ASTRONOMY 100
SPRING 2023

Dr. Edward Rhodes
MWF 2:00 p.m. – 3:20 p.m.

REGISTRATION AND QUESTIONNAIRE

PLEASE, COMPLETE AND TURN IN THE FOLLOWING:

NAME (PRINT) _____
LAST FIRST MIDDLE

SIGNATURE _____

EMAIL _____

STUDENT ID _____

SCHOOL ADDRESS _____

LOCAL PHONE NO. _____

What are your goals for this course?

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ASTRONOMY 100Lxg: The Universe

Spring Semester 2019:	**January 9, 2023 – April 28, 2023**
Course Meetings:	**MWF 2:00 p.m. – 3:20 p.m. (SLH 102 for exams only)**
Instructor:	**Dr. Edward J. Rhodes, Jr.**
Office:	**SHS 374**
Office Hours:	**M 3:25 – 4:15 p.m., WF 3:25 – 4:55 p.m. or by appointment**
Telephone:	**(818) 923-9243 (cell)**
E-Mail:	**erhodes@usc.edu**
Laboratory Room:	SGM 313
Laboratory Director:	Joseph (Joe) Vandiver
Office:	SGM 309
E-Mail:	vandiver@usc.edu
Student Services Assistant:	Giovanni Diaz
Email:	giovannd@usc.edu
Dept. Main Office:	ACB 439
Dept. Telephone:	(213) 740-1140

Textbooks, Course Readers, and Lab Manuals

Required Materials

- Theo Koupelis, ***In Quest of the Universe***, 7th Edition (packaged with student CD-ROM)
- Lecture slide set for Astronomy 100 (available on Blackboard, to be printed individually and brought to class or accessed via laptop during class)
- Laboratory manual (distributed during first lab session)

Optional Supplementary Textbook

- Roger Freedman, Robert Geller, & William J. Kaufmann, ***Universe***, 10th Edition

Exams, Lab Assignments, and Grading

Exams

There will be three 80-minute midterm examinations and one two-hour final exam. The score of the lowest of the three mid-terms will be dropped and only the scores of the two highest exams will be counted in the Overall Point Total. Students who do not take all three of the mid-term exams will have only the scores recorded for the one or two exams that they do take. In addition to the examinations, you must complete the laboratory portion of the course. The lab assignments will be described later. Your Raw Lab Scores will be scaled so that they will count up to 48 points, or 20 %, of the Overall Point Total. Your Raw Final Exam Scores will be scaled so that they will count up to 72 points, or 30 % of the Overall Point Total of 240 points. The Overall Point Total will be computed as follows:

Component	Maximum Points	Percentages
Two highest mid-term exam scores	2 * 60 = 120	2 * 25% = 50%
Scaled Laboratory Scores	48	20%

Scaled Final Exam Scores	72	30%
Overall Point Total	240	100%

The Overall Point Total will be curved to determine the final grades in the course. Historically, there have been about 22-24% As and A-s, 30% B+s, Bs, and B-s, 40% C+s, Cs and C-s, and 6-8% D+s, Ds and D-s. During the semester, I will prepare and announce approximate grading curves based upon each of the three mid-term exams. In computing these curves, I will rank the raw scores from highest to lowest and apply my historical percentages to the ranked scores to determine the cutoff points between the different grade brackets. No scaling will be applied to your raw mid-term exam scores. Also, I will not record the letter grades on these individual curves, rather I will record only your raw scores instead. After we have had all three of the mid-term exams, I will also prepare and announce another grading curve that will be based upon the sum of everyone's two highest mid-term exams in a similar manner. Once I have received the Scaled Lab Scores, I will prepare and announce a Pre-Final Grade Curve that will be based upon the sum of the two highest mid-terms plus the Scaled Lab Scores. I will announce each of these five different grading curves via Blackboard.

After the Final Exam has been administered and scored, I will prepare the Final Grade Curve. The Final Grade Cure will be based upon then sum of the Pre-Final Point Totals plus the Scaled Final Exam Scores. Since there will be 126 questions on the Final Exam, the Scaled Final Exam Scores will be computed by multiplying the Raw Final Exam Scores by the quotient of 72/126 so that a perfect score on the Final Exam will count 72 points as a Scaled Final Score. The course grades will be assigned using the Final Grade Curve.

If you are taking this class on a Pass/No Pass basis, you must receive at least the equivalent of a C- to on the Final Grade Curve to receive a pass. Attendance will be taken during each Zoom lecture and recorded. This attendance information will be used in deciding upon the divisions of the Final Grade Curve that will be computed using your Overall Point Totals.

