Astronomy
NaSc 109 Summer 2019
Exam 1

Name _____

Don't Panic! Take a big deep breath... hold it... now let it out. A table of some important constants and equations can be found at the back of the exam. Work on this exam efficiently; if you don't know an answer right away, move on and go back to the question later (but don't forget to go back). The exam is worth 100 points. You have 56 minutes to complete the exam. Initial the bottom right of the next page for a free point if you have read this. If you finish early, feel free to turn it in – after checking your answers – and leave, but don't forget to come back at 3:45 pm.

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1. (3 pts.) We are currently sitting at 118°W long. 34°N lat.

   When you to face north, the pole star is ___**34**____ degrees above the horizon.

   The celestial equator is ___**90**____ degrees from the pole star.

2. (3 pts.) Where is *zenith*?

   - ☐ Directly south
   - ☐ Directly north
   - ■ Directly overhead
   - ☐ Directly in the ecliptic
   - ☐ Changes position depending on the time
   - ☐ At Best Buy in the television department.

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   a finger-width at arm's length is about __**1°**___ of angular distance, and will cover the both the Moon and the Sun.

4. (6 pts.) Check all of the celestial bodies which you might find on or near the ecliptic that change position with respect to the stars.

   ■ Sun ■ Moon ☐ Polaris ■ Jupiter ■ Neptune ☐ The star Arcturus

5. (3 pts.) The larger the magnitude of a star the _____ the star is.

   - ■ fainter
   - ☐ brighter
   - ☐ more red
   - ☐ farther to the east
   - ☐ uglier

6. (5 pts.) In the July 1997 issue of *Sky & Telescope* (one of the popular astronomy journals), it was reported that data obtained from the *Hipparcos* satellite has placed the Andromeda Galaxy at a distance of 2.9 million light-years from the Milky Way galaxy (our galaxy). Until this discovery, Earth-based measurements had placed the Andromeda Galaxy at a distance of 2.4 million light-years. Thus, for years the accepted distance to the Andromeda Galaxy had been 500,000 ly in error.

   What may be said about the theories involved in determining cosmic distances?

   - ☐ The theories are perfect in every way; only human error has determined the distance of Andromeda incorrectly.
   - ■ The theories naturally have some amount of error associated with them and should be modified to more accurately predict cosmic distance.
   - ☐ The theories are absolutely wrong and must be completely discarded and replaced with theories which give the right answer.
   - ☐ This is a completely unreasonable question since stars and galaxies are embedded in a crystalline sphere just outside the orbit of Pluto.

7. (3 pts.) With a simple diagram show what the statement "The Moon subtends and angle of ½°" means. The Sun also subtends an angle of ½°. How do you reconcile that the two objects (Sun and Moon), clearly at vastly different distances from the Earth, can visually subtend the same angle?

8. (5 pts.) Jupiter is 6.32 x 10^8 km (6.32 x 10^{11} m) from the Earth at opposition. How long does it take (in seconds) for reflected light from Jupiter to arrive at Earth?

$$c = 3.00\times10^8 \ {}^{\text{m}}\!/_{\text{s}}$$

$$d = r \times t \quad \text{so....} \quad t = \frac{d}{r}$$

$$t = \frac{6.32\times10^{11}\,\text{m}}{3.00\times10^8 \ {}^{\text{m}}\!/_{\text{s}}} = \boxed{2107\ \text{s} = 35\ \text{min}}$$

9. (3 pts.) In only the space provided, describe why the pole star was Thuban (α-Draconis) for the ancient Egyptians (~3000 B.C.) but is now a different star. Brevity in the discussion will be rewarded more than wordiness.

The shifting position of the NCP among the stars is due to the precession of the axes

10. (3 pts.) Stars that are _____ are cooler (such as Arcturus) than stars that hotter (such as Spica).

- ■ red to orange
- ☐ blue
- ☐ lead guitarists in grunge bands
- ☐ science geeks

11. (5 pts.) What is the geocentric point of view of the cosmos? What is one strong evidence (not proof) that the geocentric model of the cosmos is the correct?

Stars, Moon, planets, Sun rise in the east and set in the west.

12. (3 pts.) At the current time in history, where must you be standing on Earth for Polaris to be visible on the western horizon?

- ☐ Equator
- ☐ South pole
- ☐ Malibu
- ■ The premise of the question is wrong: Polaris can never be seen in the west.

13. (3 pts.) What is meant by the *apparent magnitude* of a star?

- ■ How bright a star is when viewed from Earth.
- ☐ How bright a star is when viewed from a distance of 10 parsecs.
- ☐ How bright a star is when viewed from a distance of 10 ly.

14. (4 pts.) On May 11 at 8:30 p.m. you may have observed the bright star Zubenelgenubi (α-Librea), rising off the horizon on the ecliptic.

    At approximately what time would you have seen Zubenelgenubi rising one week earlier on May 4?

