Principles of Astronomy

AST K101
CRN: 32839
Fall 2015
Three Rivers Community College
Norwich, CT 06360

Instructor: Professor William J. Dopirak, Jr.
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Office Location: C-130
Office Hours: T 1:00-3:00pm; R 2:00-3:00pm
(Or by appointment)

Required Text:

1) Seeds, M.A. and Backman, D.E. 2008. *Perspectives on Astronomy*. Thomson~Brookes/Cole. 385p. ISBN-13: 978-0-495-11352-2

2) Miller Planisphere, star charts, field guides, binoculars and/or telescopes

Catalog Description: *Corequisite: **ENG* K096** or higher. Please note: if completing **ENG* K096** prior to enrolling in **AST* K101** , a grade of "C#" or better is required for registration into this course.*

This course covers the ideas that account for the earth and heavenly bodies and their characteristics. This course is designed to develop an appreciation of the beauty and order of the universe. Observational exercises, including star identifications and use of the telescope, are included.

Primary Objectives: In addition to understanding the mechanisms involved in ascertaining distance, temperature, and movements of celestial bodies, students will be able to orientate themselves with the night sky by using constellations as guides.

Attendance Policy:

Students are expected to attend class sessions regularly. If a class is missed due to circumstances beyond your control, **please**, be sure to notify your instructor and make the necessary arrangements for obtaining the lecture notes. **You will be responsible** for the material. **If 3 classes are missed, a deduction of 5-POINTS will be taking from your final grade. TEN-POINTS will be deducted from your final grade if 5 or more classes are missed.** A 5-point bonus will be added to your final grade if 100% attendance is noted.

Grade Evaluation:

There will be two exams, a mid-term and the final exam. There will be (AT LEAST) eleven weekly quizzes. The lowest quiz grade will be dropped. Exam and quiz questions will consist of multiple choice, short answers, and/or essays. Every student is responsible for at least one "Constellation Report" AND a "Research Project".

Your constellation report will consist of describing the stars that make up that constellation. You must sign up for your constellation (Table 1), and report on it in front of the class.

Your special report will consist of a research project of your choice. More will be discussed on these throughout the semester.

Fifteen percent of your AST K101 final grade will consist of a Constellation Report.

The constellation report must include celestial coordinates of your constellation and characteristics of each star in that constellation. You must indicate where on the Herztsprung-Russell (H-R) diagram, the types of stars in your constellation. The luminosity, distance, and star names must also be included in this report. Nebulae and galaxies also may be in your constellation that you will incorporate in your report. You may also add any mythology associated with your constellation.

-AND -

Fifteen percent of your AST K101 final grade will consist of a Research Project.

The research project may include a 3-page report on a current astronomic issue. More creative projects may include:

1) Monitoring the moons hourly shadow and angle, during a waxing gibbous phase.
2) Follow the moon daily for one synodic month.
3) Record, semi-weekly, sunsets throughout the semester.
4) Follow and record the movement of the circumpolar stars
5) Monitor the movements of the planets throughout the semester
6) Measure the angle of the noonday sun throughout the semester.
7) Any other creative idea you may have, ***but please check with me first***.

Grading:

Final grade will based on the following:

Exams	60%
Quizzes	10%
Research project	15%
Constellation report	15%
	100%

Final Grade:

100.0-99.0= A	79.4-77.5= C+
98.9-93.5= A	77.4-72.5= C
93.4-90.5= A-	72.4-69.5= C-
90.4-87.5= B+	69.4-63.5= D+
87.4-84.5= B	63.4-59.5= D
84.4-79.5= B-	59.4-00.0= F

College Withdrawal Policy:

A student who finds it necessary to discontinue a course once class has met must provide written notice to the registrar. **See Registrar for dates.** After that period, a student wishing to withdraw must obtain written authorization of the instructor to receive a "W" grade on their academic record, non-punitive grade indicating termination of class participation. Students who do not withdraw, but stop attending **will receive** a grade of "F" for the final grade. **Verbal withdrawals cannot be accepted**.

Disabilities Statement:

If you have a hidden or visible disability, which may require classroom or test-taking modifications, please see me as soon as possible. If you have not already done so, please be sure to register with disability counselors by contacting Student Services Office.

