Astronomy 15L

Section 1 (Mon. 1:30 - 4:20pm, room S-15)

Lab Final

As you may have noticed on the grading page, your course grade will consist mostly of the grades from your labs. Since I have to give a comprehensive final exam (in order for your credits to transfer to a 4-year school), there will be a final exam at the end of the quarter. (It will be at the regularly scheduled time, from De Anza's final exam schedule.

If I were feeling really cruel, this could be a real whopper of a test - like the finals for Astronomy 4 and Astronomy 10 combined - yikes! Don't worry, it won't be like that, since this is only a 1-credit class. I'll hit the highlights from each lab, without going into all the details that you'd get in a 5-credit lecture class.

As you go through this list, it's a good idea to look at your old Student Guide from each lab. (There were a few labs that didn't have UNL Student Guides, but in most cases there will be one to follow along with.) It will probably also be helpful to be able to look at the relevant simulators, which are linked from the main page for each lab.

The exam will consist of about 30 multiple-choice questions.

From Lab 1: Maps of the Sky

Make sure you know how **latitude** and **longitude** work on the Earth.

Also make sure you understand the coordinates we use for the sky: **Right Ascension** and **Declination**. How are these coordinates similar to (and different from) their terrestrial counterparts?

What *units* are used for each of these four types of coordinates?

If you were given a piece of a star map, make sure you could read off the RA and Dec coordinates of an object on the map.

<u>Sample Questions:</u> (answers are at the bottom of this webpage.)
(Note that these sample questions for Lab 1 also include some concepts from Lab 2.)

1) The star Capella, in the constellation Auriga, has a right ascension of 5h 17m, and a declination of +43 degrees. The star Rigel, in the constellation Orion, has a right ascension of 5h 15m, and a declination of -8 degrees, 12 minutes. Which of the following statements is most accurate?

1. Capella is closer to the celestial equator.
2. Rigel is farther north (on the `sphere' of the sky) than Capella.
3. Rigel is closer to the celestial equator.
4. Both of these stars are near the north celestial pole.

2) Let's say you're looking up the coordinates of two stars in a table of astronomical data. They both have the same declination (let's say it's +20 degrees), but they have different right ascensions. Star A has an RA of 12h, and Star B has an RA of 13h. Which of the following statements in the most accurate? (Assume you're in the Earth's northern hemisphere.)

1. If you were looking at the two stars in the sky, Star A would appear north of Star B.
2. If you were looking at the two stars in the sky, Star A would appear to the right of Star B, when they're near the meridian.

3. If you were looking at the two stars in the sky, Star A would appear to the left of Star B, when they're near the meridian.
4. If you were looking at the two stars in the sky, Star A would appear below Star B, when they're near the meridian.

3) What is different about the directions on a star map, compared to a map of the ground?

1. A star map looks like it's been rotated 180 degrees while lying flat on the table.
2. East and West are reversed, compared to a map of the ground.
3. The directions on a star map aren't actually any different from a map of the ground.
4. The N–S and E–W directions on a star map aren't at right angles to each other, the way they are on all maps of the ground.

