Astronomy
NaSc 109 Summer 2019
Exam 2

Name ____________________________

Don't Panic! Take a big deep breath... hold it... holllld it… now let it out. Use your available time on this exam very 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). You may not share calculators. You have 56 minutes to complete the exam. If you finish early, feel free to turn it in after checking your answers and quietly leave, but remember to come back at 3:45 pm.

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1. (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.

2. (6 pts.) A comet which orbits the Sun has a period of 125 years.

   a. What is the comet's average distance (in AU) from the Sun?

$$P^2 = a^3$$

$$P = 125 \text{ y}$$

$$\sqrt[3]{(125 \text{ y})^2} = 25 \text{ AU}$$

   b. Given that at perihelion the distance of the comet is 0.2 AU, what is the comet's distance from the Sun at aphelion? (Hint: A picture may help.)

$$\text{Total orbital distance} = \text{major axis} = 2 \times 25\text{AU} = 50 \text{ AU}$$

$$\text{Aphelion} = 50 \text{ AU} - 0.2 \text{ AU} = 49.8 \text{ AU}$$

3. (3 pts.) On May 14 at 6 am you observed the famous star of song and story, our Sun, rising off the horizon.

What direction are you looking?

- ■ north of east
- ☐ directly east
- ☐ south of east
- ☐ north of west
- ☐ directly west
- ☐ south of west

4. (3 pts.) What is *parallax* (for example, in the phrase *stellar parallax*)?

- ☐ A pair of stellar laxes
- ■ Changing of the angular distance between two celestial bodies depending upon where they are observed.
- ☐ The motion of the exterior planets as they move against the backdrop of the stars.
- ☐ The motion of the interior planets as they move against the backdrop of the stars.

5. (3 pts.) Which of the following are evidences (not proofs) of a geocentric (homocentric) model of the cosmos? (Check all that apply.)

- ■ planets appear to revolve around the earth
- ■ sun and moon appear to revolve around the earth
- ■ stars appear to revolve around the earth
- ☐ epicycles, deferents, and eccentrics
- ■ lack of an observable stellar parallax
- ☐ retrograde motion of the planets

6. (3 pts.) Which of the following are modern criteria for a good scientific theory? (Check all that apply.)

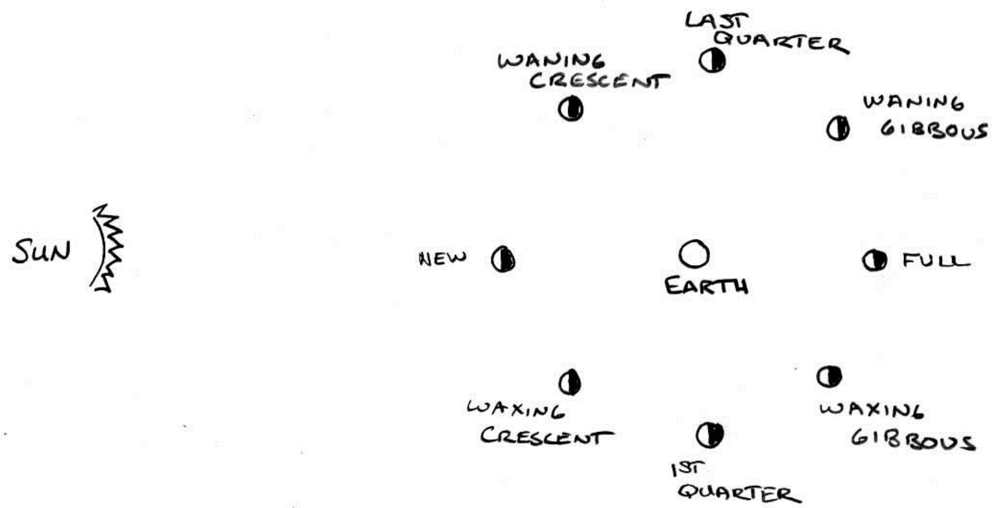
- ☐ A theory should be agreed upon by all scientists.
- ■ It should be possible to experimentally prove the theory wrong.
- ■ A theory should fit or explain current known data.

7. (3 pts.) Stellar parallax can be used to accurately measure distance to stars out to about

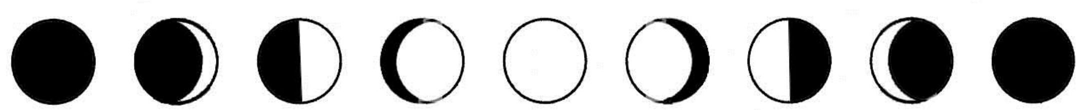
- ☐ 10 ly.
- ☐ 50 ly.
- ■ 500 ly.
- ☐ 500,000 ly.
- ☐ none of these answers are correct. We discovered in lab that parallax is not at all accurate for measuring distance.