TRCC Disabilities Service Providers Counseling & Advising Office Room A-119	
Matt Liscum (860) 383-5240	• Physical Disabilities • Sensory Disabilities • Medical Disabilities • Mental Health Disabilities
Chris Scarborough (860) 892-5751	• Learning Disabilities • ADD/ADHD • Autism Spectrum

Academic and Classroom Misconduct:

The instructor has the primary responsibility for control over classroom behavior and maintenance of academic integrity, and can order the temporary removal or exclusion from the classroom, and/or laboratory, of any student engaged in conduct violative of the general rules and regulation of the institution. Extended or permanent exclusion from classroom, and/or laboratory, or further disciplinary action can be effected only through appropriate college procedure. Plagiarism, cheating, or any form of academic dishonesty is **prohibited**. Students guilty of academic dishonesty directly or indirectly will receive a **zero** for an exercise or exam and may receive an **F** for the course in addition to other possible disciplinary sanctions that maybe imposed through the regular institutional procedures. Any student that believes he or she has been erroneously accused may appeal the case through the appropriate institutional procedures if their grade was affected.

Digication

All students are required to maintain an online learning portfolio in Digication that uses the college template. Through this electronic tool students will have the opportunity to monitor their own growth in college-wide learning. The student will keep his/her learning portfolio and may continue to use the Digication account after graduation.

A Three Rivers General Education Assessment Team will select and review random works to improve the college experience for all. Student work reviewed for assessment purposes will not include names and all student work will remain private and anonymous for college improvement purposes. Students will have the ability to integrate learning from the classroom, college, and life in general, which will provide additional learning opportunities. If desired, students will have the option to create multiple portfolios.

Principles of Astronomy
Tentative Schedule
Fall 2015
Lecture: Monday - 6:30-9:50pm - (A-221)

Required readings in:
Seeds & Backman 2008

Date	Topic	Chapter #'s
09/21	Introduction, The "New" Solar System/Celestial Orientation	**1**
09/28*	Measurable Time/Lunation/Eclipses	**2**
10/05*	Historic aspect of Astronomy/ Newtonian Physics/Kelper's Laws	**3**
10/12	**Columbus Day Observed: CLASSES NOT IN SESSION**	
10/19*	Kepler's laws applied/ Angulations/Parallax	
10/26*	*Seaport Planetarium Field Trip, Mystic, CT*	
11/02*	Tools of the Trade: Types of and physics of Telescopes	**4**
11/09	**Mid-Term Exam**	
11/16*	Our Sun/Stellar Luminosity	**5**
11/23*	Temperatures & Brightness of Stars/H-R Diagram	**6**
11/30*	Structure of stars	**7**
12/07*	Stellar births & Deaths	**8,9**
12/14*	Galaxies/ Comparative Planetology	**10,13**
12/21	**FINAL EXAM**	

*Quiz Day; quiz will be on previous lecture material

Syllabus Revisions:
This schedule may be subject to change as the instructor sees fit. The instructor will announce any changes in advance.

Principles of Astronomy
AST K101
Detailed Objectives

Upon completion of this course the student should be able to:

1) List the main constituents of our solar system, galaxy, and universe.
2) Describe a few of the exciting topics being investigated by modern astronomers.
3) Outline some key events in the history of the Universe.
4) Construct a scale model of the Universe that illustrates the relative distances and sizes of various celestial objects.
5) Discuss how time (*as we perceive it*), is influenced by distance.
6) Explain the foundations of anthropogenic calendars.
7) Understand the use of scientific notation and the metric system.
8) Discuss sidereal time and how it relates to a synodic month.
9) Describe the lunar cycle and its effects on earth.
10) Understand stellar parallax and parsecs.
11) Summarize some of the accomplishments of early Greek Astronomers.
12) Discuss the models of the Universe developed by Aristotle, Ptolemy, and Copernicus.
13) State and apply Kepler's three laws of planetary motion.
14) Discuss the importance of geometric principles in association with astronomy.
15) Discuss Newton's contributions to Astronomy, physics, and mathematics.
16) State Newton's three Laws and examples of each.
17) Describe Newton's Law of universal gravitation, and summarize the reasoning used by Newton to deduce it.
18) Explain how we can say that the Moon is falling towards Earth.
19) Compare and contrast the properties of the terrestrial and the jovian planets.
20) Explain why Mercury's night and day are twice as long as its year.
21) Explain what the "Greenhouse Effect", both stable and runaway, and apply it to the atmosphere of Venus.
22) Understand Earth's dynamic properties; plate tectonics and atmosphere.
23) Discuss the Martian landscape, atmosphere, and possible life.
24) Summarize Jupiter's four main moons.
25) Describe the appearance, origin, and nature of Saturn's rings.
26) List some discoveries made when Voyager II visited Uranus and Neptune.
27) Explain what a "Shooting Star" is.
28) Discuss the origin of comets, as well as their physical and orbital properties.
29) Summarize the methods used by astronomers to detect and study light.
30) Sketch the path of light rays follow in different types of telescopes.
31) State the main purposes of telescopes.
32) Calculate the relative light-gathering power of two telescopes, given their diameters.
33) Explain the different types of optical telescopes.
34) Explain why radio telescopes are much larger than optical telescopes.
35) Discuss the nature of electromagnetic radiation.
36) Define what is meant by a spectrum, and identify the electromagnetic region that visible light occupies.
37) Explain the nature of light and its properties.
38) Define wavelength, frequency, period, and speed of a wave.
39) State the relationship between energy and frequency (for wavelength) of a photon.
40) Summarize some arguments for thinking that light has both wave-like and particle-like properties.