From Lab 2: Image Hunt, Seasons of the Sky, and Diurnal Motion

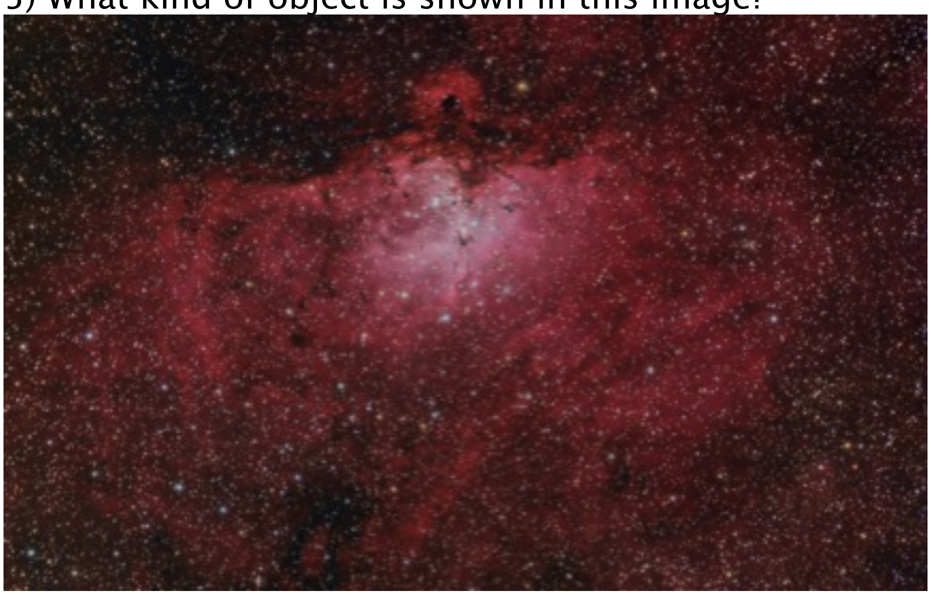
If you are shown an image of one of these types of object, make sure you can recognize which type you're looking at:

Planetary nebula
Bright nebula
Dark nebula
Open star cluster
Globular star cluster
Galaxy
Galaxy cluster

4) What kind of object is shown in this image?

1. A planetary nebula
2. A globular star cluster
3. A galaxy
4. An individual star

5) What kind of object is shown in this image?



1. A galaxy
2. An open star cluster

3. A bright nebula
4. A globular star cluster

6) Which of the following lists the objects in the correct order of INCREASING size?

1. Planetary nebula, globular cluster, galaxy, galaxy cluster
2. Galaxy, planetary nebula, globular cluster, dark nebula
3. Bright nebula, galaxy cluster, planetary nebula, globular cluster
4. Galaxy cluster, galaxy, globular cluster, planetary nebula

What causes different constellations to be seen at night during different times of year?

Why are some constellations (like Cygnus, Aquila, Sagittarius, and Scorpius) seen during the northern-hemisphere summer?

Why are some constellations (like Orion, Gemini, and Auriga) seen during the northern-hemisphere winter?

What are the **celestial poles** and the **celestial equator**, and how do they relate to the system of RA and Dec?

How does the system of **horizon coordinates** work? What are Azimuth and Altitude?

(If you feel like downloading Stellarium and playing with it on your own computer, that would be a good tool for understanding these concepts. It's at stellarium.org. You might also want to carefully examine the view from an all-sky camera. Can you find the celestial pole in that video?)

Sample Questions: (answers are at the bottom of this webpage.)

7) If you're in the middle-latitudes of the northern hemisphere, why can't you see Gemini during the summer?

1. The stars in Gemini are all variable stars, and they are too dim to be seen at this time of year.

2. The Earth is at a point in its orbit that makes the Sun appear in front of Gemini at that time.
3. The declinations of the stars in Gemini change during the year, and they're too far south to be seen at this time.
4. It isn't visible from this latitude; you'd have to go to the southern hemisphere.

8) Imagine you're looking at a diagram of the sky, and it shows what the sky looks like around 10pm at the current time of year. There is a constellation shown on the diagram, and the constellation is just above the eastern horizon. If you look at the sky around 10pm, three months later, where will the constellation appear to be?

1. Very low on the western horizon – it will be setting.
2. It will appear to be at the north celestial pole.
3. Very low in the sky, just above the southern horizon.
4. High in the sky, not too far south of the zenith..

9) If you are observing an object that has an altitude of 90 degrees, where is it in the sky?

1. It is just above the northern horizon.
2. It is just setting in the west.
3. It is directly overhead.
4. It is out of sight, directly beneath you (i.e. on the other side of the Earth).

From Lab 3: Moon Phases

Know the order of the Moon phases, and how the **terminator** appears to move across the nearside of the Moon as the phases progress. The Lunar Phase – Background 1 page shows the phases, but it will take a little thought to figure out which image represents which phase. What do the terms **waxing**, **waning**, **gibbous**, and **crescent** mean?

