Name ______________________ **Test 1** Planetary and Stellar Astronomy 2017
(Last, First)

The exam has 20 multiple choice questions (3 points each) and 8 short answer questions (5 points each). This is a closed-book, closed-notes exam. You can use a pen/pencil, eraser and calculator for the exam. No wireless devices, phones or pre-programmed equations are allowed. **Please write your name on each sheet of paper in the space provided.**

I agree to adhere to the W&M Honor Code in all aspects of this test

Your Signature: ______________________

Useful Formulas and Values

M_{sun} = 1.99 x 10^{30} kg
M_{earth} = 5.97 x 10^{24} kg
M_{moon} = 7.35 x 10^{22} kg
R_{sun} = 6.96 x 10^{8} m
R_{earth} = 6.38 x 10^{6} m
R_{moon} = 1.74 x 10^{6} m
$d_{earth \rightarrow moon}$ = 3.84 x 10^{5} km
G = 6.67 x 10^{-11} $\frac{m^3}{s^2 kg}$
g = 9.80 m/s^2
c = 3.00 x 10^{8} m/s
10^9 nm = 10^6 μm = 1 m
1 AU = 1.5 x 10^{11} m
1 ly = 9.46 x 10^{15} m
1 y = 3.16 x 10^{7} s
1000 m = 1 km
1 m = 100 cm
3600 arcsec = 1 degree

1 pc = 3.26 ly
1 pc = 3.09 x 10^{16}m
d = vt
F = $\frac{GMm}{d^2}$
V = $\sqrt{\frac{GM}{d}}$
V = $\sqrt{\frac{2GM}{R}}$
g = $\frac{GM}{R^2}$
$p^2 = a^3$
M = $\frac{4\pi^2 a^3}{Gp^2}$
$\frac{L}{2\pi d} = \frac{\alpha}{360^o}$
$V_{sphere} = \frac{4}{3}\pi r^3$
A = $\pi r^2 = \pi D^2/4$
C = 2πr
σ = 5.671 x 10^{-8} $\frac{W}{m^2 K^4}$
h = 6.62 x 10^{-34} J s
L = σ T^4
L = Power/Area

E = $\frac{hc}{\lambda}$
T = $\frac{2.9 \, x \, 10^6 nm \cdot K}{\lambda_{max}}$
v = c $\cdot$ $\frac{\Delta\lambda}{\lambda_o}$
R = 1.097 x 10^{7} m^{-1}
$\frac{1}{\lambda}$ = R($\frac{1}{4}$ - $\frac{1}{n^2}$)
$Area_{sphere} = 4\pi R^2$
v = c = $\lambda\nu$
θ = 2.5 x $10^5 \frac{\lambda}{D}$
Light gathering power $\propto$ D^2

Multiple Choice Section. Circle the letter of the correct answer

1. One important characteristic of a scientific theory is that it
   (A) can be tested by observation.
   (B) consists of at least three separate hypotheses.
   (C) is mathematical.
   (D) need not have a connection with physical reality.

2. The distance to the red star in Orion (Betelgeuse) is 643 light years, which is:
   (A) 8.97 x 10^{31} AU
   (B) 9.65 x 10^{13} AU
   (C) 4.06 x 10^{7} AU
   (D) 1.02 x 10^{-2} AU

3. On the celestial sphere, which term refers to the path of the Sun?
   (A) Equinox
   (B) Ecliptic
   (C) Zodiac
   (D) Equator

4. Which of the following statements correctly describes the relationship between stars and constellations?
   (A) Only stars within the zodiac close to the ecliptic, are located in constellations.
   (B) Only those stars that were visible to the ancient Greeks are located in constellations.
   (C) Only the brighter stars are in constellations.
   (D) Every star is located in a constellation.

5. The two angles used by astronomers to define the position of a star in the sky and define a coordinate system applicable anywhere on Earth are
   (A) latitude and longitude.
   (B) right ascension and declination.
   (C) azimuth and elevation
   (D) longitude and horizontal angle

6. When does the new Moon phase occur?
   (A) When the Earth is between the Sun and the Moon
   (B) When the Sun is between the Earth and the Moon
   (C) When the Moon is between the Earth and the Sun
   (D) When the Moon and the Sun are on the celestial equator

7. What causes the seasons?
   (A) The changing distance between the Earth and the Sun.
   (B) The tilt of the Earth's spin axis relative to the Earth's orbit.
   (C) The Earth's spin axis is tilted from the poles of the celestial sphere.
   (D) The elliptical shape of the Earth's equator.

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8. Which of the following astronomical observations was not an accomplishment of the Greek astronomers (i.e. accomplished before the renaissance)?
(A) Measuring the radius of the Earth.
(B) Measuring the relative size of the Earth and the Moon.
(C) Demonstrating that the Moon was much closer than the Sun.
(D) All of these were accomplished by the Greeks.

9. Epicycles were added to the geocentric model of Ptolemy to account for
(A) the phases of Venus
(B) lunar eclipses
(C) the motion of comets
(D) retrograde motion of the planets

10. Which of the following is **not** an accomplishment of Kepler?
(A) Showed that a supernova was at a great distance.
(B) Observed a mathematical relationship between orbital size and period.
(C) Inferred that planets move slower when further away from the Sun.
(D) Demonstrated Mars moves in an elliptical orbit.

11. Galileo made many important discoveries when he used a telescope to look at the sky for the first time. Which one was the most convincing in persuading his learned colleagues that the Solar system was heliocentric?
(A) He observed that Venus had all phases.
(B) He observed that the Milky Way was made up of countless stars.
(C) He first observed Sun spots and determined the Suns period of rotation.
(D) He observed four large moons that orbited Jupiter like a miniature solar system.