Table 1. A compiled list of recognized constellations found in most star charts and planispheres.

Constellation	Abbreviation	English Translation
Andromeda	And	Princess
Antlia	Ant	Air Pump
Aquarius	Aqr	Water Bearer
Aquila	Aql	Eagle
Ara*	Ara	Alter
Aries	Ari	Ram
Auriga	Aur	Charioteer
Boötes	Boo	Herdsman
Caelum	Cae	Burin (engraving tool)
Camelopardalis	Cam	Giraffe
Cancer	Cnc	Crab
Canes Venatici	CVn	Hunting Dogs
Canis Major	CMa	Big Dog
Canis Minor	CMi	Little Dog
Capricornus	Cap	Sea Goat
Cassiopeia	Cas	Queen
Centaurus*	Cen	Part Human and Part Horse
Cepheus	Cep	King
Cetus	Cet	Whale
Columba	Col	Dove
Coma Berenices	Com	Berenice's Hair
Corona Australis	CrA	Southern Crown
Corona Borealis	CrB	Northern Crown
Corvus	Crv	Crow
Crater	Crt	Cup
Cygnus	Cyg	Swan
Delphinus	Del	Dolphin
Dorado**	Dor	Swordfish
Draco	Dra	Dragon
Equuleus	Equ	Little Horse
Eridanus**	Eri	River
Fornax	For	Furnace
Gemini	Gem	Twins
Grus*	Gru	Crane
Hercules	Her	Hero (Divinity)
Horologium**	Hor	Clock
Hydra	Hya	Water Monster
Indus*	Ind	Indian
Lacerta	Lac	Lizard
Leo	Leo	Lion
Leo minor	Lmi	Little Lion
Lepus	Lep	Hare
Libra	Lib	Scales

*southern constellation, shown in part from this latitude

**southern constellation, no stars may be seen from this latitude

Table 1. (cont.)

Constellation	Abbreviation	English Translation
Lupus*	Lup	Wolf
Lynx	Lyn	Lynx
Lyra	Lyr	Lyre
Microscopium	Mic	Microscope
Monoceros	Mon	Unicorn
Norma*	Nor	Set Square
Ophiuchus	Oph	Serpent Bearer
Orion	Ori	Hunter
Pegasus	Peg	Winged Horse
Perseus	Per	Prince
Phoenix*	Phe	Immortal Bird
Pictor*	Pic	Painter's easel
Pisces	Psc	Fishes
Pisces Austrinus	PsA	Southern Fishes
Puppis*	Pup	Stern of a ship
Pyxis	Pyx	Mariner's Compass
Sagitta	Sge	Arrow
Sagittarius	Sgr	Archer
Scorpius	Sco	Scorpion
Sculptor	Scu	Sculptor
Scutum	Sct	Shield
Serpens	Ser	Serpent
Sextans	Sex	Sextant
Taurus	Tar	Bull
Telescopium*	Tel	Telescope
Triangulum	Tri	Triangle
Ursa Major	Uma	Big Bear
Ursa Minor	Umi	Little Bear
Vela*	Vel	Sails
Virgo	Vir	Virgin
Vulpecula	Vul	Little Fox
Apus**	Apu	No Feet
Carina**	Car	Keel
Chamaeleon**	Cha	Chameleon
Circinus**	Cir	Compass
Crux**	Cru	Southern Cross
Hydrus**	Hyd	Hydra
Musca**	Mus	Housefly
Norma**	Nor	Right Angle
Octans**	Oct	Octant
Pavo**	Pav	Peacock
Reticulum**	Ret	Crosshair
Tucana**	Tuc	Toucan