8. (7 pts.) Show, with a simple diagram, the origin of the phases of the moon; that is, if you are looking down from above on the Sun-Earth-Moon system, what it would look like. On the diagram below show what the moon would look like from Earth at each phase and label each lunar view (new, full, etc.). For full credit, label the diagram with the *approximate* date of <u>each</u> phase if new moon occurs on July 1.

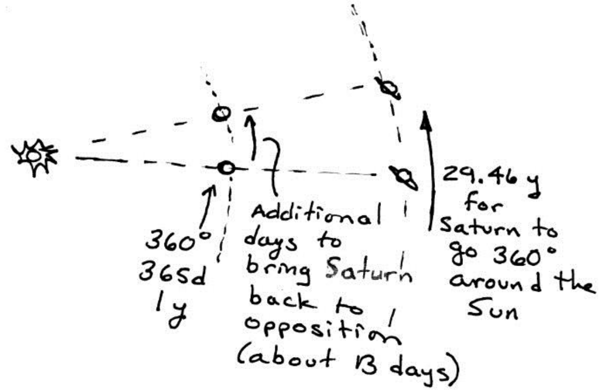
Heliocentric diagram:



Phase diagram



9. (3 pts.) The synodic period of Saturn is 378.10 days while the sidereal period of Saturn is 29.46 years. Explain this observation. (hint: a diagram will help.)



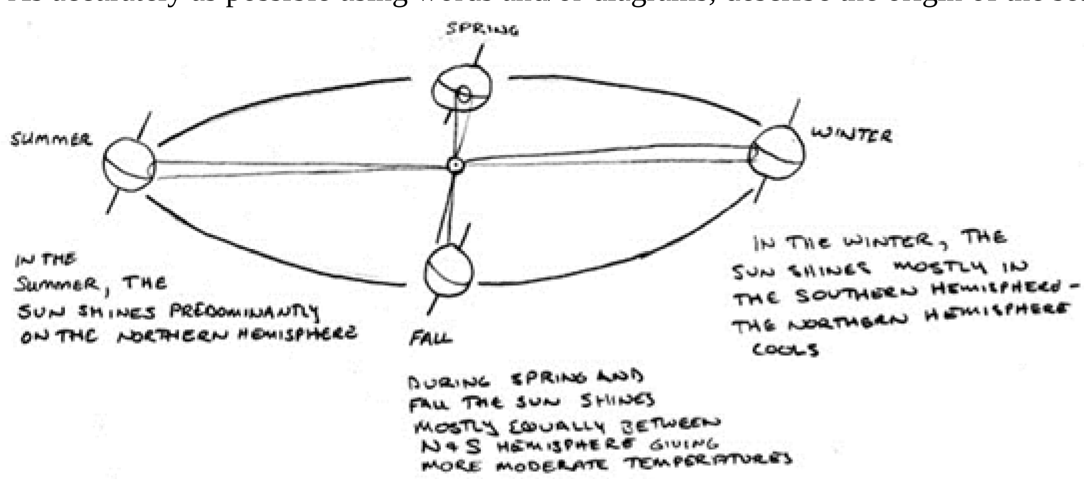
10. (3 pts.) A particular person has a *mass* of 60 kg (about 132 pounds). What is their *mass* when in orbit around the Jupiter, a much more massive planet than Earth?

- ☐ zero
- ■ 60 kg
- ☐ between zero and 60 kg since Jupiter is much more massive than Earth.
- ☐ greater than 60 kg since Jupiter is much more massive than Earth.
- ☐ How dare you tell someone's mass to the public.

11. (3 pts.) Referring to the prior question, what is their *weight* while in orbit around Jupiter?

- ■ zero
- ☐ 60 kg
- ☐ between zero and 60 kg since Jupiter is much more massive than Earth.
- ☐ greater than 60 kg since Jupiter is much more massive than Earth.
- ☐ How dare you tell someone's weight to the public.
- ■ But as long as you're asking about this, give me one free point for checking this box.

12. (4 pts.) As accurately as possible using words and/or diagrams, describe the origin of the seasons.



13. (4 pts.) The sidereal period of Jupiter is 11.86 years. How many days will pass for Jupiter to go from one opposition to the next?

