



# Starry Night College

Grades 12+

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[www.simulationcurriculum.com](http://www.simulationcurriculum.com)  
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## Foreword

Welcome and congratulations for joining a vast community of Starry Night users. Over the years, I have found Starry Night to be the finest piece of educational astronomical software available. Its precision, ease of use, incredible graphics and flexibility make it one of the most useful teaching tools in my arsenal. I can quickly set up almost any kind of astronomical scenario, over an incredible range of dates, and present it to my students to wonderfully illustrate the workings of the skies. I have seen my students nod and make assenting “noises” time and time again when I demonstrate such things as lunar phases, eclipses and shadow cones, seasons, proper motion, precession, spin-orbit lock, planetary motion, analemmas on different planets and moons, coordinate systems or spatial distributions of various celestial objects like globular clusters. I love the ability to save all of my scenarios as Favorite files and then simply load them and you’re ready to go! No need to reinvent the wheel each time.

Students also love to work with the program themselves. Its comfortable and easy to learn interface is a snap to computer literate young people. Starry Night College makes it even easier by integrating over 45 computer exercises into the program and making them accessible via a point-and-click interface that takes minutes to learn.

In addition to tremendous software, the developers behind Starry Night are profoundly committed to excellence in education in general and astronomy education in particular. Many times in the past several years I have made suggestions for improvements and additions to Starry Night, and lo and behold almost all of those have made it into the current version. It’s extremely satisfying to know that the folks that work on Starry Night share my own lifelong dedication to astronomy education at all levels. I love working with the program and the people behind it, and I have no doubts whatsoever that you will as well.

Starry Night has revolutionized my astronomy teaching and energized my students. It has given them a strong foundation in understanding how the universe works. I am certain that you will enjoy using and discovering new things with Starry Night and I know that your students will appreciate putting their hands on the universe.

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*March 10, 2009*

## Starry Night College

### Grades 12+

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## Section 1: Getting Started

## About This Educator Guide

“ The art of teaching is knowing how to stimulate students to feel the joy of learning. And we have an absolutely delicious subject to teach! ”

*Robert F. Garrison, PhD  
Professor Emeritus of Astronomy and Astrophysics  
University of Toronto, Canada.*

This guide will show you how an advanced software application can enhance your astronomy course and textbook. The step-by-step Starry Night computer exercises are designed to help your students understand astronomical concepts, and to help you teach a satisfying astronomy course. There are “Click On” preset explorations that you and your students can do with the software as you explore the universe. Starry Night makes it easy and fun.

Starry Night offers you an integrated package of educational tools. In addition to the main Starry Night computer activities, we have provided student worksheets (available online), computer exercise answer keys, appendices and lesson mapping to your textbook. Everything you need to supplement your astronomy course is right here.

**It is permissible for classroom instructors to make photocopies of Starry Night computer exercise student worksheets, answer keys, and other pertinent pages from this guide for use in the classroom. Any other uses, including reproduction for resale, are strictly prohibited.**

Starry Night puts the universe at your fingertips. Explore Starry Night yourself to see what it can do. Encourage your students to experiment with the software outside the framework of the prepared computer exercises. The possibilities and learning potential are almost limitless.

A look at the table of contents will give you a good idea of how this guide is organized, with introductory information, student exercises, and helpful appendices. There is a feedback form so you can tell us how we’re doing. We appreciate your comments and will use them to improve future editions.

### Textbook Mapping

To further assist your teaching, all of the Starry Night College computer exercises have been mapped to chapters in some of the more popular introductory astronomy textbooks currently available. Starry Night College’s textbook mapping tables are available in Portable Document Format (PDF) as free downloads on our Web site: [www.starrynighteducation.com/college](http://www.starrynighteducation.com/college)

Learn more about the Starry Night family of astronomy and space exploration multimedia products at [www.starrynighteducation.com](http://www.starrynighteducation.com).

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## Teaching Introductory Astronomy

Astronomy brings special challenges to an educator. Among them are:

- The three-dimensional nature of processes like seasons and moon phases,
- Frame-of-reference problems in understanding these processes,
- Many complex and abstract topics, and
- The existence of deep-rooted misconceptions.

In many instances, your students are enrolled in one of the few science courses they'll take in college. Some astronomical concepts can be difficult if the student has no background or familiarity with the subject. *Starry Night* can help your students develop an understanding of the universe around them by engaging them in interactive simulations.

