# General Education Course NMHED Recertification Form

*This form has been designed to guide you through the recertification process for the UNM General Education course in question. Please fill out your contact information below, and then review the information about the course provided to us by the* New Mexico Department of Higher Education *(*NMHED*). After this, you will be instructed to fill out three separate narratives concerning the course and its relevance to NMHED's area and skills associated with the course.*

## UNM Course Information

| | |
|---|---|
| Prefix | **ASTR** |
| Number | **1115** |
| Name | **Introduction to Astronomy (LEC)** |

## Contact Information

| | |
|---|---|
| Name | John Matthews |
| Title | Professor |
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| Email | Johnm@phys.unm.edu |

# NMHED's Description and Outcomes for the Common Course

*The description and student learning outcomes below come from NMHED's* Common Course Catalog, *which can be found here, and is meant to designate standard descriptions and outcomes of courses registered as a NMHED* Common Course.

## ASTR 1115: Introduction to Astronomy (LEC)

*This course surveys observations, theories, and methods of modern astronomy. The course is predominantly for non-science majors, aiming to provide a conceptual understanding of the universe and the basic physics that governs it. Due to the broad coverage of this course, the specific topics and concepts treated may vary. Commonly presented subjects include the general movements of the sky and history of astronomy, followed by an introduction to basic physics concepts like Newton's and Kepler's laws of motion. The course may also provide modern details and facts about celestial bodies in our solar system, as well as differentiation between them -- Terrestrial and Jovian planets, exoplanets, the practical meaning of "dwarf planets", asteroids, comets, and Kuiper Belt and Trans-Neptunian Objects. Beyond this we may study stars and galaxies, star clusters, nebulae, black holes, clusters of galaxies and dark matter. Finally, we may study cosmology -- the structure and history of the universe.*

**Student Learning Outcomes:**

Upon successful completion of the course,
1. Students will discuss the night sky as seen from Earth, including coordinate systems, the apparent daily and yearly motions of the sun, Moon, and stars, and their resulting astronomical phenomena.
2. Students will list and apply the steps of the scientific method.
3. Students will describe the scale of the Solar System, Galaxy, and the Universe.
4. Students will explain telescope design and how telescopes and spectra are used to extract information about Astronomical objects.
5. Students will describe the formation scenarios and properties of solar system objects.
6. Students will describe gravity, electromagnetism, and other physical processes that determine the appearance of the universe and its constituents.
7. Students will describe methods by which planets are discovered around other stars and current results.
8. Students will describe the structure, energy generation, and activity of the sun.
9. Students will compare our sun to other stars and outline the evolution of stars of different masses and its end products, including black holes.
10. Students will describe the structure of the Milky Way and other galaxies and galaxy clusters.
11. Students will describe the origin, evolution, and expansion of the universe based on the Big Bang

Theory and recent Astronomical observations.

12. Students will describe conditions for life, its origins, and possible locations in the universe.

## Institution-specific Student Learning Outcomes

*Please add additional SLOs of the general education course to the ones provided by NMHED, or if no SLOs are provided by NMHED, input the SLOs used in assessment for the course.*

1. The laws of physics are universal: Students will be able to apply the laws of physics as we know them on Earth to other objects in the universe.
2. Electromagnetic radiation as an astronomical tool: Students will be able to identify ways in which electromagnetic radiation can be used to interpret information about the universe.
3. The scientific method: Students will be able to recognize use of the scientific method in refinement of our understanding of the universe.
4. Our place in the universe: Students will be able to recognize how astronomy informs them of their own origin and place in the universe.

# Area and Essential Skills

*Below gives information concerning the area and associated skills of the course to be re-certified. The area here matches the General Education Area of UNM; the "Essential Skills" and their respective Component Skills are characterizations of the area determined by NMHED. You will use this information to fill out the narratives below.*

## Area in which *ASTR 1115* resides: Science

## Essential Skills in the Area:

### Critical Thinking

**Problem Setting:** Delineate a problem or question. Students state problem/question appropriate to the context.

**Evidence Acquisition:** Identify and gather the information/data necessary to address the problem or question.

**Evidence Evaluation:** Evaluate evidence/data for credibility (e.g. bias, reliability, and validity), probable truth, and relevance to a situation.