You should make sure you understand how the Moon's cycle of phases works, and what each phase looks like as seen from the Earth. A good starting point is to memorize a diagram like the one on the Lunar Phase – Background 2 page.

Also make sure you're clear on what causes day and night, and where the observer would be located (both on the Earth and relative to the Sun's rays) at sunrise, sunset, midnight, and noon. This is well-illustrated on the Lunar Phase – Background 3 page.

Page 2 of the Student Guide for this lab is a good way to practice your basic understanding of the Moon phases. Another good practice page is page 4, in which you work with the Moon Bisector Demo. (I love the Moon Bisector Demo! I can just play with that for hours, and it really helps me visualize the Moon's phases.)

It wouldn't be a bad idea to redo page 7 for practice. I might ask multiple-choice questions similar to the exercises on this page. Don't worry about memorizing the `Age' and `Percent Illumination' stuff, but if you're given something like the left-hand column, it would be good to be able to identify the phase, and identify a correct-looking `sketch'.

For each of these phases, know where the Moon would be in the sky at sunrise, sunset, noon, and midnight:

1. New Moon
2. First Quarter
3. Full Moon
4. Third Quarter

Sample Questions: (answers are at the bottom of this webpage.)

10) Imagine you're looking at the Moon when it's near the meridian, and you're in the Earth's northern hemisphere. The right side of the Moon's nearside is illuminated. What phase is this?

1. Third Quarter
2. New Moon
3. First Quarter
4. Full Moon

11) If you wanted to observe deep-sky objects (such as faint nebulae and galaxies), which phase of the Moon would provide the **least** light to interfere with your observations?

1. Full Moon
2. New Moon
3. Third Quarter
4. First Quarter

12) Imagine it's sunset and the Moon is in its Full Phase. Where will the Moon appear in the sky?

1. On the eastern horizon
2. High in the sky, to the south
3. Low in the western sky
4. It won't rise for several more hours.

From Lab 4: Kepler's Laws of Planetary Motion

Make sure you know and understand the basic idea behind each of Kepler's three laws.

What does **eccentricity** mean? There are several different ways to define it mathematically, but you should understand the version that's used in this lab, involving the dimensions `c' and `a' (see p. 1 of the Student Guide for this lab).

What are **perihelion** and **aphelion**?

Working through the `Kepler's 2nd Law' exercises again wouldn't be a bad idea. Make sure you understand how the idea of `equal areas in equal times' relates to the speed at which a planet is moving in its orbit.

In Kepler's 3rd law, how does the semi major axis of a planet's orbit relate to the planet's period of revolution?

<u>Sample Questions:</u> (answers are at the bottom of this webpage.)

13) Most comets have orbits that are very long, skinny ellipses. Which of the following statements about a comet's orbit is most accurate?

1. The Sun is not at either focus, since the orbit is so far from being a perfect circle.
2. The comet will probably take a very short time to complete such an orbit, compared to any of the planets.
3. When the comet is far from the Sun, at the far point of its orbit, it will be moving very fast.
4. The comet will be moving fastest at perihelion.

14) Here are the semi-major axes of the orbits of Mercury, Earth, Jupiter, and Neptune, in astronomical units: 0.387, 1.000, 5.203, and 30.07. Which planet will take the longest to orbit the Sun?

1. Neptune
2. Earth
3. Jupiter
4. Mercury

From Lab 5: Image Processing

From this lab, you want to remember the basics of how **color** images are made from **black & white** images.

For example, what are the three primary colors that our eyes use in order to form color images? (Note: These may be different from the `primary colors' in some art classes.)

What was the importance of stretching a deep-sky image? Why was it necessary for us to use the FITS Liberator program on the deep-sky images before doing the `RGB combination'?

What is the importance of filters in making color images? Why is it important for an astronomical camera to have a filter wheel?