Calculate the synodic period of Jupiter:

$$\frac{1}{P}=\frac{1}{E}-\frac{1}{S} \quad \text{so.....} \quad \frac{1}{S}=\frac{1}{E}-\frac{1}{P}=\frac{1}{1\text{ y}}-\frac{1}{11.86\text{ y}}=0.91568$$

$$\text{thus.....} \quad S=\frac{1}{0.91568}=1.092\text{ y}$$

problem asks for days......

$$S=1.092\text{ y}\times 365.26\,\tfrac{\text{day}}{\text{y}}=398.9\text{ days}$$

14. (7 pts.) Match the historical characters to their "claims-to-fame." It is possible that the old-dead-guys may be used more than once. If you don't see the correct old-dead-guy is listed, write in your answer.

__c_ Historically, he was the first to seriously propose a heliocentric model of the cosmos.

__a_ Insisted that perfection was found in spheres.

____ Just really a nice guy, after all.

__i_ Developed the laws of motion, optics, and gravity.

__h_ First to observe and report that Venus passes through phases similar to the Moon.

__d_ Suggested that, when comparing two theories, the one which has the fewest untestable hypotheses is likely to be the best theory.

__b_ Wrote the *Mathematika Syntaxis* (translated into the *Almagest*), traditionally thought of as the first astronomical textbook containing comprehensive stellar descriptions, the coordinates and magnitudes of over a 1000 stars, and tables of predicted planetary positions.

a. Arisotle
b. Claudius Ptolemy
c. Aristarchus
d. William of Occam
e. Nicolaus Copernicus
f. Tycho Brahe
g. Johannes Kepler
h. Galileo Galilei
i. Isaac Newton
j. Ole Römer
k. Christiaan Huygens
l. Léon Foucault
m. Christian Doppler
n. James Maxwell
o. Max Planck
p. Niels Bohr
q. Albert Einstein
r. Dr. Green
s. None of these

15. (4 pts.) On January 29 at 7:30 p.m. you observe the bright star Regulus (α-Leonis), rising off the horizon on the ecliptic.

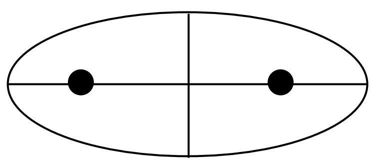
At approximately what time will you see Regulus rising 7 days later, on February 5?

7 d x 4 min/day = 28 min earlier: 7:02 p.m.

16. (3 pts.) We qualitatively determine the temperature of a star by

- ☐ examining its absorption line spectrum.
- ☐ examining its emission line spectrum.
- ☐ examining the wavelength at which it emits with the highest intensity; that is, λ_{max}.
- ■ examining its color.
- ☐ feeling its forehead.

17. (4 pts.) Draw an ellipse. Show and label the axes and foci. In one sentence, explain the astronomical significance of an ellipse.



The planets follow an ellipse in their orbit around the Sun.

18. (3 pts.) During the year 2017 a line joining the Sun and Saturn swept out an area of 10.1 AU^2 as Saturn progressed through its orbit. What will be the area swept out by the Sun-Saturn line during the year 2018 when Saturn is slightly further from the Sun?

- ☐ less than 10.1 AU^2
- ■ exactly 10.1 AU^2
- ☐ more than 10.1 AU^2
- ☐ need additional information to answer this question

19. (4 pts.) Draw the electromagnetic radiation spectrum for all forms of light from short wavelength to long wavelength. In one sentence, identify which wavelength range or ranges are not used in astronomy.

20. (3 pts.) Studying *globular clusters* is important for understanding or determining

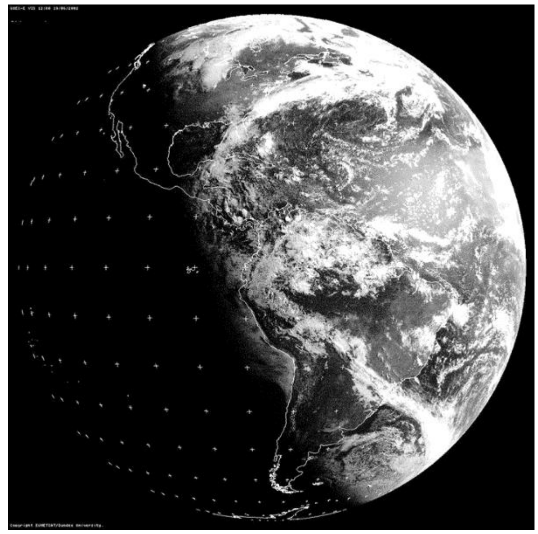
- ☐ stellar mass.
- ☐ stellar temperature.
- ☐ stellar color.
- ■ stellar evolution and age of the universe.
- ☐ Cepheid and RR Lyrae variables.
- ☐ a sugar-coated breakfast cereal.