**Reasoning/Conclusion:** Develop conclusions, solutions, and outcomes that reflect an informed, well-reasoned evaluation.

### Personal and Social Responsibility

**Intercultural reasoning and intercultural competence**

**Sustainability and the natural and human worlds**

**Ethical Reasoning**

**Collaboration skills, teamwork and value systems**

**Civic discourse, civic knowledge and engagement -- local and global**

### Quantitative Reasoning

**Communication/Representation of Quantitative Information:** Express quantitative information symbolically, graphically, and in written or oral language.

**Analysis of Quantitative Arguments:** Interpret, analyze and critique information or a line of reasoning presented by others.

**Application of Quantitative Models:** Apply appropriate quantitative models to real world or other contextual problems.

# Narrative Input

In the boxes provided, write a short (~300 words) narrative explaining how the course weaves the essential skills associated with the content area throughout the course. Explain what students are going to do to develop the essential skills and how you will assess their learning. The narrative should be written with a general audience in mind and avoid discipline specific jargon as much as possible.

*Be sure to address the component skills listed next to each essential skills. The number of component skills that must be addressed by your narrative is listed.*

**Critical Thinking:** *Problem Setting; Evidence Acquisition; Evidence Evaluation; Reasoning/Conclusion.*

Astronomy, starting from planet Earth, is the study of the Universe. Of the sciences astronomy is special in relying completely on observation. In practice properties of electromagnetic radiation are used to analyze observational data based on known physics to determine the properties of distant planets, stars, star forming regions, galaxies, the 3-dimensional distribution of matter (galaxies) and the time history of the universe. In summary astronomy is a vast collection of observations that must be correctly interpreted. Thus astronomy, and the Astro1115 class, mostly emphasizes Critical Thinking skills.

As Critical Thinking is so central to the day to day practice of Astronomy, these skills begin on the first day of class and go through the final exam. A good example is provided by the motions of the Earth and the Moon. Why is there day and night? Why are different stars visible at different times of the year? Why are there seasons? Why are there Solar and/or Lunar eclipses? Often what we consider familiar provides some of the best opportunities to grow Critical Thinking skills. When challenged with even this short list of questions students must understand what each problem is asking (problem setting), then associate relevant personal experiences and course material (evidence acquisition) and then use Critical Thinking to sort the more relevant from less relevant/irrelevant information (evidence evaluation). Students are then encouraged to apply the scientific method to appreciate that the many observations are explained by a handful of basic facts (reasoning/conclusion).

Students develop their Critical Thinking skills profiting from many standard learning tools including class lectures and demonstrations, online homework, tests, in class discussions including use of clicker, etc. Students get feedback on their progress from their homework (which uses the online Pearson Mastering Astronomy), from the 4 midterm/final examinations and from in-class and email questions. With this high level of feedback there are no options for "extra credit" or other ways to avoid taking the class seriously from the

**Personal and Social Responsibility:** *Intercultural reasoning and intercultural competence; Sustainability and the natural and human worlds; Ethical Reasoning; Collaboration skills, teamwork and value systems; Civic discourse, civic knowledge and engagement -- local and global.*

Astronomy, starting from planet Earth, is the study of the Universe. Of the sciences astronomy is special in relying completely on observation. In practice properties of electromagnetic radiation are used to analyze observational data based on known physics to determine the properties of distant planets, stars, star forming regions, galaxies, the 3-dimensional distribution of matter (galaxies) and the time history of the universe. In summary astronomy is a vast collection of observations that must be effectively and correctly interpreted. Thus astronomy, and the Astro1115 class, emphasizes the need for unbiased data obtained as uniformly as is possible (intercultural reasoning and intercultural competence), realizing that data quality typically improves with time as data collecting instrumentation improves. This is true even when the science is uncomfortable, such as human impact on Global Warming and the need to be aware of scarce world resources such as helium that is not retained in Earth's atmosphere (sustainability and the natural and human worlds, and ethical reasoning). Students are confronted with stark data and then asked: what are healthful alternatives for humanity (collaboration skills, teamwork and value systems, and civic discourse, civic knowledge and engagement – local and global)? In this way the class contributes to students' growth in Personal and Social Responsibility skills.