In astronomy everything is relative. We see the universe from a tilted, moving platform. We do not feel ourselves moving. We are rooted on Earth's surface. To us on the ground, Earth's daily rotation on its axis and yearly revolution about the Sun make it look as though the sky is moving. Some of the motions we see are real while others are merely reflections of Earth's motions.

Visualization through computer simulations can help reconcile what are often conflicting ideas by enabling the viewer to gain otherwise impossible perspectives of celestial systems in motion.

How something looks depends on the frame of reference within which it is viewed. In astronomy, the ability to change one's frame of reference is crucial to understanding some common astronomical concepts. This *Starry Night* package, with its interactive computer models, allows you and your students to easily switch between different frames of reference to gain a fuller understanding of our place in the solar system, the galaxy, and the universe. It will help students sort out what is real motion and what is apparent motion.

## The Student Exercises

The heart of *Starry Night College* are the student exercises, written with the student in mind and designed to integrate with your course. Each interactive *Starry Night* computer exercise addresses a specific topic. The exercises are tabbed according to big topic areas, for example: solar system, stars, and galaxies and the universe.

Section 2 of this guide contains information on all of the student exercises available in *Starry Night College*. The information provided for each exercise follows the same structure:

- Introduction
- Objectives
- Key Concepts
- Time Required
- Notes

The **Introduction** provides an overview of the exercise. Next comes the student learning **objectives**.

Each Starry Night exercise covers certain **key concepts** and these are addressed in the computer exercises. The exercises will provide students with a variety of avenues to explore the topic. Also provided are **notes** that include special instructions, tips and additional information that you can use to enhance your student's learning experience.

Student worksheets containing the questions found in each computer exercise are available in Portable Document Format (PDF) as free Web downloads on our Web site:

[www.starrynighteducation.com/college](http://www.starrynighteducation.com/college)

These can be printed or digitally distributed to each student. You can collect the worksheets for evaluation or use them for student self-assessment.

Computer exercise answer keys are located in **Appendix C** of this guide.

## SkyGuide



The computer exercises described in Section 2 of this guide are preloaded in the Starry Night College software and can be found in the **SkyGuide** pane.

To open the SkyGuide pane, launch Starry Night College and click on the **SkyGuide** tab that runs along the left hand side of the Starry Night program window. Select **Student Exercises** to start.

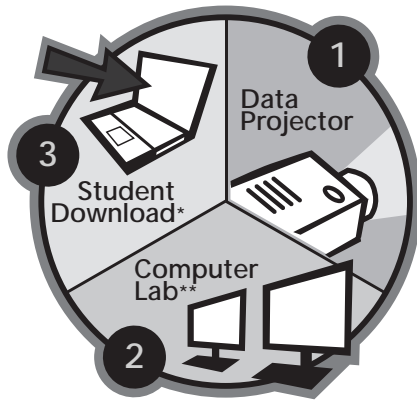
Navigating in SkyGuide is like navigating on the web: point and click. In addition to the computer exercises, SkyGuide also has links to additional information on a great variety of astronomy topics.

Each student exercise contains a number of questions for the student to answer. In SkyGuide, these questions are highlighted in yellow.

**Tip:** Students are encouraged to complete the tutorial exercise that has been designed to familiarize them with the basic controls of Starry Night College. The tutorial can be found by clicking on **Student Exercises-Tutorial** in the SkyGuide pane.

## Integrating Starry Night College Into Your Class

It is easy to integrate Starry Night College into your class. There are three approaches.



(1) If you purchased a single license of Starry Night College, you can project Starry Night and go through the exercises and simulations with your students in the classroom.

(2) The student exercises in SkyGuide were written with the student in mind and are more effective if each student has access to a computer lab with Starry Night College loaded on each computer. A multi-seat license is required. Please call 1-877-290-8256 for affordable educator discounts.

(3) For **increased student success**, the most effective and most flexible option is for each student to have their own copy of Starry Night installed on their computer (see Digital Download Option below). With the digital download option, you provide your students with a download code (included) that allows them to download Starry Night at a special discount student rate.

However you approach the logistics, Starry Night is sure to engage your students in a rich and rewarding exploration of our universe.

**Data projection tip:** You may need to increase the image brightness and contrast on your projector in order to achieve the best Starry Night images, especially if your classroom cannot be sufficiently darkened.

### The Digital Download Option

As an educator using Starry Night College you can provide your Students with their own copy of Starry Night at a discounted rate. The digital download option of Starry Night College provides each student with a 10-month license.