*southern constellation, shown in part

**southern constellation, no stars may be seen

Principles of Astronomy
AST K101
Detailed Outline

I <u>Introduction</u>

- **a)** Observational Science
- **b)** Positions, movements, and evolution of celestial bodies
- **c)** One of the oldest sciences
  - -thousands of years of observations

A) Movement of Earth

- **a)** Rotation vs Revolution
  - i. Rotation velocity
  - ii. Revolution velocity
- **b)** Inclination
- **c)** Precession
- **d)** Astronomic Unit

B) The "New" Solar System (2015)

- **a)** μ – value
- **b)** Pluto?
- **c)** 'dwarf' planets
- **d)** Debris and a host of asteroids
- **e)** Sun is a star

C) Beyond the Solar System

- **a)** Milky Way Galaxy
- **b)** Local Group
- **c)** Local Supercluster
- **d)** "Virgo Cluster"
- **e)** Astronomical Hierarchy

D) Brief overview of scientific notation & metric system

- **a)** Scientific notation
  - i. Exponential Notation
- **b)** Metric System
- **c)** Absolute (Kelvin) scale

E) Terrestrial Latitude and Longitude

- **a)** degrees(°)
- **b)** minutes (')
- **c)** seconds (")
- **d)** Latitude
- **e)** Longitude (Meridians)
- **f)** Time zones

II <u>Celestial Sphere</u>

- **A) Sky measures**
  - **a)** Celestial Coordinates
    - i. Celestial Poles
    - ii. Celestial equator
    - iii. Horizon and Zenith
  - **b)** The Ecliptic
    - i. Spring (vernal) Equinox & Autumnal Equinox
  - **c)** Analemma
  - **e)** Zodiacal constellations

- **B) Alt/Az System**
  - **a)** Altitude
  - **b)** Azimuth

- **C) Equatorial Coordinate System (ECS)**
  - **a)** Right Ascension
  - **b)** Declination

- **D) Earth's Seasonal Fluctuations**
  - **a)** Solistice
  - **b)** Equinox

III <u>Relative Position & Movement of the Moon from Earth</u>

- **A) Phases of the moon**
  - **a)** Synodic Month
  - **b)** Sidereal Month
  - **c)** Lunar cycle
    1. waxing waning phases
    2. waning gibbous
- **B) Eclipses**
  - **a)** Nodes
    1. Umbra
    2. Penumbra
  - **b)** Lunar eclipses
  - **c)** Solar eclipses
    1. Annular
    3. Total
    4. Partial

IV <u>Time and Distance</u>

- **A) Lunation & lunisolar calendars**
- **B) Angular Measurement of Distance**
  - **a)** Physical size and Distance of an object
    - i. Angular size vs Distance
- **C) Time**
  - **a)** Rotational time
  - **b)** Dynamic Time
  - **c)** Ephemeris Time
  - **d)** Atomic Time
  - **e)** International Standards

C) Time (cont.)

f) Twilight

i. Civil Twilight
ii. Nautical Twilight
iii. Astronomical Twilight

V History of Astronomy

A) Pre-Renaissance

a) Aristotle
b) Aristarchus
c) Erastosthenes
d) Ptolemy

B) Copernicus Revolution

a) Nicolaus Copernicus
b) Tycho Brahe
c) Johannes Kepler

i. Kepler's laws of planetary movement

1. *"Harmonic Law"*

d) Galileo Galilei
e) Isaac Newton

i. Newton's 3 Laws of Motion

B) The Universal Law of Gravity

a) Inverse square of distance ($1/d^2$)
b) Gravitational Law: $F_G = -G(Mm/d^2)$
c) How gravity produces an orbit
d) Gravity and Inertia
e) Newton derived and generalized Kelper's 3 Laws
f) Newtonian Physics Summary

C) Electromagnetic forces

a) The world of physics
b) Uncertainty Principle"

i. Quarks
ii. Leptons
iii. Bosons

c) Strong Nuclear
d) Weak Nuclear
e) Gravity

VI Modern Astronomy

A) Quantum physics

a) Einstein's "Theory of Relativity"

i. Stage 1:"Special Relativity"

1. $E = mc^2$

i. Stage 2: "General Theory of Relativity"

b) Hubble
c) "Big-Bang Theory"