Examples of multiple choice questions from recent midterm exams show how the students are challenged to apply Personal and Social Responsibility skills in astronomical applications.

Students develop their Personal and Social Responsibility skills profiting from many standard learning tools including class lectures and demonstrations, online homework, tests, in class discussions including use of clicker, etc. Students get feedback on their progress from their homework (which uses the online Pearson Mastering Astronomy), from the 4 midterm/final examinations and from in-class or email questions. With this high level of feedback there are no options for "extra credit" or other ways to avoid taking the class seriously from the very onset. Lectures, homework assignments and tests evolve with time to address (with the goal to resolve) areas of confusion.

**Quantitative Reasoning:** *Communication/Representation of Quantitative Information; Analysis of Quantitative Arguments; Application of Quantitative Models.*

Astronomy, starting from planet Earth, is the study of the Universe. Of the sciences astronomy is special in relying completely on observation. In practice properties of electromagnetic radiation are used to analyze observational data based on known physics to determine the properties of distant planets, stars, star forming regions, galaxies, the 3-dimensional distribution of matter (galaxies) and the time history of the universe. In summary astronomy is a vast collection of observations that must be effectively interpreted. Thus astronomy, and the Astro1115 class, needs and emphasizes Quantitative Reasoning skills.

Typically Quantitative Reasoning is required to optimize the collection of and the interpretation of astronomical data. Examples range from the design and optimization of astronomical telescopes, to the application of Black Body physics to obtain detailed information of star properties, to the use of the distance luminosity relation to measure source distances based on standard-candle light sources, to the use of Newton's laws (including gravity) to detect and map dark matter in the universe.

Astronomy provides a natural opportunity to develop and use effective communication skills (communication/representation of quantitative information), thus e.g. essentially unimaginable quantities are expressed as simple ratios: luminosity of a star to the luminosity of our Sun, or mass of a star to the mass of our Sun. Astronomy also provides an ideal opportunity to use known quantitative relationships, e.g. stars' apparent brightnesses to their intrinsic brightness and distance, to guide which measurements will let us learn about things that we do not know (analysis of quantitative arguments, application of quantitative models).

Students develop their Quantitative Reasoning skills profiting from many standard learning tools including class lectures and demonstrations, online homework, tests, in class discussions including use of clicker, etc. Students get feedback on their progress from their homework (which uses the online Pearson Mastering Astronomy), from the 4 midterm/final examinations and from in-class and email questions. With this high level of feedback there are no options for "extra credit" or other ways to avoid taking the class seriously from the very onset. Lectures, homework assignments and tests evolve with time to address (with the goal to resolve) areas of confusion.