Because of my recent health concerns, this course will be taught in a hybrid mode of instruction. I will teach all of the lectures in SLH 102 via Zoom to an empty classroom, but you will all be expected to come in to SLH 102 to take all of your mid-term exams and the final exam. You will also be expected to participate in all of your lab session in person in SGM 313. I will make recordings available after each of the lectures so that you will be able to view them whenever you are unable to participate in the Zoom meetings while the lectures are in progress.

Please note that the third mid-term exam will serve as a make-up exam for either of the first two exams. **There will not be any other make-up exams**. Any student missing two of the three mid-terms will only have recorded the points scored on the one exam taken unless he or she also completes the required minimum number of laboratory assignments.

The questions on the exams will cover the lectures, and the assigned readings. The questions on the exams will mainly be objective (multiple choice or matching); however, there may be a few short answer questions as well. The final exam will cover material from the whole course, although it will emphasize the material in the latter portion of the course. Each exam will be an individual effort, closed book, closed notes exam.

Examples of past examinations will be available on the course website on Blackboard.

Course Structure

During most weeks there will be three lectures. All three meetings will be held in the lecture hall. During some weeks, I will schedule an afternoon review session before each of the exams. I will also post study guides before each of the review sessions which we will go over during those sessions.

Course Outline

The detailed course outline and reading assignment list are attached. Please note that the dates of the midterm exams listed on the course outline are subject to change during the course. Any changes in the mid-term schedule will be announced during the week preceding the scheduled time. All such announcements will be made during lecture only.

Course Readers

Course Readers are available on the class website on Blackboard. You may print out each set of slides prior to the lecture and bring the printouts with you or you may bring a laptop to class and view the slides on the laptop.

Lecture Attendance Policy

Attendance will be taken during all lectures using the participation reports that Zoom will generate after each of the lectures. As mentioned earlier, the overall lecture attendance will be taken into consideration when I am determining the different cutoff points of the grade brackets on the Final Grade Curve at the end of this semester.

Laboratory Sections

The laboratory meetings will be held during alternating weeks beginning on the Mondays or Tuesdays listed on the lab schedule that is given later. Attendance during the first week is mandatory. Failure to attend the lab session for which you are registered may result in the cancellation of your lab registration. Each laboratory meeting will last approximately 110 minutes.

In addition to the assignments to be done in the laboratory, there will also be one mandatory on-campus evening observing session will be scheduled to view the sky. More details of these sessions will be announced later. Sign-ups for each of the campus observing sessions will be handled by the TA's during the lab meetings. Additional evening observing sessions will be scheduled in case any of the planned sessions have to be canceled due to inclement weather. If bad weather interferes with all of the scheduled observing sessions, a required alternative assignment will be announced late in the term.

In order to get the maximum possible lab score, you will need to do all seven assignments and attend the evening observing session. Each of the seven assignments will count for a maximum of 20 points for a total of 140 possible points. The observing session will count for an additional 40 points, so that the maximum possible score you can have for the lab portion of the course will be 180 points. To convert this Raw Lab Score into a Scaled Lab Score, your Raw Lab Score will be multiplied by the ratio of 48/180 so that a perfect Raw Lab Score of 180 points will become a Scaled Lab Score of 48 points. If you skip any of the assignments, you will receive a zero score for those assignments. While 20 percent of the final course grade may not sound like it will affect your course grade by much, please keep in mind that failure to complete the laboratory component of the course, can result in a dramatic lowering of your final grade. Even failure to complete all seven of the assignments and to participate in the On-Campus Observing Session can lower your final course grade substantially.

Labs will take place in SGM 313. All lab policies are outlined in the Laboratory Manual, including your attendance at one evening On-Campus Observing Session.

Course Goals

My goals for each of you this semester include the following:

1) That you will learn to understand how science is done, what questions science can answer, and what questions science cannot answer
2) That you will gain an appreciation for the historical development of astronomy, including the importance of past discoveries in the development of new knowledge
3) That you will gain a better appreciation for the wonders of the universe
4) That you will cultivate an interest in learning more about astronomy throughout your lives, such that you will want to read articles about astronomy in the future after this class has ended
5) That you will have an opportunity to observe the heavens using USC's refurbished Campus Observatory

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:

Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

The Office of Student Accessibility Services
Provides certification for students with disabilities and helps arrange relevant accommodations. osas.usc.edu

Faculty Liaison
All courses in the Department of Physics & Astronomy have an assigned Faculty Liaison to serve students as a confidential, neutral, informal, and independent resource when they wish to discuss issues concerning their course without directly confronting their instructor. The Faculty Liaison for this course is Prof. Jack Feinberg, feinberg@usc.edu, 213-740-1134, SSC 327.