#### How it works

When you purchase Starry Night College, you will be emailed a registration key. The registration key will have the following format:

**pu6-xxxx-xxxx-xxxx- xxxx**

The last four digits of your registration key is the discount code you can provide to your students. This code will enable them to download a digital download version of Starry Night College at the special student discount.

After you provide your students with the discount code, they can be directed to the following website to download Starry Night:

[www.starrynighteducation.com/college](http://www.starrynighteducation.com/college)

After downloading Starry Night, students will be able to complete all of the exercises from their own computer and on their own schedule.

## Additional Resources

Rounding out this Starry Night package are these additional resources:

- **Starry Night Favorite Files:** a library of preset simulations organized by broad topic areas. To access these files, open the Favorites pane.
- **Starry Night User's Guide:** a comprehensive 210-page manual. Starry Night has been designed to be intuitive and easy to learn. Before reading this manual we encourage you to plunge in and give it a try. The manual is in PDF format and is accessible via the help menu in Starry Night College.
- **Starry Night Companion Book:** a 192-page introduction to astronomy by well-known astronomy educator John Mosley. The book is in PDF format and is accessible via the help menu in Starry Night College. You may find it helpful to browse through this first if you are new to astronomy or are teaching it for the first time.
- **Starry Night's Education Website:** here you will find more information on our educational products, software updates, and more astronomy resources. Log on to our teacher area at:

[www.starrynighteducation.com](http://www.starrynighteducation.com)

## The Appendices

Wrapping up this guide are the appendices. Here you will find information on how to get started using Starry Night. Starry Night is a comprehensive astronomy program but to do the exercises you only need a few of Starry Night's controls, and their use is intuitive. You and your students will be experts in no time.

There is also a keyword-to-exercise matrix, the answer key to the computer exercises, information on how to export data from Starry Night (star charts, movies and images), and a glossary of astronomical terms.

Everything you need to lead your students on a satisfying course that gives students a real insight into the universe using Starry Night is right here, at your fingertips.

## Section 2: Student Exercises

# A – Earth, Moon, and Sun

## Exercise A4: Measuring Angles in the Sky

### Introduction:

Angles and a system of measuring angles on the sky is an important tool for astronomers. It allows us to keep track of the position of an object in the sky, measure the angular distance between objects, and determine angular diameters.

### Objectives:

- To understand angular distance, angular diameter, arc minute and arc second.
- To learn how to use your hands to estimate the angular distance between objects.
- To know the angular diameters of the Sun, Moon and bright planets.
- To calculate the diameter of Mars.

### Key Concepts:

- Astronomers use angles to describe the separation of objects, and the apparent sizes of objects in the sky.
- Angles are measured in degrees. A circle equals 360 degrees; a right angle has 90 degrees.
- A degree can be subdivided into 60 arc minutes; an arc minute can be subdivided into 60 arc seconds.
- Angles are used to describe the angular size of an object in the sky (how much area of the sky it covers), and are independent of the actual distance to the object.
- Your hands can be used to estimate angular distance between objects in the sky.

### Time Required:

15-20 minutes

### Notes:

- *Both Sun and Moon appear to be the same size on the sky. In an interesting coincidence, the solar diameter is 400 times that of the Moon, and its distance is also 400 times that of the Moon. See Exercise A12: Lunar and Solar Eclipses.*
- *If you know the distance to an object, you can calculate its true size from its angular measure on the sky. In this exercise students will calculate the diameter of Mars by using the formula:*  
$$D = (\text{angular diameter of object in arcsec}) (\text{distance}) / 206,265$$

## Exercise A7: Solar and Sidereal Days

### Introduction:

The Sun is not a good timekeeper for two main reasons. Firstly, Earth's orbit is not a perfect circle. As Earth orbits around the Sun in its elliptical orbit, the apparent speed of the Sun in the sky varies. The Sun travels faster when the Earth is closer to the Sun and slower when the Earth is further from the Sun. Secondly, Earth's spin axis is tilted 23.5 degrees with respect to the celestial equator.

As a result, the Sun's daily eastward progress in the sky changes over the course of the year, and there are variations in the length of the apparent solar day.

To overcome these time-keeping challenges, astronomers developed two different ways of measuring time: the mean solar day and the sidereal day. Your wristwatch measures the mean solar day, but sidereal time is most useful for astronomers.

### Objectives:

- To understand why the apparent solar motion across the sky is non-uniform.
- To understand the concepts of apparent solar day, mean solar day and sidereal day.
- To understand the difference between the apparent solar day, mean solar day and sidereal day.