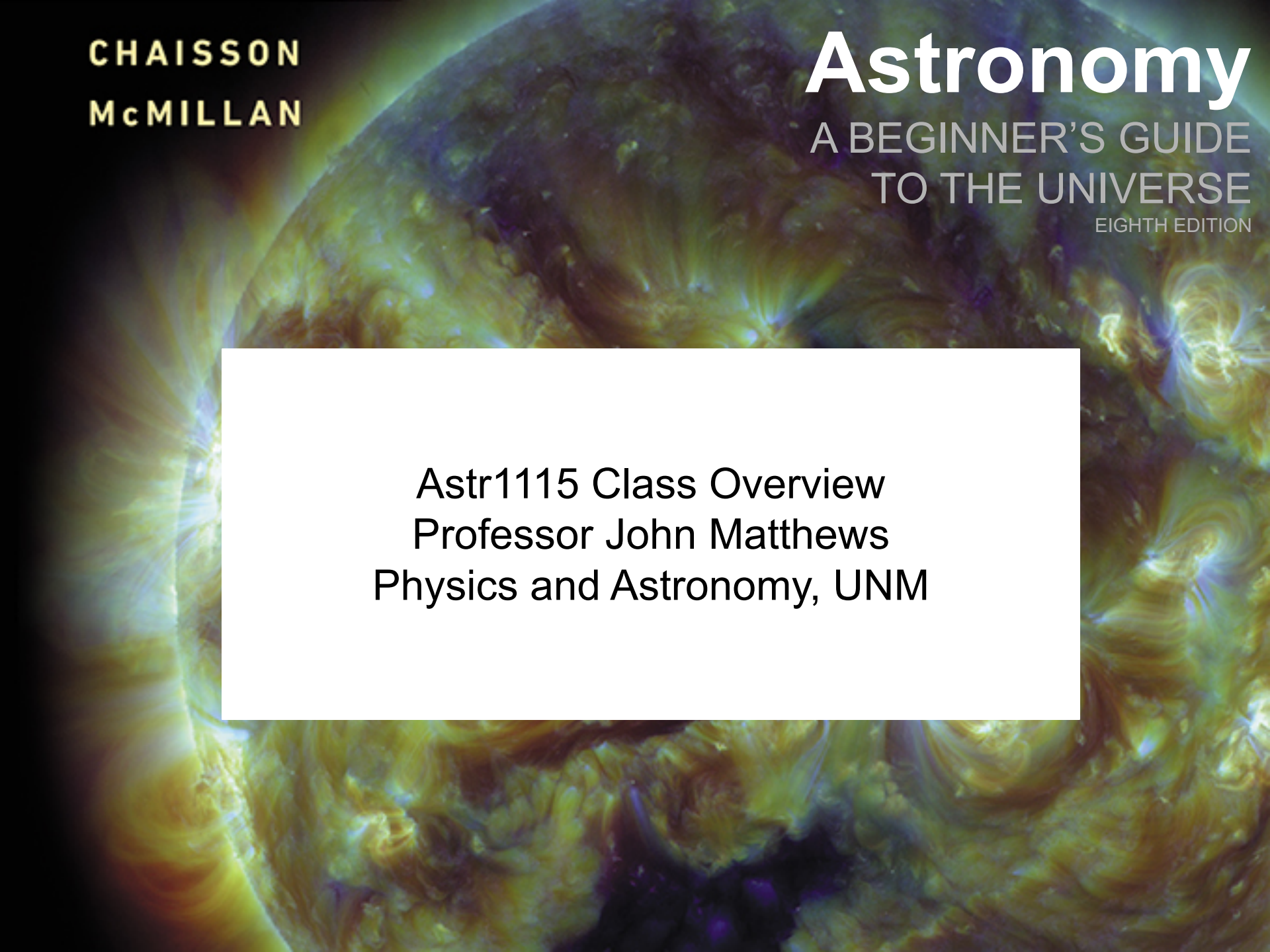
# Additional Information

## Course Materials

*NMHED requires that both a syllabus and a sample course assignment (project, paper, exam,etc.) from the course in question to be attached to the recertification form. Be sure and pick an assignment that correlates with the descriptions provided in the narratives above.*

## Assessment Plan

*When it is submitted to NMHED, each general education course will also have attached the assessment plan that is used for General Education Assessment at UNM. For more information on this process, please visit this page from UNM's Office of Assessment.*




Astr1115 Class Overview
Professor John Matthews
Physics and Astronomy, UNM

# Astronomy: A Beginner's Guide to the Universe

This is a textbook used at major institutions in the US.

As a consequence our course provides a broad introduction to, and overview of, astronomy to help you appreciate the almost daily astronomy news items that you will find on the web.

The structure of the text is:

I. FOUNDATIONS

0. Charting the Heavens: The Foundations of Astronomy [Intro to Scientific Method]
1. The Copernican Revolution: The Birth of Modern Science [Copernicus - Newton]
2. Light and Matter: The Inner Workings of the Cosmos [Getting the most from light]
3. Telescopes: The Tools of Astronomy [Getting the best data at many wavelengths]

II. OUR PLANETARY SYSTEM

4. The Solar System: Interplanetary Matter and the Birth of the Planets
5. Earth and Its Moon: Our Cosmic Backyard
6. The Terrestrial Planets: A Study in Contrasts
7. The Jovian Planets: Giants of the Solar System
8. Moons, Rings, and Plutoids: Small Worlds Among Giants

# Astronomy: A Beginner's Guide to the Universe

III. THE STARS
9. The Sun: Our Parent Star
10. Measuring the Stars: Giants, Dwarfs, and the Main Sequence
11. The Interstellar Medium: Star Formation in the Milky Way
12. Stellar Evolution: The Lives and Deaths of Stars
13. Neutron Stars and Black Holes: Strange States of Matter