VII Light and Telescopes

- **A) Light**
- **B) Electromagnetic Radiation**
  - **a)** Oscillating electric & magnetic fields
  - **b)** Speed of light (*c*) = 300,000 km/s (186,000 mi/s)
    1. wavelength = speed of light divided by the frequency

$$\lambda = c / f$$

- **C) Optical Telescopes**
  - **a)** Sidereal drive
  - **b)** Equatorial Mounting
  - **c)** Alt-Azimuth Mounting
  - **d)** Refracting telescopes
  - **e)** Reflecting telescopes
  - **f)** achromatic lens
  - **g)** Newtonian focus
  - **h)** Cassegrain focus
  - **i)** Schmidt-Cassegrain telescope

- **D) Powers of Optical Telescopes**
  - **a)** Light-gathering power (brighter)
    i. area of lens (or mirror) diameter = $\pi(D/2)^2$
  - **b)** Resolving power (clearer)
    i. Diffraction fringe
  - **c)** Magnifying power (larger)
    i. Focal length

- **E) Radio Telescopes**
  - **a)** Radio interferometer

VIII The Sun

- **A) Sunspots**
- **B) Prominences**
- **C) Dark Filaments**
- **D) Solar Flares**
- **E) Solar atmosphere**
  - **a)** Photosphere
  - **b)** Chromosphere
  - **c)** Corona
- **F) Granulation**
- **G) Coronal mass ejections (CMEs)**

IX Distance of Stars

- **A) Parallax**
  - **a)** Arcsecond
  - **b)** Parsec

X To determine Luminosity of Stars

- **A) Intrinsic power of stars**
  - **a)** Apparent brightness
  - **b)** Photometry (charged coupling device)
- **B) Brightness of Stars**
  - **a)** Brightness Scale
    1. "Absolute Magnitude"
- **C) Spectral Analysis**
  - **a)** Stefan-Boltzman Law
    1. $\epsilon = \sigma T^4$
  - **b)** Wiens Law
    1. $\lambda_m T$ = constant (2.9×10^6 nm-K)
- **D) Classification of all stars based on Surface Temperature**
  - **a)** Apparent Brightness
    1. $\mathbf{4\pi d^2}$ = inverse square law
  - **b)** Luminosity (power)

XI Brightness of Stars

- **A)** Brightness Scale
  - **a)** Apparent Magnitudes
  - **b)** Absolute Magnitude
  - **c)** Apparent Brightness
- **B)** Stefan-Boltzman Law
- **C)** Wiens Law

XII Luminosity-Temperature-Diameter Relationship

- **A)** Hertzsprung-Russell (H-R) Diagram
- **B)** Typical Stars
- **C)** Principles Governing structures of Main-Sequence stars

XIII Structure and formation of Stars

- **A)** Stellar Structure Laws
  - **a)** Conservation of mass
  - **b)** Conservation of energy
  - **c)** Hydrostatic equilibrium
  - **d)** Energy transport
- **B)** Stellar nuclear fusion
- **C)** Red, Brown, & sub-Brown Dwarfs
- **D)** Pressure-Temperature and Mass-Luminosity Relationships

XIV Types of Nebulae

1) Emission nebulae
2) Reflection nebulae
3) Dark nebulae

XV Giant Stars

XVI Variable Stars

XVII White dwarfs

XVIII The Planets of the Inner Solar System:

- **A) Mercury**
  - **a)** Caloris Basin
  - **b)** Lobate scarps
  - **c)** Gravitational resonance
- **B) Venus**
  - **a)** Run-Away Greenhouse Effect
  - **b)** Thick atmosphere
- **C) Earth**
  - **a)** Standard of comparative planetology
  - **b)** Geologically active
- **D) Mars**
  - **a)** Moons
    1. Phobos
    2. Diemos
- **E) Asteroid Belt**
  - **a)** Kirkwood's Gaps

XVIX The Planets of the outer Solar System

- **A) Jupiter**
  - **a)** Gallilean moons of Jupiter
    1. Io
    2. Europa
    3. Ganymede
    4. Callisto
- **B) Saturn**
  - **a)** rings of Saturn are billions of ice crystals
  - **b)** Cassini's Divisions
    1. Ring A – Outmost ring
    2. Ring B – Middle ring
    3. Ring C – Inner ring
  - **c)** Moons of Saturn
    1. Over 12 moons
    2. Outermost moons have co-orbits
- **C) Uranus**
  - **a)** High in methane
  - **b)** rings of Uranus
  - **c)** Moons of Uranus

    5 moons
    1. Miranda
    2. Ariel
    3. Umbriel
    4. Titania
    5. Oberon
- **D) Neptune**
  - **a)** Neptune's atmosphere
  - **b)** Rings of Neptune
  - **c)** Neptunes Moons

    Triton & Nereid