Here's another good introduction to astronomical imaging, from the folks who distribute the FITS Liberator software.

<u>Sample Questions:</u> (answers are at the bottom of this webpage.)

15) Let's say you use a CCD camera to take an image of a distant galaxy. When you first open the image in an image-processing program, it looks completely black, with only a few bright stars visible. Why SHOULDN'T you panic?

1. Actually, since it looks so dark, you must not have taken a long-enough exposure, so your time at the telescope was, in fact, wasted.
2. The galaxy image is probably still there, it's just that the galaxy is only a teeny-tiny bit brighter than the dark background - you need to stretch the image mathematically.
3. This is probably a region of space dominated by a mysterious substance called dark matter, so it's no wonder that there is almost no visible-wavelength light to be seen.
4. The big problem here is that you shot your image through a color filter. Those absorb so much light that they should always be avoided.

16) Imagine that you're responsible for programming a sequence of images to be taken by a robotic Mars rover. You instruct the rover's camera to take images through a number of different filters. However, you forget to command the camera to take an image through the R (red) filter. If you try to make an image with only the two remaining visible-wavelength color filters, what sort of `color bias' will the resulting image show?

1. It will look unnaturally red.
2. It will, in fact, look perfectly natural, since only two color filters are necessary.
3. It will look unnaturally bluish-green.
4. It will look unnaturally yellow.

From Lab 6: Blackbody Spectra and Filters

Starting with Lab 6, we really started to get into topics from Astronomy 10. Things started to get a bit more technical at this point.

What's the **electromagnetic spectrum**? What do we mean by **wavelength**?

For starters, make sure you're clear on the three types of spectra: **Continuous**, **Emission**, and **Absorption.** What would each one look like? What would be a typical astronomical source for each type?

Two of these 3 types have `lines' in them. What causes the lines?

What do we mean by **blackbody radiation**? What sort of astronomical object would be called a `blackbody'?

What does the **blackbody spectrum** (a.k.a. `blackbody curve') look like? How does this spectrum change as the temperature of the emitting object increases?

How could we use filters to compare one blackbody emitter to another?

<u>Sample Questions:</u> (answers are at the bottom of this webpage.)

17) Let's say you're using a spectroscope to look at a star through a cool cloud of low-density interstellar gas. What sort of spectrum will you see?

1. An absorption spectrum with dark lines in it
2. A continuous spectrum that varies smoothly from short to long wavelengths
3. An emission spectrum, consisting of a few bright lines
4. An emission spectrum, which has dark lines on a bright background

18) If we compare a hot star to a cool star, what will be different about their spectra?

1. The spectrum of the cool star will have a peak that's higher and at a shorter wavelength than that of the hot star.
2. The two stars will have blackbody spectra that are essentially identical, since they're both producing continuous spectra.

3. The spectrum of the hot star will have a peak that's lower and at a shorter wavelength than that of the cool star.
4. The spectrum of the hot star will have a peak that's higher and at a shorter wavelength than that of the cool star.

19) Imagine we're measuring the brightness of two stars, one of which is relatively hot, and the other one relatively cool. For each star, we use two filters: A red one and a blue one. Which of the following statements is most accurate?

1. The hot star will look brighter through the red filter than it does through the blue filter.
2. The two stars will look equally bright through all filters.
3. The hot star will look brighter through the blue filter than it does through the red filter.
4. The hot star should really be measured through an infrared filter, since it only emits heat radiation.

From Lab 7: The Hertzsprung-Russell Diagram

You should understand the basic layout of the H-R diagram. What does each axis represent?

It's worth taking a little time to make sure you're clear on how the horizontal axis of the H-R diagram works. Notice that temperature increases toward the LEFT. The horizontal axis also represents the *colors* of the stars. Which end of the axis has the *blue* stars, and which end has the *red* stars?

If you had to draw (or identify) the *main sequence* on an H-R diagram, make sure you could do that. Also remember that stars don't move *along* the main sequence, rather they <u>spend a portion of their lifetime on it</u>.