IV. GALAXIES AND THE UNIVERSE
14. The Milky Way Galaxy: A Spiral in Space
15. Normal and Active Galaxies: Building Blocks of the Universe
16. Hubble’s Law and Dark Matter: The Large-Scale Structure of the Cosmos
17. Cosmology: The Big Bang and the Fate of the Universe

# Topics: Draft Schedule

| | | |
|---|---|---|
| Class Intro | Aug 18 | |
| Chapt 0 (0.4 later) | Aug 18 - 20 | 78 slides |
| Chapt 1 | Aug 25 | 50 slides |
| Chapt 2 | Aug 27 - Sept 1 | 82 slides |
| Chapt 3 | Sept 3 | 46 slides |
| Chapt 4 | Sept 8 | 50 slides |
| Chapt 5 | Sept 10 - 15 | 131 slides |
| Chapt 6 (Mer/Ven) | Sept 17 | 48 slides |
| | | |
| Midterm #1 | Sept 22 | Chapt 0 - 4 |

# Topics: Draft Schedule

| | | |
|---|---|---|
| Chapt 6 (Mars) | Sept 24 | 54 slides |
| Chapt 7 | Sept 29 | 50 slides |
| Chapt 8 | Oct 1 | 93 slides |
| Chapt 9 | Oct 6 - 8 | 66 slides + chapt 9 notes |
| Chapt 10 | Oct 13 | 73 slides |
| | | |
| Midterm #2 | Oct 15 | Chapt 5 - 8 |

# Topics: Draft Schedule

| | | |
|---|---|---|
| Chapt 10/11 | Oct 20 | 48 slides |
| Chapt 12 | Oct 22 - 27 | 69 slides |
| Chapt 13 (skip 13.5/6) | Oct 29 | 57 slides |
| ----- Nov 3 one day break ------ | | |
| Chapt 14 | Nov 5 | 57 slides |
| Chapt 15 | Nov 10 | 73 slides |
| Chapt 16 | Nov 12 | 51 slides |
| | | |
| Midterm #3 | Nov 17 | Chapt 9 - 12 |

# Topics: Draft Schedule

| | | |
|---|---|---|
| Chapt 17 | Nov 19 - 24 | 88 slides |
| Review | Dec 1 - 3 | 19 slides |
| Final/Midterm #4 | Probably Tuesday Dec 8, 2020<br>Chapt 13 - 17 | |

# Topics: Course grade

20% for Mastering Astronomy **quiz** assignments

20% for Mastering Astronomy **homework** assignments

20% / midterm for 3 midterms
To calculate the exam component of your grade, I will choose your THREE best exam scores (from the 4 exams).

Then the letter grades in the course will be:

| | | |
|---|---|---|
| A | 85 - 100+ | (Plus and |
| B | 65 - 84 | minus grades will |
| C | 45 - 64 | be assigned.) |
| D | 30 - 44 | |
| F | below 30 | |

## Critical Thinking

**Problem Setting:** Delineate a problem or question. Students state problem/question appropriate to the context.
**Evidence Acquisition:** Identify and gather the information/data necessary to address the problem or question.
**Evidence Evaluation:** Evaluate evidence/data for credibility (e.g. bias, reliability, and validity), probable truth, and relevance to a situation.
**Reasoning/Conclusion:** Develop conclusions, solutions, and outcomes that reflect an informed, well reasoned evaluation.

Sample Assessment Questions (Multiple-choice questions could be given on an exam or as a clicker question in class.):

1) What physical property of Earth gives rise to the seasons?

a) The variation in its distance from the Sun

b) The precession of its axis

c) Changes in the day-night cycle

d) The 23.5 degree tilt of its rotation axis

e) Its global warming and cooling

2) Night and day have approximately equal length at what time or times of the year?

a) Summer solstice

b) Summer equinox

c) Winter solstice

d) Winter equinox

e) Vernal and autumnal equinoxes

3) If Earth rotated twice as fast as it currently does, but its motion around the Sun stayed the same, then:

a) the year would be half as long.

b) the year would be twice as long.

c) the night would be twice as long.

d) the night would be half as long.

e) the length of the night would be unchanged.