### Key Concepts:

- An apparent solar day is the time it takes the Sun to return to its highest point in the sky at local noon. The average time of an apparent solar day is 24 hours.
- The length of an apparent solar day varies throughout the year due to the Earth's elliptical orbit and the tilt of its spin axis.
- A mean solar day is a mathematical construction that addresses the shortcomings of an apparent solar day. A fictitious mean sun was created that moves along the celestial equator at a constant rate of speed. A mean solar day is exactly 24 hours long.
- A sidereal day is the amount of time needed by the Earth to complete one rotation around its spin axis. It is measured with reference to the fixed stars.
- A sidereal day, at 23 hours 56 minutes and 4 seconds, is approximately four minutes (3 min 56 sec) shorter than a solar day.

### Time Required:

15-20 minutes

Notes:

- *The difference in time between a solar day and a sidereal day is due to the motion of the Earth along its orbit around the Sun. This motion moves the Earth about one angular degree along its orbit as it completes a single rotation around its spin axis (one sidereal day). After a sidereal day, the Earth still needs to rotate a little further before the Sun again reaches its highest point. This is why a mean solar day is about four minutes longer than a sidereal day.*
- *See exercises **A9: The Analemma** and **B3: Johannes Kepler and Elliptical Orbits** for more information about planets' orbital motion about the Sun.*

## Exercise A13: Precession and Nutation

### Introduction:

The tidal forces of the Moon and Sun cause a slow wobbling of Earth's spin axis over a large period of time. This phenomenon is called precession and it causes both the north and south celestial poles (NCP, SCP) to appear to move in a circle around a fixed position among the stars.

The tidal force of the Sun and Moon also causes the precession of the equinoxes to vary over time with the result that the speed of precession is not constant. The resultant 'nodding' in the Earth's spin axis is called nutation.

In this exercise students will visualize and measure the effects of precession and nutation of the Earth's spin axis.

### Objectives:

- To understand Earth's spin axis undergoes a long-period wobble in orientation called precession.
- To understand that precession of the poles and equinoxes causes a slow shift in the celestial coordinate system.
- To understand that tidal forces in the solar system vary, producing a secondary nodding motion called nutation.

### Key Concepts:

- The tidal forces of the Moon and Sun cause Earth's spin axis to wobble (precession) and nod (nutation) slowly over time.
- Precession and nutation can be measured by using the position of stars on the celestial sphere. The period of precession is about 25, 800 years.
- The period of nutation is about 18.6 years.

### Time Required:

15-20 minutes

### Notes:

- *A spinning gyroscope demonstrates precession very clearly.*
- *The Moon has a larger influence on nutation than does the Sun. Lunar nutation is connected to the tilt of the Moon's orbital plane around Earth, and the 18.6-year period of rotation of the Moon's line of nodes. This causes a shift of +/- 9 arc seconds in the position of the celestial poles over an 18.6-year period.*

## B – The Solar System

## Exercise B2: Planetary Orbits and Configurations

### Introduction:

The introduction of the heliocentric model by Copernicus led to a better understanding of planetary motions in the solar system. The model introduced definable points based on planetary orbits and configurations of the planets within those orbits. Central to this model is the idea of inferior planets (those that orbit the Sun inside Earth's orbit) and superior planets (those that orbit the Sun outside Earth's orbit). Copernicus also found a relationship between the size of an orbit and the length of time it took for a planet to revolve around the Sun.

### Objectives:

- To define inferior planet, superior planet, inferior conjunction, superior conjunction, opposition, conjunction, greatest eastern and western elongation.
- To calculate the sidereal and synodic periods of a superior and inferior planet.

### Key Concepts:

- The heliocentric model defined by Copernicus led to a better understanding of planetary motion.
- Inferior planets have smaller orbits than the Earth.
- Superior planets have larger orbits than the Earth.
- When an inferior planet is between the Earth and the Sun it is at inferior conjunction, when it is on the opposite side of the Sun it is at superior conjunction.
- When a superior planet is opposite the Sun it is at opposition, when it is behind the Sun it is at conjunction.
- At greatest eastern elongation, inferior planets are best seen at sunset; at greatest western elongation, inferior planets are best seen at sunrise.

