**
83 – 86.9% = **B**
80 – 82.9% = **B-**
77 – 79.9% = **C+**
73 – 76.9% = **C**
70 – 72.9% = **C-**
67 – 69.9% = **D+**
63 – 66.9% = **D**
60 – 62.9% = **D-**
Below 60 = **F**

The final course grade is issued after **all** lessons and exams have been graded.

Self-Study **Review for Exams**

These are lessons 4 and 9. They are for exam preparation only; do not submit them for grading.

Acts of academic dishonesty, including cheating or plagiarism are considered a very serious transgression and may result in a grade of F for the course.

About the Course Developer

Dr. Bryan Barclay grew up on a dairy farm in South Eastern Idaho (West of Blackfoot). He received a bachelor's degree in mechanical engineering from Brigham Young University, then worked for Boeing, the commercial airline company, in Everett, Washington. While at Boeing he earned a master's degree in physics at the University of Washington.

After Boeing, he worked for Morton-Thiokol in Utah. Two years later, he began his teaching career at Salt Lake Community College. In another two years, he went back to graduate school and earned a Ph.D., in physics from Utah State University (USU) in 2001. While working on his doctorate, he taught math and physics part time for USU and Weber State University. He is currently teaching physics and math for the College of Technology at Idaho State University. His research involves astrophysics and the title of his dissertation is “Probing Void Structure Using Galaxy Number Count Techniques.” He enjoys camping, bike riding, and playing his banjo. He is married and has three kids.

Contacting Your Instructor

Instructor contact information is available in Canvas.

Assignment Submission Log

Lesson	**Projected Date for Completion**	**Date Submitted**	**Grade Received**	**Cumulative Point Totals**
1				
2				
3				
4				
It is time to take Exam 1.				
Exam 1				
5				
6				
7				
8				
9				
10				
It is time to take the Final Exam.				
Final Exam				

Lesson 1

The Night Sky and How We Learn About the Universe

Lesson Objectives

- Be more familiar with the key units and notation of astronomy.
- Appreciate the scale of distances in the Universe.
- Identify several constellations in your sky for your time of the year (particularly those of the zodiac).
- Explain the motion of celestial objects during the various seasons of the year.
- Describe the apparent motion of the Sun in relation to the background of stars, due to the Earth's revolution.
- Describe the apparent motion of objects in the sky, which is due solely to the Earth's rotation.
- Illustrate and explain why the Moon shows phases.
- Discuss the contributions of Copernicus, Tycho, and Kepler.
- Recognize the dangers of placing faith in a science that can and does change.
- Explain how the heliocentric model of Copernicus was a better match for the astronomical observations.
- Explain retrograde motion from a modern perspective.
- Explain the Greek geocentric model.
- List and discuss Kepler's three laws.
- List Galileo's major scientific works and discoveries.
- Express Newton's three laws of motion in your own words.
- Explain Newton's Law of Gravitation.
- List the different classifications of radiation within the electromagnetic spectrum.
- State at least two properties of a star that can be determined by observing its spectrum.
- Describe the fundamental terms of wave motion.
- Describe how color can be used as a measure of temperature.
- Describe the Doppler effect and its use in astronomy.
- Determine how gases produce observed spectra.
- Explain the Bohr model of the atom.

Reading Assignment

All readings are from the *Explorations* text:

- Preview, pages 1-14
- Chapter 1, pages 15-38
- Essay 1, pages 62-72
- Chapter 2, pages 39-61
- Chapter 3, pages 73-88
- Chapter 4, pages 89-115

Helpful Web sites:

- Moon Photo – **www.netaxs.com/~mhmyers/cdjpgs/fullplus5h.jpg**
- Kepler's Laws – **http://csep10.phys.utk.edu/astr161/lect/history/kepler.html**
- Moon Phases – **www.enchantedlearning.com/subjects/astronomy/moon/Phases.shtml**

- Powers of 10 – **www.wordwizz.com/pwrsof10.htm**
- Retrograde Motion – **http://alpha.lasalle.edu/~smithsc/Astronomy/retrograd.html**
- Sky Chart — **http://heavens-above.com/**

Important Terms

You may use your favorite search engine such as Google to look up a term that is not explained in the textbook or lecture.