12. If you double the distance between two bodies, the force of gravity between them would
(A) double.
(B) become four times as strong.
(C) decrease by a half.
(D) decrease to a fourth.

13. Newton's modification of Kepler's 3rd law allows astronomers to determine the __________ of celestial objects.
(A) mass
(B) period
(C) distance
(D) acceleration

14. Who first showed that light is a wave?
(A) James Clerk Maxwell
(B) Thomas Young
(C) Isaac Newton
(D) Albert Einstein

15. A perfect blackbody is so named because it
(A) absorbs all radiation falling on it and reflects none.
(B) reflects only the radiation falling on it and emits none of its own.
(C) never emits radiation.
(D) both reflects and emits light in a manner determined by its temperature.

16. The energy flux from a star is the
(A) average amount of visible light energy emitted by each square meter of the star's surface each second.
(B) total energy emitted by the star over its lifetime.
(C) average amount of energy emitted by the entire star each second.
(D) average amount of energy emitted by each square meter of the star's surface each second.

17. At the mirror of a reflecting telescope, the light reflects from a coated surface rather than refracting through a lens. This eliminates
(A) spherical aberration.
(B) chromatic aberration.
(C) coma.
(D) astigmatism.

18. During the past few decades a number of techniques have been developed to enhance the performance of optical and radio telescopes. These include all of the following except one. Which one is the exception?
(A) placing optical telescopes in orbit above the atmosphere
(B) building lens telescopes comparable in size to the largest mirror telescopes (approximately 10 meters)
(C) computer connections allowing radio telescopes thousands of miles apart to be used in unison
(D) adaptive optics, allowing the shape of a telescope mirror to be changed rapidly to compensate for atmospheric turbulence

19. The primary reason CCDs can more efficiently observe faint stars compared to photographic film is
(A) the information on CCDs can be stored electronically.
(B) CCDs are much more efficient at recording the light that falls on them.
(C) CCDs are cheaper to build.
(D) CCDs reduce the diffraction-limited angular resolution.

20. A spectrograph is usually used in astronomy to measure the
(A) variation of the mass of an object as it moves through space.
(B) distribution of light intensity among the various colors.
(C) vibration of Earth following an earthquake.
(D) brightness of light at one specific color.

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Short Answer Section Your answer must be legible for credit.

1. Describe the Celestial sphere and how to locate a star's position on the Celestial sphere.

   The Celestial sphere is an imaginary sphere with the North (South) celestial pole directly above the Earth's north (south) pole. The Earth's equator is projected out onto the Celestial sphere. Objects are located by the declination (degrees from the equator like latitude) and right ascension (like longitude). It is measured in hours (24 hr = 360 deg) from the spring equinox.

2. Why does a solar eclipse **not** occur every month?

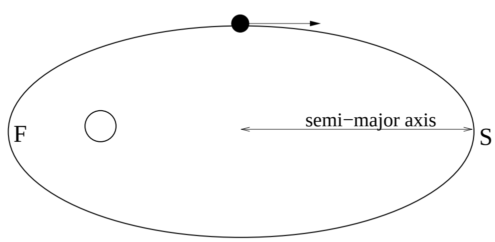
   The axis of the Moon's orbit is tilted 5 deg with respect to the Earth's orbit. Only when the intersection of these two planes (called the 'line of nodes) points at the sun is there a solar eclipse

3. Suppose a very distant object is discovered with a semi-major axis of 100 AU. What is its period around the Sun?

   $a^3 = (100)^3 = 1 \text{ x } 10^6 = p^2$

   $p = (1 \text{ x } 10^6)^{\frac{1}{2}} = 1000$ years

4. On the diagram below of a satellite in an elliptical orbit, mark the diagram with a 'F' where the satellite's speed is the largest. Mark with a 'S' where the satellite's speed is the lowest. Draw a line that shows the semi-major axis of the orbit.



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5. List the following in order of increasing wavelength (they are now alphabetical): blue, gamma ray, green, infrared, radio, red, ultraviolet, X-ray.

   gamma ray, x-ray, ultraviolet, blue, green, red, infrared, radio

6. Shortwave radio uses frequencies between 1.6 MHz (1.5 x 10^6 Hz) to 30 MHz (3.0 x 10^7 Hz). What is the wavelength of a 30 MHz electromagnetic wave?

   v = c = $\lambda\nu$

   λ = c/ν = (3 x 10^8 m/s)/(3 x $10^7 s^{-1}$) = 10 m

7. Two objects are identical except that one object has twice the absolute temperature of the other. How many times more blackboard radiation does the hotter object emit per square meter than the cooler object.?

   L = σ T^4 and $T_{hot} = 2T_{cold}$

   $\frac{L_{hot}}{L_{cold}} = \frac{\sigma T_{hot}^4}{\sigma T_{cold}^4}$

   $\frac{L_{hot}}{L_{cold}} = \frac{(2T_{cold})^4}{T_{cold}^4}$

   $\frac{L_{hot}}{L_{cold}} = \frac{16T_{cold}^4}{T_{cold}^4}$ = 16 or 16 times more luminosity

8. One telescope primary mirror has three times the diameter of a smaller telescope. How much more light does the larger telescope collect than the smaller telescope? Show your work.

   Light gathering power $\propto$ D^2 so

   $\frac{Light\ large\ telescope}{Light\ small\ telescope} = (\frac{3}{1})^2$ = 9 times more light.