### Time Required:

15-20 minutes

### Notes:

- *Copernicus' heliocentric model made it possible to argue that the location of a planet in the sky was a result of the size of its orbit and its location on that orbit. Copernicus found a correlation between the size of a planet's orbit and the time (period) it takes for a planet to go around the Sun.*
- *Inferior planets always appear close to the Sun in the sky. They cannot be seen opposite the Sun in the nighttime sky.*
- *Venus has come to be known as the "morning star" and "evening star" because it is an inferior planet.*
- *Mercury's orbit is so close to the Sun that it is a difficult planet to observe.*

## C – The Planets

## Exercise C3: Direct and Retrograde Motion of the Planets

### Introduction:

The primitive cloud of gas and dust from which the solar system formed was rotating as it collapsed into a flat disk. This rotation can be seen today in the planets' common orbital plane and in the common direction of motion of the planets as they move around the Sun in their orbits.

The planets are held in their orbits by the Sun's gravity. The strength of gravity's pull is related to the distance from a massive object (in this case, the Sun). The closer to the Sun a planet is, the more strongly it feels the pull of the Sun's gravity, and the faster it moves in its orbit. The more distant a planet is from the Sun, the weaker is the pull of the Sun's gravity, and the more slowly the planet moves.

### Objectives:

- To define direct and retrograde motion of the planets.
- To understand that orbital speed and distance from the Sun are closely related and predictable. The relationship is described by Newton's Laws of Universal Gravitation.
- To use a planet's orbital period to determine its mean distance from the Sun.

### Key Concepts:

- Planets move around the Sun in a regular and predictable way.
- Planets move around the Sun in the same direction, in roughly circular orbits.
- Gravity is the force that keeps planets in orbit around the Sun.
- Planets move along a narrow path around the sky called the ecliptic.
- The planets appear to move across the sky compared to the background stars.
- Some planets appear to move backwards in the sky at certain times.

### Time Required:

15-20 minutes

## Notes:

- A planet's orbital speed is related mathematically to its distance from the Sun. Kepler's third law of planetary motion describes the relationship. It states that the square of a planet's orbital period is proportional to the cube of its semi-major axis (i.e.: its mean distance from the Sun.). The equation is written this way:

$$P^2 \text{ (in Earth years)} = a^3 \text{ (in astronomical units)}$$

Try using a planet's orbital period in this formula to determine its mean distance from the Sun. If you do the calculation for several planets, compare the ratios of  $P^2 / a^3$  for each planet. The results should all be close to 1.0.

- For more on orbits, see exercise **B3: Johannes Kepler and Elliptical Orbits**.
- For more on Newton's laws and orbits, see exercise **B5: Modern Overview of the Solar System**.

# D – Small Solar System Bodies

## Exercise D1: Asteroids of the Main Belt

### Introduction:

The location, motion and composition of the asteroids hold clues to the formation and history of the solar system. The asteroids, or minor planets, formed at the same time as the rest of the solar system, and Jupiter's strong gravity influences their orbits. The combined mass of all known asteroids is less than that of Earth's Moon.

The material that makes up an asteroid is little changed from the early days of the solar system. It has never been incorporated into the body of a full-fledged planet, so it has not been subjected to the geological processing that normally occurs in the interiors of large planets.

In this exercise students will explore asteroids in the main belt that lies between the orbits of Mars and Jupiter.

### Objectives:

- To examine the orbits of several asteroids in the main asteroid belt.
- To explore the physical characteristics of a typical asteroid.
- To understand Jupiter's role in shaping the asteroid belt.

### Key Concepts:

- Asteroids are small, irregular solar system bodies made of mostly rock and metal.
- Asteroids orbit the Sun like the planets do.
- Most asteroids are found between Mars and Jupiter in a reservoir called the main asteroid belt.
- The asteroid belt is about 1.5 AU wide and its extent is strongly influenced by Jupiter's gravity.
- Main belt asteroids are made of primitive material from the early history of the solar system.
- The dwarf planet Ceres is the largest object in the asteroid belt.

### Time Required:

15-20 minutes

## E – Star Finding and Constellations

## Exercise E2: The Magnitude Scale

### Introduction:

Astronomers measure the brightness of a celestial object according to a system originally devised by Hipparchus in 120 B.C. Hipparchus ranked the brightness of stars in the sky on a scale of 1 to 6 as seen from the Earth. The brightest stars he could see were classified as first magnitude and the faintest were sixth magnitude. Centuries later we use a modernized version of the apparent magnitude scale of Hipparchus.

In this exercise student will learn about the apparent magnitude scale and where some of the brighter stars and planets fit within this scale. They will use the inverse-square law to determine an object's absolute magnitude and luminosity.