You should also be able to identify roughly where the Sun is located on the main sequence.

How does the size of a star vary, depending on where it's located on the H-R diagram? The most basic thing to remember from this lab is: What happens to both the *size* and the *color* of a star, as you move the cursor around on the H-R diagram simulator? Playing around with this simulator for a while may be the simplest way to reinforce these concepts.

Sample Questions: (answers are at the bottom of this webpage.)

20) As you go from left to right across the Hertzsprung-Russell diagram, what happens to the temperature of the stars?

1. They get hotter.
2. They get cooler.
3. Star temperatures are actually plotted on the vertical axis of the H-R diagram.
4. There's no change, since all stars have the same temperature.

21) If you wanted to find a large blue star on the H-R diagram, where would you look?

1. In the center of the diagram
2. In the upper-left corner of the diagram
3. Along the right-hand edge of the diagram
4. In the lower-right corner of the diagram

22) Stars that are near the Sun on the H-R diagram have what color?

1. White
2. Blue
3. Red
4. Green

From Lab 8: Extrasolar Planets

For this lab, the questions from the final exam will mostly focus on things we learned about the *radial-velocity* method.

It will be worth reviewing Questions 1 and 2 - these were tricky! Compare questions 1 and 2 to the animation in the upper-left corner of the Center-of-Mass page. If we are looking at a star with one planet orbiting it, how does the star's velocity (as seen from Earth) relate to the positions of the planet and star in their orbits? When would the star be appear to be approaching Earth, and when would it appear to be receding from Earth?

You should remember how the **Doppler shift** works. What would cause a **blueshift** or a **redshift** of a star's light? How could an astronomer use a star's spectral lines (such as the absorption lines) to detect the star's radial motion?

Make sure you understand what was meant by the **amplitude** of the radial-velocity curve, in the exercises in the Student Guide. From the standpoint of an observer on Earth, why do we want the star's radial-velocity curve to show a large amplitude?

Here are two basic, important points to know: How does the *planet's mass* affect the amplitude, how does the *star's mass* affect the amplitude, and how does the *size of the planet's orbit* affect the amplitude? (This is covered in the questions on page 3 of the Student Guide.)

What's the meaning of the *inclination* of an exoplanet's orbit? As seen from the Earth, what sort of inclination do we want the exoplanet system to have, in order for us to be able to detect the planet?

For the table between Questions 16 and 17 of the Student Guide, you evaluated the likelihood of detecting exoplanets, based on their masses and the sizes of their orbits. Try to think of two reasons why it's hard to detect an exoplanet that orbits far from its star. What sorts of planets are most easily detectable by our present searches?

Sample Questions: (answers are at the bottom of this webpage.)

23) Imagine you are an alien observing our solar system from a few dozen light-years away. If the Earth is moving away from you (as it orbits the Sun), what would you notice about the light from the Sun?

1. The Sun’s light wold be completely blocked by the Earth.
2. The frequencies of the star’s spectral lines wouldn’t show any Doppler shift.
3. The Sun’s spectral lines would be shifted towards the blue end of the spectrum.
4. The Sun’s spectral lines would be shifted towards the red end of the spectrum.

24) Most of the exoplanets that have been detected so far are called `hot Jupiters’. What makes these planets (relatively) easy to detect?

1. Since these planets have very low masses, they don’t interfere with their stars’ orbits around the center of the Galaxy.
2. Being so hot, these planets emit a lot of infrared energy, which we can see with our telescopes on Earth.
3. These planets are actually very hard to detect, since they orbit close to their stars.
4. By being close to their stars, and by having large masses, they cause their stars to have (relatively) large relative-velocity `wobbles’.

25) There’s a method of planet-hunting called the *astrometric* method, in which one looks at changes in a star’s position against the background of the sky. For this method, it helps to look at star systems in which the planets’ orbits are seen `face-on’. Why would these systems be *bad* for detecting planets by the radial-velocity method?