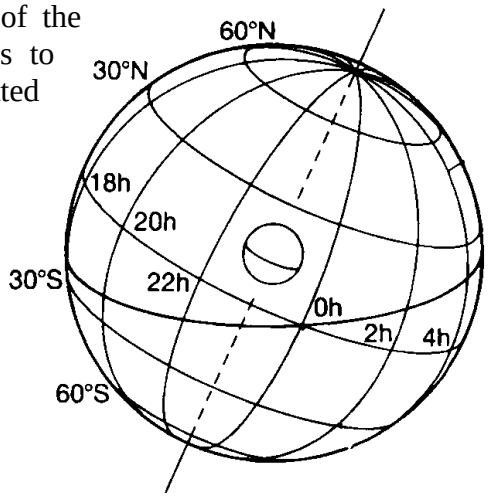
    4 min/day x 7 days = 28 min: 8:58 pm

15. (3 pts.) In one sentence, define the light-year. (A numerical value is not required.)

    The distance light travels in one year.

16. (6 pts.) On the picture of the celestial sphere, identify each of the following lines or points. Use the letter code in parentheses to prevent clutter. The sphere in the middle is the Earth and the dotted line is the north-south axis of Earth's rotation.

    A right ascension line (RA)
    A declination line (dec)
    The ecliptic (E)
    The celestial equator (EQ)
    North celestial pole (NCP)



17. (3 pts.) There is some compelling evidence that Mars had, at one time in its history, liquid water on its surface and a hospitable atmosphere. Give one evidence that supports this conclusion.

    River washes, flood basins, terracing, layering/stratification

18. (12 pts.) List the 12 zodiacal constellations in the ecliptic. Listing in order from west to east gets one extra credit point total. Correctly identifying all 12 of the objects that the zodiacal constellations describe also gets one extra credit point total.

Pisces	**Fishes**
Aries	**Ram**
Taurus	**Bull**
Gemini	**Twins**
Cancer	**Crab**
Leo	**Lion**
Virgo	**Maiden**
Libra	**Scales**
Scorpius	**Scorpion**
Sagittarius	**Archer**
Capricornu	**Sea Goat**
Aquarius	**Water Bearer**

19. (4 pts.) The celestial equator is an imaginary arc across the sky that goes from directly east to directly west. The ecliptic crosses the celestial equation at an angle of 23.5°. Why?

- ☐ In the homocentric model of the universe, the stars were tilted 23.5° to maintain the perception of perfection.
- ■ The earth is tilted from the plane of its orbit around the Sun by 23.5°.
- ☐ If the equator and ecliptic were parallel the universe would be unstable, thus the planets would fly off to infinity (…and beyond).
- ☐ The heliocentric view of the universe defies religious tradition so the ecliptic and celestial equator must not be parallel.

20. (3 pts.) Which of the following are evidences of the Big Bang? (Check all that apply)

- ■ Nearly all galaxies are moving away from us.
- ■ The farther a galaxy is away from us, the faster it is receding.
- ☐ The pole star is at our current latitude.
- ■ No matter where we point in space an instrument which can accurately determine temperature, we find that space is about 2.7°K (-269°C).
- ☐ Earth really *does* revolve around the sun.

21. (2 pts.) Which of the evidences, if any, of the Big Bang in the previous question are <u>proofs</u> that the Big Bang Theory is absolutely correct?

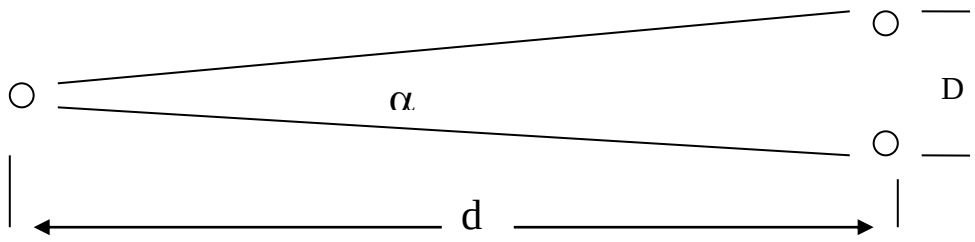
None of them. Scientists don't prove anything correct.

22. (4 pts.) Currently accepted scientific theories regarding the cosmos put the age of the universe at

- ☐ 4000-10000 years.
- ☐ 1 to 2 million years.
- ☐ 10 million to 1 billion years.
- ■ 10 billion to 15 billion years.

23. (5 pts.) Mizar, the second star in the handle of the "Big Dipper" of Ursa Major, has a nearby companion: Alcor. However, Mizar itself is actually a binary star system, the stars of which can be resolved only in a telescope. The angular separation between the stars is 14 arcsec and the stars are 78.2 ly away. Calculate the distance between the two stars (in km).