### Objectives:

- To learn the apparent magnitude scale.
- To calculate the difference in brightness between two objects.
- To define apparent and absolute magnitude.
- To calculate an object's absolute magnitude given its apparent magnitude and distance from the Earth.
- To calculate a star's luminosity given its apparent brightness and distance.

### Key Concepts:

- The apparent magnitude scale is a logarithmic scale: one magnitude difference is equal to a brightness difference of about 2.5 times.
- The greater the apparent magnitude, the dimmer the star.
- The brighter planets and stars have negative magnitudes. The Sun, being the brightest object in the sky, has a magnitude of  $-26$ , followed by the full Moon at magnitude  $-11$ . Venus is the brightest planet at  $-4.4$  and Sirius is the brightest star at  $-1.4$ .
- Absolute magnitude is the apparent magnitude a star would have if it were 10 parsecs distant from the Earth.
- The inverse-square law relates a star's luminosity, distance and apparent brightness.

### Time Required:

15-20 minutes

### Notes

- *The apparent magnitude of a star describes how bright the stars looks. The star's luminosity is an intrinsic property of the star, and tells us about the amount of energy being produced by the star.*
- *The apparent brightness of a star is directly proportional to its luminosity and inversely proportional to the square of its distance.*

# F – The Stars

## Exercise F2: Stellar Parallax

### Introduction:

Knowing the distance to a celestial object is one of the most important pieces of information for an astronomer. Distance is a fundamental parameter without which other data might be useless. Measuring the annual stellar parallax of stars can reveal their distances. This information has become a keystone of other distance-determination methods in astronomy. The first star to have its parallax measured was 61 Cygni, in 1838.

In this exercise students will learn how to measure stellar parallax and calculate a stars distance.

### Objectives:

- To define stellar parallax.
- To calculate a stars distance based on its parallax.

### Key Concepts:

- Parallax can reveal a stars distance.
- The relationship between a star's distance ( $d$ ) and its parallax ( $p$ ) can be stated as  $d=1/p$ .
- Parallax uses Earth's orbit as a baseline, and is measured by observing the position of a star at opposite points in the Earth's orbit.

### Time Required:

15-20 minutes

### Notes:

- *The parsec is a unit of distance. The word comes from combining the words "parallax angle" and "arc second." One parsec equals 3.26 light years of distance.*

# G – Galaxies and the Universe

## Exercise G4: Structure in the Nearby Universe

### Introduction:

Galaxies in the universe are organized into clusters. Clusters can be poor or rich, depending on how many galaxies a cluster contains. Poor clusters are often referred to as groups.

The Milky Way galaxy is part of the Local Group, a cluster of 40-plus galaxies. Clusters of galaxies are organized into superclusters that typically contain dozens of individual clusters, and superclusters make up the enormous filaments and sheets that surround vast voids of space. Taken together, the large-scale structure of the universe can be likened to that of foam.

In this exercise students will see the large-scale structure of the near universe.

### Objectives:

- To recognize that the universe is not randomly organized.
- To recognize that galaxies form clusters of galaxies which themselves form superclusters.
- Superclusters connect to form filaments and sheets on the largest scale.
- To identify the Local Group, the Virgo Cluster, the Local Supercluster, the Great Attractor, and the two Walls.

### Key Concepts:

- The Milky Way galaxy is a member of the Local Group of galaxies, which contains over 40 galaxies.
- The largest member of the Local Group is the Andromeda galaxy (M31), followed by the Milky Way galaxy.
- Most of the galaxies in the Local Group are dwarf elliptical galaxies.
- The Milky Way is surrounded by a number of smaller satellite galaxies.
- Galaxies are grouped into clusters and superclusters of galaxies that connect to form filaments and sheets.
- Between the filaments and sheets there are dark voids that contain few galaxies.
- Clusters of galaxies are distributed unevenly in the universe.

### Time Required:

10-15 minutes

### Notes:

- *The foam-like structure of the universe suggests that the galaxies are distributed over the surfaces of huge bubble-like voids. The filaments and superclusters seem to be located where there is an intersection of two or more voids.*

# H – Space Exploration and Technology

# Exercise H1: Artificial Satellites and the Space Environment

## Introduction:

Satellite technology has practical applications in everyday living as well as allowing us to explore the universe in ways not otherwise possible. Individual satellites are designed to carry out specific functions and are designed to operate in the harsh environment of space. Astronomical satellites must work within highly specific and stringent parameters that sometimes require unusual orbits.