electromagnetic radiation
electromagnetic waves
spectrum (or spectra)
black body
Wien's law
absorption lines
electrons
protons
Bohr atom
phase
full moon
gibbous moon
crescent moon
first quarter
third (or last) quarter
constellations
retrograde
model
geocentric
major axis
minor axis
eccentricity
rotation
Eratosthenes

wavelength
photons
speed
frequency
nuclei
neutrons
energy level
Balmer lines
redshift
celestial poles
Polaris
horizon
solstice
autumnal equinox
light
absolute zero
epicycles
heliocentric
foci
revolution
Solar System
Newton's laws
inertia
escape velocity

angstrom
atoms
quantized orbits
emission lines
Doppler shift
Celsius
light-year
Kelvin
blueshift
celestial sphere
right ascension
declination
zodiac
vernal (spring) equinox
seasons
circumpolar stars
Copernicus
Tycho Brahe
Kepler
Galileo
Newton
Kepler's laws
Aristarchus
transits

Introductory Lecture

Many of you have taken this course because you already have a feel for astronomy. You've been fascinated by the night-time sky, you've witnessed the phases of the Moon, or maybe you know the names of a few constellations and can point out a few stars. The purpose of this lesson is to introduce you to your subject and set the foundation for the rest of the course.

The first step in the study of astronomy is to examine the night sky. The assigned reading does a good job of explaining the apparent motions of the Moon, planets, and stars. Be sure that you study these sections carefully. The text, however, has one major weakness: its lack of information on the appearance of the night sky. We supplement the book here with a discussion of the stars and constellations.

The **constellations** have their origins in antiquity. Some of the earliest references to constellations extant are from clay tablets of ancient Babylon (about 3000–500 B.C.E.). The writings of the early Greeks have many references to the constellations, as does the Old Testament.

Until 1928, the constellations were ambiguously defined. Before that time many stars and objects could only be defined as being near or in the general area of a particular constellation. In 1928 the International Astronomical Union divided the entire sky (both northern and southern hemispheres) into the 88 standard constellations we have today.

To overcome the difficulties many find in learning the constellation shapes and recognizing them in the night sky, learn them by separating them into two groups. The first group of constellations is one that is easy to recognize because of a very distinctive pattern or bright star in the grouping. The second group can be found by their location near those of the first group. For example, many have difficulty finding Ursa Minor (The Little Dipper). But by drawing an imaginary line extending from the outer two stars of the bowl of the Big Dipper you come to Polaris, the North Star, which is in the end of the handle of the Little Dipper. Now that you can find these two constellations, you can find the obscure constellation Draco, which winds its way between the Big and Little Dippers. It will probably take several evening sessions of studying the sky to become comfortable with the constellations. Also, use the *Starry Night* software to orient yourself with the sky before your sessions. Don't be disappointed if you don't learn all of the constellations visible in one evening. Although not a specific requirement for this course, you really should get out and see the sky!

As you watch the stars in the evening, most stars will appear to rise generally in the east and set generally in the west. You will notice, however, that one group of stars neither rises nor sets below the horizon. These stars will appear to revolve about **Polaris**, the North Star; they are referred to as **circumpolar stars.** The set of circumpolar stars changes, dependent upon the latitude of the observer. To an observer at the North Pole, for example, Polaris would be directly overhead. As the Earth rotates, all of the stars visible down to the **horizon**, appear to revolve around Polaris. None of the stars visible will set below the horizon. The same stars are seen throughout the night. All stars, here, are circumpolar. At the equator, the North Star appears on the horizon and no star remains, as the Earth turns, above the horizon for more than 12 hours. Therefore, at the equator, there are no circumpolar stars. At the middle latitudes, we are somewhere in between with some stars remaining above the horizon (the circumpolar ones) and the rest setting sometime during the day or night.

From middle latitudes such as that of Pocatello, Idaho, the following are circumpolar constellations. As discussed earlier, associating them with common shapes or patterns can better help you to recognize some constellations. Included in the tables below is the common shape for those that have them.