USC Support and Advocacy (USCSA) – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.
Provides overall safety to USC community. dps.usc.edu

Spring 2023 Lab Schedule

Week of Semester	Dr. Rhodes Sections
Jan. 9th	Basic Aspects of Astronomy
Jan. 16th	No Labs
Jan. 23rd	Starry Night
Jan. 30st	No Labs
Feb. 6th	Optics
Feb. 13th	No Labs
Feb. 20st	Telescopes
Feb. 27th	No Labs
Mar. 6h	Kepler's Laws
Mar. 13th	Spring Break
Mar. 20st	No Labs
Mar. 27th	The Sun
Apr. 3rd	No Labs
Apr. 10th	Digital Astrophotography
Apr. 17th	No Labs
Apr. 24th	No Labs

ASTRONOMY 100
REQUIRED READING ASSIGNMENTS
COURSE OUTLINE AND EXAM SCHEDULE
(All required reading assignments are in parenthesis after the topics)

Wk.	Lec.	Date	Topics
WEEK 1	1	January 9	Introduction; Early Astronomy (pp.1-5; middle of page 28 to bottom of page 31)
	2	January 11	Celestial sphere; geographic coordinates; celestial coordinates; Earth's motions and orientation in space (pp.6 – middle of p.12)
	3	January 13	The equinoxes and solstices; the seasons; the zodiac; Early Greek Astronomy (The Geocentric view); Aristotle; Proofs for Rotation and Revolution of the Earth (middle of p.12 – middle of p.17; pp.38 – bottom of p.43; middle of p 46 – middle of p.48)
WEEK 2		January 16	**NO CLASS – Martin Luther King Jr. Birthday Holiday**
	4	January 18	Motions of the Planets; the Ptolemaic Model; Criteria for choosing among models; Pre-Renaissance Astronomy; Copernicus and the Heliocentric Model (bottom of p. 43 – middle of p. 46; section 1-7; sections 2-5 and 2-6)
	5	January 20	Comparison of Ptolemaic and Copernican Models; Tycho Brahe; Johannes Kepler; Kepler's Laws of Planetary Motion; (Sections 2-7, 2-8, and 2-9 through top of p.63)
WEEK 3	6	January 23	Galileo Galilei; Newton and his laws of physics; circular motion; Newton's Law of Universal Gravitation; (p. 69 – through section 3-5)
	7	January 25	Angular momentum; Center of Mass; tides; Non-Spherical Shape of the Earth (Sections 3-6 and 3-7; middle of p.153 – through middle of p.156)
	8	January 27	Precession; Effects of Precession on the Seasons; Perturbation Theory; Discovery of Neptune; Spacecraft Orbits (middle of p.156 – p.157; Historical Notes on page 269 and on page 273)
WEEK 4	9	January 30	Electromagnetic Radiation or Light; Wave Nature of Light; The Speed of Light; Refraction; Dispersion; Interference Thermodynamics; Heat; Temperature; Heat Transfer; Black body Radiators; (p.95-end of p.103)
	10	February 1	Radiation Laws; The Quantum Idea; The Photoelectric Effect; The Beginnings of Astrophysics; Kirchhoff's Rules of Spectral Analysis; Early 20th Century Models of the Atom; (top of p.104 – bottom of p.105)
	11	February 3	The Bohr Model of the Atom; Energy Levels in Atoms; Excitation, de-excitation, ionization, and recombination of electrons; Absorption and emission of light by atoms; the Particle Nature of Light; Quantum Modifications of the Bohr Model of the Atom; The Heisenberg Uncertainty Principle; (section 4-6)
WEEK 5	12	February 6	The Doppler Effect; Radial Velocity; The Inverse-Square Law of Light; Size of the Moon; Distance of the Moon; Lunar Phases; Blue Moons; (middle of p.113-middle of p. 118; pp. 149– middle of p.153; middle of p.17 – to middle of p.20)
	E1	**February 8**	**Midterm Exam 1 (Wed.)**
	13	February 10	Lunar and Solar Eclipses; The Structure of the Earth; the Geomagnetic Field; (middle of p. 20 –middle of p. 26; p.158 – bottom of p.161) The Earth's Magnetosphere; Plate Tectonics;
WEEK 6	14	February 13	The Ice Ages; Earth's Atmosphere; Ozone Layer Depletion; Global Warming Controversy; (bottom of p.161 – to end of section 6-3) The Surface, Interior, and History of the Moon;
	15	February 15	the Origin of the Moon; Measuring Distances and Masses in the Solar system; classifying the Planets: The Terrestrial and Giant Planets; (sections 6-4, 6-5, and 6-6; p.177 – middle of p.187)
	16	February 17	Planetary Atmospheres and Escape Velocities; Formation of the Solar System; Discovery of Planets orbiting other stars; Interplanetary Spacecraft; Julia Childs and the Building Blocks of Life; (p. 187 – p. 203; sections 19-4 through 19-6)
WEEK 7		February 20	NO CLASS Presidents' Day Holiday