In this exercise students will explore a few different types of satellites, their orbits and some of the applications for, and benefits of, satellite technology.

## Objectives:

- To understand the role of satellites and their benefits.
- To distinguish between geocentric, geosynchronous and polar orbits.
- To calculate the orbital speed of a satellite.
- To recognize that some astronomical satellites require special orbits in order to function.

## Key Concepts:

- The environment of space is very harsh.
- Technology developed for space exploration has benefits for people living on Earth.
- Space probes and satellites have given us information about the universe that would be otherwise impossible to obtain.
- Satellites are placed in different orbits depending on their function.

## Time Required:

10-15 minutes

## Notes:

*The orbital speed of a satellite can be calculated using:*

$$v^2 = GM/R$$

*Where:*

*G = gravitational constant  $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$*

*M = mass of the Earth  $5.97 \times 10^{24}\text{kg}$*

*R = radius of the orbit ( $6.38 \times 10^6 + \text{altitude}$ ) in meters*

# Appendices

## Appendix A: Starry Night Quick Start Guide

The main Starry Night Screen is divided in two with a tool bar across the top. The right panel is your current view of the sky. The side panes at the left include a series of tabs that give you access to specific functions, options, and detailed information.

### The Tool Bar

The Tool Bar provides precise information about Starry Night's current view of the sky. It also gives you all the tools you need to move through time and space.

1. **Time and Date** shows the time and date for the current view. Starry Night can display the sky as it looks right now or take you back or forward in time. To change the time or date, use any of the predefined buttons or click any of the fields in the display and enter a number. To change the month, enter a number between 1 and 12. Or use the up and down arrows to step through time.
2. **Time Flow Rate** controls the speed at which time is flowing.

### Changing Your View

3. To change your **Viewing Location**, choose Options > Viewing Location. To return to your home location, click **Home**. To change your home location, choose File > Set Home Location in Windows, or Starry Night > Set Home Location on a Macintosh. Or use the up and down buttons to blast off from the surface of any planet you travel to.
4. **Gaze** indicates the direction you're looking. **Alt** (altitude) measures the height in degrees above the horizon. An altitude of zero degrees means you're looking straight ahead, 90° means you're looking straight up, and -90° is straight down. **Az** (azimuth) indicates the direction you're facing: zero degrees is north, 90° is east, 180° is south, and 270° is west.

To change your view, click the direction buttons, or move your mouse onto the current display until it becomes the hand cursor, click and hold to grab the sky, and drag the display around.