21. (5 pts.) Accurately draw the analemma for 1 year at noon. The line is your horizon. On the short line below the horizon, indicate what direction you are facing. There are 4 significant dates on the analemma: identify them.:

22. (5 pts) By current thinking, epicycles are a nonsensical celestial mechanical construction. Even by the time of Copernicus, the concept of epicycles was somewhat discounted. Why, then, was the Copernican theory not accepted immediately even though the model is more physically accurate than the homocentric model. (Don't be comprehensive; give only one of the several reasons.)

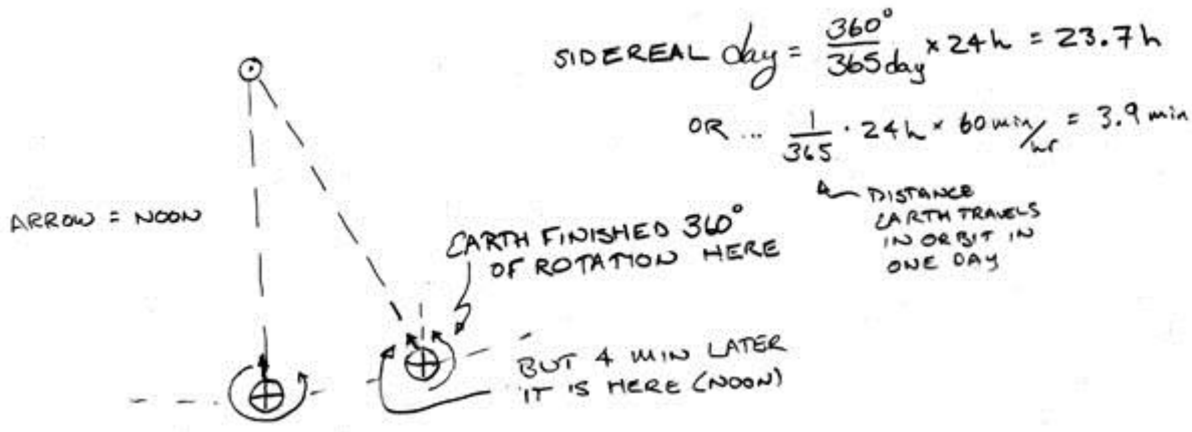
The Aristotelian/Ptolemaic system worked very well for explaining the motion of the cosmos. Ptolomy's modifications even made planetary prediction reasonably accurate. This, in addition to the resistance to change by the Church and the inability of the Copernican view to predict planetary positions accurately over even a few years, prevented the acceptance of the Copernican model.

23. (6 pts.) The picture on the right was made by the GOES atmospheric monitoring satellite, which is in geosynchronous orbit. In the center of the image is South America. At the top of the image, the north pole is completely illuminated by the Sun. In what month was this picture probably taken? In one or two sentences, explain your reasoning.



The entire north pole is illuminated. The picture was taken between May and July. Incidentally, it was June 21.

24. (5 pts.) Diagram with a simple heliocentric (sun-centered) drawing why the ecliptical (zodiacal) constellations (in fact all constellations) appear to move towards the west a small amount each night during the year when viewed at the same local-mean-time (local-mean-time is the time on your watch) of, say, midnight. You will not be penalized for having stars or constellations incorrectly labeled or out of order.



25. (3 pts.) A binary star system is one in which one star is orbiting another -- similar to a planet orbiting the Sun, only on the scale of stars orbiting one another. Among other interesting things, studying binary star systems is important for understanding or determining

- ■ stellar mass.
- ☐ stellar temperature.
- ☐ stellar color.
- ☐ Cepheid and RR Lyrae variables.

Extra credit

During the February 20, 2002 occultation (covering up) of Saturn by the Moon, an amateur astronomer noticed that 84 seconds passed between "first contact" of the Moon with Saturn and the point at which the Moon completely occulted the planet. What is the angular diameter (in arcseconds) of Saturn? (Hint: You will need to convert the Moon's angular speed from degrees per day to arcseconds per second.)

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

Angular Distance

1 complete circle = 360°
1° = 60 arcmin = 60'
1 arcmin = 60 arcsec = 60"

Constants

$c = 3.00 \times 10^8\ ^{m}/_{s}$

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

$\pi = 3.14159265$

$\sigma = 5.67 \times 10^{-8}\ ^{W}/_{m^2 \cdot K^4}$

$h = 6.63 \times 10^{-34}$ J·s

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

solar constant = 1370 W/m^2

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

Apparent Magnitude (Sun) = -26.7

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

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

$c = \lambda \nu$

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

Wien's Law: $\lambda_{max} = \frac{0.0029 \text{ m} \cdot \text{K}}{T}$

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

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

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

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

Brightness/Magnitude relationship:

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

Einstein's Energy/Mass Relationship:

$$E = mc^2$$

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

Hubble Law: $v = H_0 \times d$

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

Sidereal/Synodic Period Relationship:

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