	17	February 22	Mercury and its Motions; Venus (pp.207 – bottom of p. 221)
	18	February 24	Mars: Its Motions and Topography; Volcanoes on Mars; Search for Life on Mars; Martian Polar Caps; Martian Atmosphere; Possible Past Martian Water, (bottom of p. 221 – middle of p. 238)
WEEK 8	19	February 27	Martian Moons; Properties of Giant Planets; Jupiter: Its Size, Mass, and Density; Jupiter's Rapid Rotation and Oblate Shape; Spacecraft visits to Jupiter; Jupiter's Atmosphere and Clouds; Jupiter's Interior and Magnetic Field; Jupiter's Magnetosphere; (Middle of p.238 – 240; p. 244 – bottom of p.251)
	20	March 1	Jupiter's Moons; Jupiter's Ring System; Saturn and Its Ring System; Saturn's Motions; Saturn's Rotation and oblateness; Saturn's Atmosphere; Saturn's Moons; (bottom of p.251 – bottom of p.263)
	21	March 3	Roche Limit; Formation of Saturn's Rings; Uranus and its Ring System; Unique Orientation of Uranus; Its Moons; Its Magnetic Field; Neptune; Neptune's Ring System; Neptune's Moons; (bottom of p.263 – bottom of p.273) Accidental Discovery of Pluto; Discovery of Pluto's Moon, Charon; Pluto's Mass; Pluto's Atmosphere; What is Pluto? The Asteroids; Discovery of Ceres; Asteroid Orbits and
WEEK 9	22	March 6	Kirkwood's Gaps; The Trojan Asteroids; Origin of the Asteroids; (p. 277 – end of section 10-3)
	23	March 8	Halley's Comet; Comets: their Parts and their Orbits; The Oort Cloud and the Kuiper Belt; Meteoroids; Meteors; Meteor Showers and Comets; Meteorites; Asteroid Impacts on Earth; did an Asteroid Impact Kill the Dinosaurs? (section 10-4 to end of chapter 10 on p. 303)
	24	March 10	Basic Solar Data; the "Solar Constant" and Why It Is Not Constant; The Solar Photosphere and Its Motions; The Solar Atmosphere; Sunspots and the Solar Activity Cycle; George Ellery Hale and the Discovery of Solar Magnetic Fields; The Zeeman Effect; The Maunder Minimum; (p.308 - end of section 11-1; section 11-5 through bottom of p.329)
WEEK 10		March 13-19	**NO CLASS – SPRING RECESS**
WEEK 11	25	March 20	A Model for the Solar Cycle; Solar Flares; Solar Filaments and Prominences; The Energy Source of the Sun; The Equivalence of Mass and Energy; Sub-atomic particles; quarks, hadrons, and leptons; Anti-Particles; (bottom of p. 329 – p. 335; and section 11-2 through top of p.312)
	E2	**March 22**	**Midterm Exam II (Wed.)**
	26	March 24	Thermonuclear fusion Reactions; The Proton-Proton Chain; The Solar Interior; The Solar Neutrino Problem; Solar Oscillations and Helioseismology; (top of p.312 through end of section 11-4)
WEEK 12	27	March 27	Observed Properties of Stars: Apparent magnitudes; absolute magnitudes; parallaxes and distances; Stellar luminosities; Stellar Motions; Spectral Classifications; Reasons for Different Appearance of Stellar Spectra; Revision of Spectral Sequence (p.339 – to the top of p.348)
	28	March 29	The Hertzsprung-Russell Diagram; The Main Sequence Stars; The Red Giant Stars; The Supergiant Stars; White Dwarfs; Luminosity Classes; Multiple Star Systems: Binaries and Stellar Mass Estimates; (top of p. 348 – bottom of p. 358)
	29	March 31	Cepheid Variable Stars; The Interstellar Medium: Gas and Dust Between the Stars; Emission Nebulae; Dark Nebulae; Reflection Nebulae (p.374; p.394-middle of p.403; p.394 – middle of p.403)
WEEK 13	30	April 3	Star Formation: Giant Molecular Clouds; Evaporating Gaseous Globules; Shockwave triggering; Protostars; Pre-Main Sequence Evolution; Star Clusters: Open and Globular Clusters; Brown Dwarfs; Life on the Main Sequence; (middle of p.374 – p.384; p.388 – middle of p.391)
	31	April 5	The Flyweight Stars; The Lightweight Stars; Post-Main Sequence Evolution of Lightweight Stars: Red Giants and the Helium Flash; There Goes the Earth; Planetary Nebulae; White Dwarfs (middle of p. 391 – bottom of p.404)
	32	April 7	Theory of White Dwarfs; Close Binary Stars, White Dwarfs, and Novae; The Chandrasekhar Mass Limit for White Dwarfs; Type I Supernovae; Middleweight and Heavyweight Stars and Type II Supernovae; Nucleogenesis; SN 1987a; (top of p.405 – top of p.411; p.415 – end of section 15-3)