1. The motions of these stars would be at right angles to the line of sight from the Earth to the star.
2. These star systems are too far away from the Earth for us to detect any Doppler shifts of the stars’ light.
3. The Doppler shifts of these stars would be too large to measure.
4. The light from the planet would drown out the light from the star, since the system isn’t seen edge-on.

From Lab 9: Distance Measurements and the Expansion of the Universe

You should have a basic understanding of how the parallax method (for determining distances to nearby stars) works. It's a good idea to make sure you understand the `NAAP Parallax Diagram' on the background page about parallax.

If we measure a parallax angle (labeled with the greek letter *pi* on the diagram) of 1 arcsecond, how far is the star (in parsec)? How about for a parallax angle of 1/2 an arcsec, or 1/4 of an arcsec? Make sure you understand the relationship between the parallax angle and the distance in parsec.

How many light-years are in a parsec?

Next, we dealt with an idea called the *distance modulus*. There's an equation for it (on the background page), but you don't have to memorize the equation. You should understand the basic idea, though.

First, make sure you know the difference between *apparent magnitude* and *absolute magnitude*. (This was probably covered in you Astronomy 4 or 10 class, too.) Which one describes how bright a star (or other object) *really is*, and which one describes how bright the star (or other object) *looks*? Next, what's the distance at which the star's apparent and absolute magnitudes will be the same?

If a star were farther away than this standard distance, would its apparent magnitude be a *larger* number or a *smaller* number than its absolute magnitude?

Supernovae: Here are the three basic things to know about supernovae as `standard candles:

- What do we mean by the concept of a `standard candle'?
- What's so special about Type 1a supernovae that makes them good standard candles? (Hint: This is described near the end of the background page on supernovae.)
- When a Type 1a supernova is at peak brightness, what's its absolute magnitude? (Hint: You can find this by looking at the supernova light curve fitting explorer.)

The Hubble Law: There are a few basic things to know about the Hubble Law. Here they are:

- How is a graph of the Hubble Law set up? What is indicated by each axis of the graph?
- How do astronomers measure galaxy redshifts? (Hint: Reviewing how you measured them on the UW lab would be a good idea.)
- When data are plotted on a Hubble-Law graph, what does the graph look like?
- What basic fact about the universe is indicated by a graph of the Hubble Law?

(In addition to the background page about the Hubble law, you may find it useful to look at the first half of this page from Ned Wright's cosmology tutorial from UCLA.)

Sample Questions: (answers are at the bottom of this webpage.)

26) Imagine you measure the parallax of a star, and it's 1/3 of an arcsecond. How far away is the star?

1. 3 parsec
2. 13 parsec
3. 6 parsec
4. 1/3 of a parsec

27) Let's say that you use the parallax method to measure the distance of a star, and it's 10 parsec away from our solar system. Its apparent magnitude is 4.5. If an identical star were located 20 parsec away, which of these would be a good guess for its apparent magnitude?

1. 4.0
2. 3.5
3. -2.0
4. 6.0

28) Imagine you discover a supernova in a distant galaxy. After observing it for a few nights, you see it reach its peak brightness, when it has an apparent magnitude of 15. What's it's real magnitude? (i.e. its

absolute magnitude?)

1. −15
2. −19.5
3. 0.0
4. 12.5

29) When Edwin Hubble made a graph of galaxy redshifts versus galaxy distances, what did it indicate about the universe?

1. Since redshift increases with distance, the universe is static, neither expanding nor contracting.
2. Since redshift decreases with distance, the universe is expanding.
3. Since redshift increases with distance, the universe is expanding.
4. Since there is no clear relationship between redshift and distance, the universe must be contracting.

Answers to Sample Questions:

1 c
2 b
3 b
4 b
5 c
6 a
7 b
8 d
9 c
10 c
11 b
12 a
13 d
14 a
15 b
16 c
17 a

18 d
19 c
20 b
21 b
22 a
23 c
24 d
25 a
26 a
27 d
28 b
29 c