Ursa Major — Big Dipper
Ursa Minor — Little Dipper
Cepheus — house shaped
Cassiopeia — "lazy" W or M
Draco __ Snake

The twelve constellations through which the Sun appears to travel are called, collectively, the **zodiac.**

Aries
Leo
Sagittarius — teacup
Taurus
Virgo
Capricorn
Gemini
Libra
Aquarius
Cancer
Scorpio
Pisces

By the end of the course you should be able to recognize the constellations listed above as well as these:

Auriga — pentagon
Bootes — kite
Cygnus — cross
Hercules — bow tie
Pegasus — square
Aquila
Canis Major
Canis Minor
Andromeda
Orion
Perseus
Lyra

You should also be able to associate the following bright stars (see page 538 in the *Explorations* Appendix and also the star charts found in the back of the text) with the constellations to which they belong:

Aldebaran
Castor
Regulus
Altair
Deneb
Rigel
Antares
Pollux
Sirius
Arcturus
Procyon
Spica
Betelgeuse
Algol
Vega
Capella

Some people, to aid them in finding the constellations, will form the bright stars into larger recognizable patterns such as geometric figures like pentagons or triangles. One of these patterns is often called the Summer Triangle (seen in the summer). The triangle is formed by the three first magnitude stars: Altair, Deneb, and Vega. Another geometric figure can be found in the winter/early spring sky. It is called the Great Hexagon, formed from six of the brightest winter stars; these are also helpful in locating the associated constellations. These stars are Sirius, Procyon, Pollux, Capella, Aldebaran, and Rigel.

You may ask why we have to learn about strange models of the **Universe** we now know are wrong. This history is important. It shows us how science and scientific knowledge can progress beyond the mistakes it makes. The struggles others had in their searches can teach us a lot about our own research. This lesson can also serve to illustrate the important approach that model building gives to science. A **model** is only good as far as it agrees with or explains our observations. A good model should also be able to predict future observations. If it is proven that the model cannot make such predictions, then the model must be changed.

In the modern era we sometimes tend to discount the insight and intellectual abilities of the ancients. It is often thought that **Copernicus** was the first to use the model of the **heliocentric** Solar System. But in the third century B.C.E. **Aristarchus** proposed a model, which had the Sun at the center. Many today believe that Columbus proved that the Earth was round. The spherical nature of the Earth was known to the Hellenic peoples of ancient Greece in the sixth century B.C.E. In fact, **Eratosthenes** (circa 250 B.C.E. made measurements of the circumference of the Earth that may have been within two percent of the accepted value today. Another important thing to remember is that although the ancients had devices that were quite crude compared to our standards, they were just as capable and ingenious as we claim to be.

As you go over the early ideas about the Universe, consider them as models. Based upon the observations of the day, were they good models? The Earth then (or now) had no apparent motion of its own. So the stationary (or even flat) Earth easily fits the early observations and, therefore, it met the basic requirement for a good model. It wasn’t until contradictory observations were made that a new model was required. Also, as you read, consider the interplay and the cooperation between scientists and the importance of accurate observations and records.

This lesson also deals with one of the greatest scientists who has ever lived—**Isaac Newton.** Newton told us that if he saw farther, it was only because he stood on the shoulders of giants. Likewise, Einstein was extensively influenced by Newton. In this lesson you will study the astronomical ideas that brought astronomy and the world into the modern scientific era. This occurred with the general ideas regarding dynamics and gravitation developed by Newton. The mathematical formulation of these ideas also allows us to draw conclusions about masses of remote bodies.

Johannes Kepler had deduced a number of empirical laws for the motions of the planets, which were capable of giving rather accurate predictions of planetary positions, but had no underlying rationale other than the evident fact that they worked. Newton went a step farther and showed that **Kepler's Laws** could be derived from more basic understanding of the motions of the bodies. Moreover, he showed that the planets and other celestial bodies obeyed the same laws as common objects on the Earth. In this respect, Newton completed the Copernican revolution. After Newton, it was no longer reasonable to assert that the Earth occupied a special place at the center of the Universe.

As you read about Newton, it is interesting to note the humble origins of this great genius. It is also instructive to see how much of his work was foreshadowed by others. Newton did not, for example, invent the idea of **inertia**, but he adopted it from the work of **Galileo** and others. Likewise, others knew that gravity followed the inverse square law, but it was Newton who invented calculus, which mathematically supported Kepler's laws of planetary motion.

Newton's laws of motion are so well and thoroughly known that they are often referred to by number. Thus, Newton's first law refers unambiguously to the law of inertia, which has a complicated statement in terms of bodies "at rest or in a state of uniform motion." Newton was the first to recognize the difference between mass, as an intrinsic property of matter, and weight, which is the effect of gravity on mass. His second law states the relationship among force, mass, and acceleration: $F = ma$. Here acceleration must be carefully defined as a "rate change of velocity," with the realization that velocity encompasses both speed and direction. His third law, that of action and reaction, is less clear than the others, but governs such diverse phenomena as the recoil of a shot gun and the flight of rockets. Finally, his law of universal gravitation combined the force between any two objects with mass. The term "universal" implied that this same force governed the orbits of the Moon and planets as well as the fall of objects on the Earth.