4) What is the cause of the phases of the Moon?

a) One side of the Moon always faces the Earth.

b) As the Moon orbits the Earth, the shadow of the Earth covers the Moon in different amounts.

c) Different percentages of the Moon's surface give off light at different points in the Moon's orbit.

d) As the Moon orbits the Earth, different parts of the side facing the Earth are illuminated by the Sun.

e) As the Moon orbits the Earth, a different fraction of the Moon's surface is illuminated by the Sun.

5) If the Moon's orbit were a little larger, solar eclipses would be:

a) more frequent.

b) more likely to be annular.

c) less likely to be annular.

d) more likely to be total.

e) unchanged in appearance.

## Personal and Social Responsibility

**Intercultural reasoning and intercultural competence**
**Sustainability and the natural and human worlds**
**Ethical Reasoning**
**Collaboration skills, teamwork and value systems**
**Civic discourse, civic knowledge and engagement -- local and global**

Sample Assessment Questions (Multiple-choice questions could be given on an exam or as a clicker question in class.):

1) What are the roles of theory and experiment (or observation) in science?

a) Theories are idealizations that do not need to be tested by experiment or observation.

b) Using repeated experimental testing, scientists modify their theories to best match the theoretical predictions with observations.

c) Scientists select a subset of experiments and observations until those agree with their theories.

d) Scientists need to adjust their experiments and observations until they agree with their theories.

e) Scientists only continue their experiments and observations until the observations agree with their theories and can be published.

2) The critical part of the atmosphere for protecting life on the ground from excessive (UV) ultraviolet radiation is the:

a) ozone layer.

b) troposphere.

c) ionosphere.

d) hydrosphere.

e) stratosphere.

3) The principal greenhouse gases in Earth's present atmosphere are:

a) hydrogen and helium.

b) oxygen and nitrogen.

c) water vapor and carbon dioxide.

d) methane and ammonia.

e) sulfuric acid vapor and $CO_2$.

4) Without the greenhouse effect operating in our atmosphere:

a) the ice in the polar regions would have melted long ago.

b) Earth would have an average temperature of -18 degrees Celsius (about 0 degrees Fahrenheit)

c) the ozone layer would not be weakening.

d) we would still be worrying about global warming

e) the Earth would have become much more like Venus long ago.

5) Atmospheric "escape speed" (or "escape velocity") means:

a) how fast air escapes from the surface of a planet/moon

b) how fast air escapes from the rocks of a planet/moon

c) the speed an air molecule needs to escape the pull of gravity

d) how fast water (vapor) escapes from the ocean (to form clouds)

e) the speed a meteor needs to return to space

## Quantitative Reasoning

**Communication/Representation of Quantitative Information:** Express quantitative information symbolically, graphically, and in written or oral language.
**Analysis of Quantitative Arguments:** Interpret, analyze and critique information or a line of reasoning presented by others.
**Application of Quantitative Models:** Apply appropriate quantitative models to real world or other contextual problems.

Sample Assessment Questions (Multiple-choice questions could be given on an exam or as a clicker question in class.):

1) What is the light-gathering power of an 8 inch telescope compared to a 4 inch telescope?

a) 2 times larger

b) 4 times larger

c) 8 times larger

d) 16 times larger

e) 32 times larger

2) Astronomers on Venus would measure a solar constant:

a) larger than on Earth

b) the same as on Earth

c) 7/10 (the ratio of the orbit radii) the value on Earth

d) much smaller than on Earth because of Venus' dense atmosphere

e) none of the above

3) Sunspots are dark splotches on the Sun. Which statement is true?

a) They are extremely cold objects, as cold as Pluto.

b) They are hotter than the surrounding areas of the Sun.

c) They are solid bodies floating on the surface of the Sun.

d) They are associated with areas of very low magnetic fields.

e) They are extremely hot, but cooler than the surrounding areas of the Sun.

4) A star has a parallax of .05 arc seconds. It's distance is:

a) 200 parsecs.

b) 66 parsecs.

c) 20 parsecs.

d) 660 light-years.

e) 200 light-years.

5) What two observations allow us to calculate the mass of the portion of the Galaxy within the Sun's orbit?

a) the Sun's mass and its age

b) the Sun's age and period of the Galactic Year

c) the Sun's orbital velocity and its distance from the Galactic Center

d) the Sun's composition and luminosity

e) the Sun's mass and velocity in orbit of the Galactic Center