This is just a small-angle formula problem



$$d = 78.2\ \text{ly} \times 9.461\times10^{12}\ \tfrac{\text{km}}{\text{ly}} = 7.399\times10^{14}\,\text{km}$$

$$D = \frac{\alpha d}{206,265''} = \frac{(14'')\left(7.399\times10^{14}\,\text{km}\right)}{206,265''} = \boxed{5.02\times10^{10}\,\text{km}}$$

22. (3 pts.) In an astounding bit of science fiction, we have finally heard an artificial radio signal from the imaginary extra-solar planet, Zarquon. The planet Zarquon was measured to be 1,250 light-years away.

    How long has the radio signal been traveling through space before we detected it?

1,250 years

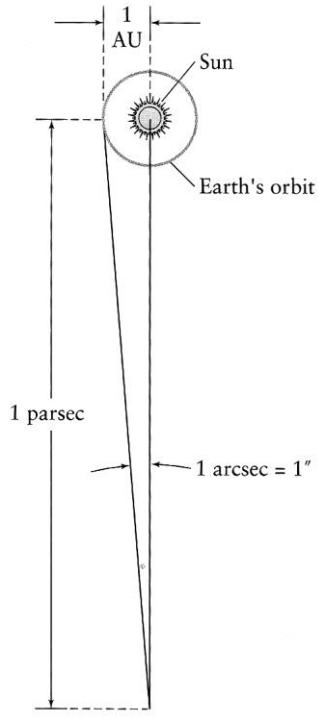
23. (3 pts.) What is a nebula?

- ☐ A dead star.
- ■ A star-birth region of gases
- ☐ The 32nd flavor of ice cream at Baskin Robbins
- ☐ The oldest stars in the universe

Extra credit problems do not receive much, if any, partial credit. Make sure you're completely finished with the main portion of the exam before attempting these. They are not ordered by difficulty or by any other discriminator.

Extra Credit

Inspect at the diagram on the right. The parsec is defined as the distance from the sun at which the apparent angular width of the Sun-Earth distance (1 AU) would be 1 arcsec. Calculate the equivalent distance of 1 parsec in light years. (Just quoting the conversion of the parsec and light year will receive no credit – you must show the mathematical origin of the parsec/light year conversion.)



Some Important Equations and Constants

Conversions

Time

1 sidereal year = 365.26 day
1 day (mean solar day) = 24 h
1 h = 60 min = 3600 s
1 min = 60 s

Linear Distance

1 AU = 1.496 x 10^8 km
1 ly = 9.461 x 10^{12} km = 9.461 x 10^{15} m
= 63,235 AU
1 pc = 3.26 ly

Angular Distance

1 complete circle = 360°
1° = 60 arcmin = 60’
1 arcmin = 60 arcsec = 60”

Constants

c = 3.00 x 10^8 $\mathrm{m/s}$

G = 6.6726 x 10^{-11} $\mathrm{N\,m^2/kg^2}$

π = 3.14159265

σ = 5.67 x 10^{-8} $\mathrm{W/m^2 \cdot K^4}$

h = 6.63 x 10^{-34} J·s

$M_\odot$ = 1.989 x 10^{30} kg

solar constant = 1370 W/m^2

$L_\odot$ = 3.85 x 10^{26} W

Apparent Magnitude (Sun) = -26.7

Hubble constant, H_0 = 22 $\mathrm{km/s/Mly}$

Equations

$$D = \frac{2\pi \cdot \alpha d}{360°} = \frac{2\pi \cdot \alpha d}{21600'} = \frac{2\pi \cdot \alpha d}{1.296 \times 10^6 ''} = \frac{\alpha d}{206,265''}$$

Distance-Parallax relationship: $d = \frac{1}{p}$

Kepler’s Third Law: $P^2 = a^3$

Newton’s Modification of Kepler’s Third Law: $P^2 = \left[\frac{4\pi^2}{G(m_1 + m_2)}\right] a^3$

Newton’s Law of Gravitation: $F = G\left(\frac{m_1 m_2}{r^2}\right)$

Escape velocity: $v_{\text{escape}} = \sqrt{\frac{2GM}{R}}$

$c = \lambda\nu$

Planck’s Law: $E = h\nu = \frac{hc}{\lambda}$

Brightness/Magnitude relationship:

$$m_2 - m_1 = 2.512 \log \frac{b_1}{b_2}$$

Wien’s Law: $\lambda_{\max} = \frac{0.0029}{T}$

Einstein’s Energy/Mass Relationship:

$$E = mc^2$$

Stephan-Boltzmann Law: $F = \sigma T^4$

Dawes Limit: $R = 2.5 \times 10^5 \frac{\lambda}{D}$

Doppler Shift: $\frac{\Delta\lambda}{\lambda} = \frac{\mathrm{v}}{c}$

Hubble Law: $\mathrm{v} = H_0 \times d$

Galactic Redshift: $z = \frac{\lambda - \lambda_0}{\lambda_0}$

Schwarzschild Radius: $R = \frac{2GM}{c^2}$

Inverse-Square Law of Light: $F = \frac{L}{4\pi d^2}$

Sidereal/Synodic Period Relationship:

$$\frac{1}{P} = \frac{1}{E} - \frac{1}{S}$$