With these tools, Newton was able to derive Kepler's laws of planetary motion and to generalize them to any situation involving orbits. Kepler's **third law** applied only to objects orbiting the Sun. The new form of the law could be applied to any other type of orbital motion as well, including the orbit of the Moon and man-made satellites about the Earth. Newton also introduced the universal law of gravity, which relates the gravitational attractive forces between two celestial bodies to their masses and distances. These concepts are useful because they are constants of motion for certain systems, including bodies in orbit. Thus the conservation of angular momentum in orbital motions led to Kepler's third law. These laws of motion led to a new and powerful understanding of our Universe, one in which it was possible to accurately calculate the motions of all sorts of objects, and understand why they move in the ways that they do.

One of the observable phenomena missing from the Copernican model was stellar parallax. Since the time of Aristarchus when the Sun-centered model was first proposed, a key test of the Earth's motion would be the apparent displacement of the nearer stars relative to the farther stars, parallax. Due to the incomprehensibly large distance to the stars they, including **Copernicus, Tycho,** and **Kepler,** could not measure it with their limited instrumentation. Thus, before Copernicus, it was concluded that the Earth could not revolve around the Sun.

Do not get bogged down in the mathematics presented in this and subsequent chapters. It is presented to aid in the explanation of the concepts, but you will not be asked to do anything more than the simplest computations, if any at all.

Astronomy is almost entirely dependent on various forms of **electromagnetic radiation** to provide information about astronomical objects. In this light, so to speak, it is important to lay the groundwork early in the course, by introducing the tools and methods of the astronomer. If you understand the ways the information has been gathered, then you will better appreciate the conclusions derived there from.

In other sciences the objects of study can be brought into a laboratory and experiments and tests can be performed on them. Astronomers cannot bring their primary objects of study into a lab to cut them open, heat them up, or probe them in any direct way. They must be content to study most of the Universe from a distance. It can be said that astronomers play a great detective game. They don't see things as they are, but mostly as they were. They piece the evidence together by first analyzing the faint light signals from distant stars and galaxies and applying the laws and principles of physics. They then deduce the distances, sizes, shapes, and other properties of these objects without ever having been near them.

As mentioned, Inertia was introduced by Galileo. It is the resistance to a change in speed or direction (acceleration). Orbital motion can be explained by the Sun's gravitational pull changing a planet's direction while it is trying to go straight according to Newton's **first law** (**law of inertia**). Mass is the measure of an object's inertia. Newton's **law of gravity** extends all through the Universe as well as describing our weight on the Earth's surface. **Escape velocity** is the velocity a projectile must achieve to outrun the Earth's gravity.

Light (we often use the term **"electromagnetic radiation"**) carries with it an amazing amount of information. The shift in its spectrum (see page 94 of *Explorations*) can tell us about the speed of the light source. The dark lines in the **spectrum** indicate what elements may be in the source. The **wavelength** at which the intensity is a maximum tells us about the temperature of the source, and so on.

Some parts of the electromagnetic spectrum can be very elusive for astronomers confined to the surface of the Earth. The Earth's atmosphere blocks, reflects, or filters most incoming light. So only a small portion of the spectrum from the Sun, for example, is actually available for study from the ground. Astronomers have therefore developed many ways to get around this problem. They observe from the ground, from balloons, from aircraft, or satellites. They use telescopes specially designed for **radio waves**, **x-rays, ultraviolet radiation,** or the **infrared.**

Written Assignment

Submit brief answers for all assigned *Questions for Review, Thought Questions,* and *Problems,* in the order they are listed and assigned. The answers for *Test Yourself (self-study)* can be found on page 530 in *Explorations.*

Written Assignment

Chapter	Pages	*Questions for Review*	*Thought Questions*	*Problems*	*Test Yourself (Do not submit)*
Preview	10-12	1,2,4,7		2	3,4
Chapter 1	35-36	1,3,4	4,5,6		1
Chapter 2	59-60	4,9	1	5	2,5
Essay 1	69-70	6,9			
Chapter 3	85-86	1,2,4,5,9	2,3	10	2,5,6
Chapter 4	113-114	1,5,9,10	7	1,4	1,2,8