WEEK 14	33	April 10	Neutron Stars and The Discovery of Pulsars: Indirect Evidence for the Existence of Neutron Stars; Deaths of Middleweight Stars: Formation of Neutron Stars; Einstein's Theory of Special Relativity; Einstein's Theory of General Relativity; (start of section 15-4 to end of section 15-6; sections 3-8 and 3-9; section 15-7)
	34	April 12	Experimental Tests of General Relativity; Binary Pulsars as Tests of General Relativity; Deaths of the Heavyweight Stars and the Formation of Black Holes; Do Black Holes Exist? Is the Universe a Black Hole? Do Black Holes Evaporate? Wormholes; The Laser Interferometric Gravitational Wave Observatory (LIGO) and the Recent Proof that Gravitational Waves Exist; Stellar Populations; Early Views of Our Galaxy; Modern Views of our Galaxy: The Milky Way Galaxy (sections 15-8 and 15-9; p.447 – middle of p.453)
	35	April 14	Components of the Milky Way Galaxy; The Galactic Nucleus; The Evolution of our Galaxy; The Controversy over the Nebulae; The Resolution of the Controversy by Edwin Hubble: Proof that Other Galaxies Do Exist (middle of p.453 – end of section 16-6)
WEEK 15	36	April 17	The Hubble Classification of Galaxy Types: Ellipticals, Spirals, Barred-Spirals, and Irregulars; Do Galaxies Evolve from one Shape to Another? Stellar contents of Different Galaxies; Distance Methods for other Galaxies; Evidence for the Expansion of the Universe: The Hubble Law; Mass Estimates of Galaxies; Clusters of Galaxies: The Local Group (pp. 473 – top of p.488)
	E3	**April 19**	**Midterm Exam III (Wed.)**
	37	April 21	Superclusters of Galaxies: The Local Supercluster; The Missing Mass; Abnormal Galaxies; Peculiar Galaxies, Radio Galaxies; Seyfert Galaxies; Active Galaxies: N Galaxies, Blazars, and Quasars; Gravitational Lenses; Cosmology: The Nature of the Universe (top of p.488 – end of chapter 17 on p.508)
WEEK 16	38	April 24	Key 20th Century Cosmological Ideas; Expanding, Relativistic Models of the Universe; Spacetime can be closed, flat, or open; Einstein's Static Model of the Universe; The Cosmological Constant: Einstein's Greatest Blunder or Not? The Steady-State Theory; What is Expanding? Spontaneous Pair Production; Grand Unification Theories; The Big Bang Model of the Universe (cont.); The Chronology of the Big Bang: The Planck Epoch; the Grand Unification Epoch; (p.512 – end of section 18-4)
	39	April 26	The Inflationary Epoch; The Quark Soup; the Big Freeze Out; The Opaque Era; The Recombination Era; The Evidence that a Big Bang Actually Occurred: the Cosmic Microwave Background Radiation; The Grand Structure of the Universe (sections 18-5 and 18-6)
	40	April 28	Cold Dark Matter Models; Top-Down vs. Bottom-Up Models; Hidden Dimensions of Spacetime; The Hubble Time and the Age of the Universe; What Model Universe De We Live In? What Will the Future of the Universe Be Like: Will We Expand Forever or Will We Fall into the Big Scrunch? (section 18-7 through end of chapter 18)
Final Exam			**Monday, May 8, 2023, 2:00-4:00 p.m.** (in SLH 102)