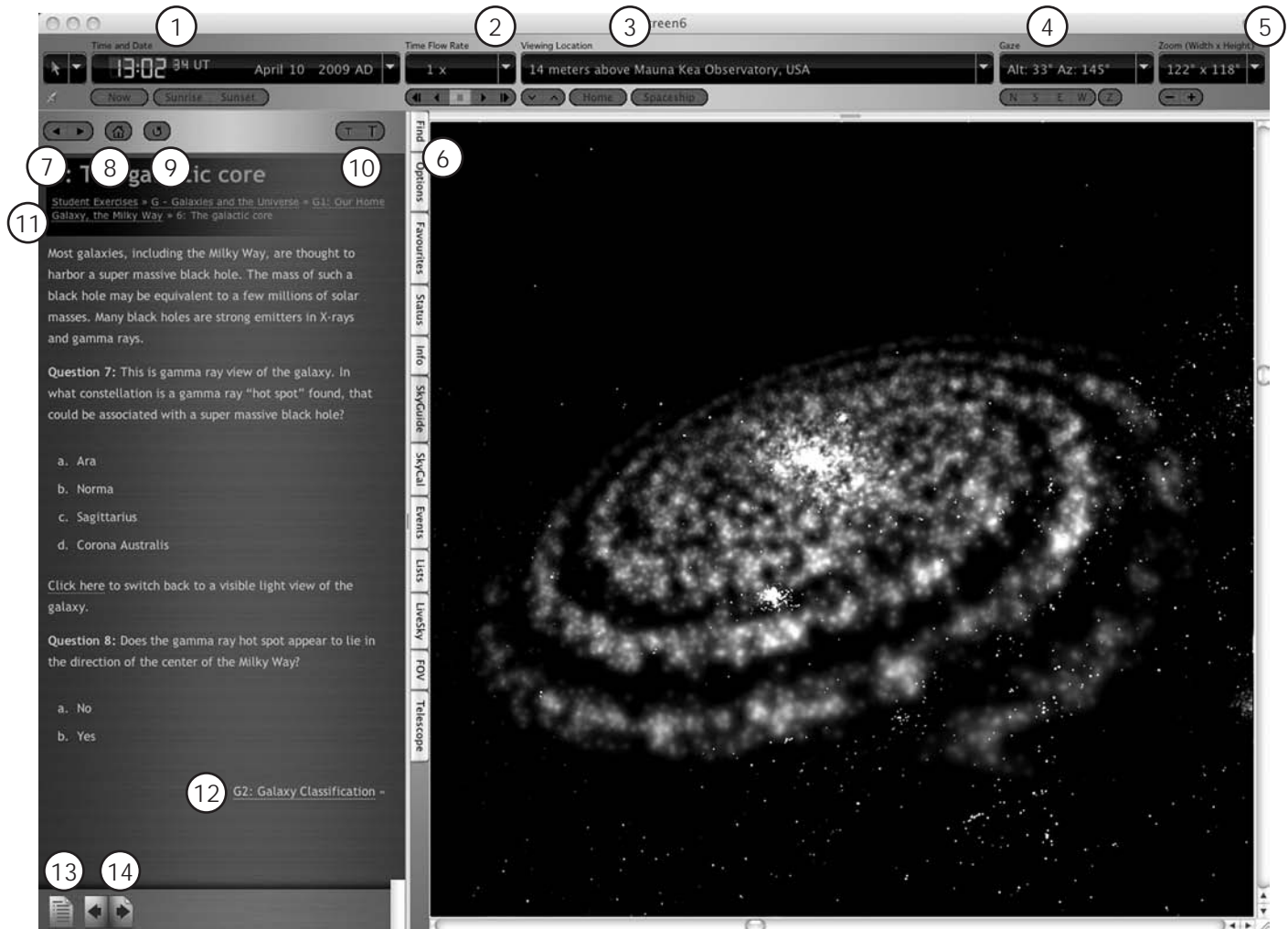
5. **Zoom** indicates how much of the sky you're seeing, measured in degrees. If you could see everything in front of you, from your right to your left, it would cover 180°, but the average person can see only approximately 100°. Binoculars typically cover 5° to 7°, and telescopes even less. Use the buttons below – or the scroll wheel on your mouse – to zoom in for a closer look at any object that catches your eye.

### The Side Panes

6. These side panes give you access to Starry Night functions, display options, and detailed astronomical information.

**Find** allows you to search through Starry Night's databases and select specific objects in the sky.

**Options** allows you to modify the appearance of your sky display, including such things as guides and gridlines, local conditions, and the objects you want to see.



**Favorites** include a menu of Starry Night files that demonstrate the application's features and key astronomical concepts. You can also store your own favorites here.

**Status** provides a handy summary of your current sky view.

**Info** provides comprehensive information on the currently selected object, including links to even more online information.

**SkyGuide** is where you will find the **Student Exercises**, as well as Starry Night's collection of interactive guided tours through the cosmos. It also includes weekly sky events, daily headline news, and step-by-step instructions on how to use the most common Starry Night functions.

**SkyCal** contains a current chronological list of upcoming astronomical events.

**Events** is a search engine that finds and lists current and future visible astronomical events like moon phases, eclipses, meteor showers and more.

**LiveSky** is Starry Night's gateway to the rich resources of the Internet. This panel gathers together the most current astronomical images and data available online.

## SkyGuide

Click the SkyGuide tab to access Student Exercises and Starry Night's collection of interactive guided tours of the cosmos. SkyGuide functions a lot like your Web browser: there are buttons to help you navigate through the pages and lots of links to explore.

7. The **Back** button takes you to the page you last visited. Click it again to move back through the pages you've seen. Click **Forward** to go forward again through the same pages.
8. Click **Home** to take you to the main SkyGuide page.
9. Click **Reload** to restart the Starry Night display.
10. **Text Increase** and **Text Decrease** change the size of the text in the SkyGuide window. (Macintosh version only.)
11. Each page in SkyGuide includes a **Path** that shows where you are and the way back to the main page, and each section in SkyGuide begins with a **Menu of Topics** to be covered. Click these links to navigate through SkyGuide.
12. At the bottom of each page, you'll find a link to the **Next Page**. If you want to read SkyGuide from beginning to end, keep clicking here. Or use the menus to explore.
13. Click **Table of Contents** to display a list of all the topics and tours SkyGuide offers.
14. Click **Page Forward** to move to the next page in SkyGuide. Click **Page Back** to move to the previous page.

