PHYSICS 176: ASTRONOMY
Special Final Exam, September 3, 1999

Name:

Lab section and TA:

Score:

As a member of William and Mary community, I pledge not to lie, cheat or steal, either in my academic or personal life. I understand that such acts violate the honor code and undermine the community of trust of which we are all stewards.

Signed:

You have three hours to complete this exam. You may use a hand-held calculator and a single sheet of formulas. In the following, circle or underline the best answer. Mark your answer clearly. Ambiguous answers will be incorrect.

Possibly useful formulae or constants:
c = 3 \times 10^8 \text{ m/s; } \lambda = c; 
(\text{arc length}) = R \theta (\theta \text{ in radians}); 
A_{\text{circle}} = \pi R^2; V_{\text{sphere}} = \frac{4}{3} \pi R^3; 
1 \text{ radian} = 57.3 \text{ deg.}; 
1 \text{ deg.} = 60\text {'}; 1'=60\text{''}; 
1 \text{ A.U.} = 1.5 \times 10^{13} \text{ km}; 
1 \text{ nm} = 1 \times 10^{-9} \text{ m}; 1 \text{ µm} = 1 \times 10^{-6} \text{ m}; 
R_{\text{Earth}} = 6400 \text{ km}; R_{\text{Sun}} = 700,000 \text{ km}; 
1 \text{ pc} = 3.3 \text{ LY} = 3 \times 10^{16} \text{ km} = 2 \times 10^5 \text{ A.U.}.

Jupiter is about ? times bigger in diameter than the Earth.
___10 ___100 ___1,000 ___10,000

Approximately how many times more massive than the Earth is Jupiter?
___1,000 ___10,000 ___300,000 ___1 million

An object has a parallax of 1 degree. What is the parallax for a similar object at twenty-five times this distance?
___1/2 deg. ___1/5 deg. ___ 25 deg. ___ 1/25 deg.

In a few seconds, light leaving Los Angeles will reach approximately as far as (choose the closest)
___San Francisco (about 500 km). 
___London (roughly 10,000 km).
___the Moon (400,000 km). 
___the Sun (150,000,000 km).

In about a day light leaving Los Angeles will reach approximately as far as (choose the closest match)
___the Sun ___Jupiter 
___the Kuiper belt ___the Oort cloud.

Given that the distance to the Moon is 4 \times 10^5 \text{ km} and its angular size is 1/2 degree, calculate the Moon’s diameter.
___5,000 km ___3,500 km ___2,000 km ___1,000 km

At 3 cm/yr, how long would it take a typical plate to traverse the present width of the Pacific Ocean, about 10,000 km?
___250 million years ___330 million years 
___200 million years ___500 million years

The elapsed time between passage of two crests of a wave is its:
___wavelength ___frequency 
___amplitude ___period

For which of the following forms of electromagnetic radiation is the Earth's atmosphere completely transparent?
___x-rays ___visible light 
___ultraviolet ___all of these

How does the apparent brightness of light emitted by a supernova change with distance?
___It does not change.
___It is proportional to the distance.
___It is inversely proportional to the distance.
___It is inversely proportional to the square of the distance.

What is the wavelength of a 30 MHz radio signal?
___100 m ___10 m ___1 m ___10 cm

What is the frequency of a 30 nm photon?
___2 \times 10^{15} \text{ Hz} ___1 \times 10^{14} \text{ Hz} 
___1 \times 10^{16} \text{ Hz} ___2 \times 10^{14} \text{ Hz}

A FREEBIE! NO RIGHT OR WRONG ANSWER!
PONDER IT FOR A FEW MOMENTS…OR A LIFETIME:

What is your best guess regarding how common intelligent life is in the Universe?
___very common
___common, but not under every rock 
___fairly rare, but not so scarce that we’re ‘alone’ 
___extremely rare, possibly we’re unique

HAVE A GREAT SUMMER!
A 2-m telescope can collect a given amount of light in 1 hour. Under the same observation conditions, how much time would be required for a 4-m telescope to perform the same task?

___30 minutes ___2 hours ___15 minutes ___4 hours

What is the cause of tectonic plate motion?

___Earth’s rotation  ___convection in the upper mantle  ___tidal forces from the Moon  ___earthquakes

If you were standing on the near side of the Moon, which object(s) would not show phases?

___Jupiter ___Earth ___Venus ___all of the above

Which of the following provides evidence that water once flowed on Mars?

___runoff and outflow channels  ___Valles Marineris  ___Olympus Mons  ___icecaps

What is the source of Jupiter’s excess energy?

___gravitational potential energy from its formation  ___tidal heating by Io  ___decay of radioactive elements  ___greenhouse effect

What is the source of Io’s volcanic activity?

___radioactive decay of elements  ___impacts from meteorites  ___tidal heating by Jupiter  ___excess heat emitted from Jupiter

What is the process that produces the Sun’s energy?

___burning of hydrogen and oxygen  ___heat left over from its formation  ___fusion of helium into heavier elements  ___fusion of hydrogen into helium

What is the main-sequence (hydrogen core burning) lifetime for stars like the Sun?

___10 million years ___10 billion years  ___100 million years ___100 billion years

The Crab Nebula is now about 1 pc in radius. If it was observed to explode in A.D. 1054, roughly how fast is it expanding? (Assume constant velocity.)

___100 km/s ___1,000 km/s  ___5,000 km/s ___10,000 km/s

A 20-km radius neutron star is spinning 200 times per second. Find the speed of a point on its equator, and compare it with the speed of light. (Consider the equator as the circumference of a circle, and recall that circumference=2πr.)

___8 % speed of light ___.0008 % speed of light  ___80 % speed of light ___.0008 % speed of light

A major discovery made by Shapley using RR Lyrae stars and globular clusters established

___That the spiral nebulae are actually galaxies outside the Milky Way.
___That the spiral arms are regions of star formation.
___The size of the galaxy and the Sun’s position in it.
___That globular clusters lie outside the Milky Way at large distances.

Where is active star formation most often found in the Galaxy?

___halo ___disk ___galactic bulge ___spiral arms

According to Hubble’s law, with \( H_0 = 75 \text{ km/s/Mpc} \), what is the recessional velocity of a galaxy at a distance of 500 Mpc?

___3,750 km/s ___1,500 km/s
___37,500 km/s ___15,000 km/s

What is the size of the largest observed structures in the universe?

___50 Mpc ___80 Mpc ___200 Mpc ___1,000 Mpc

What is Olber’s paradox?

___Why is the sky dark at night?
___Why do we appear to be at the center of the expanding universe?
___Why is the Hubble law isotropic?
___Will the universe expand forever?

What happened at the decoupling transition in the standard Big Bang model?

___Strong, weak, and electromagnetic forces were no longer one single force.
___electrons and nuclei combined to form atoms forming neutral hydrogen.
___Neutrons and protons were formed by combining quarks.
___Dark matter and baryonic matter no longer interacted.

Why is the possible discovery of water ice on the Moon important?

___possible source of fresh water for Earth ___possible that life would form there ___possible use as a resource for human habitation of the Moon.
___proves the solar system formed over 4 billion years ago.

Why is the possibility of liquid water on Europa important?

___possible source of cheap fresh water for Earth ___possible that life would form there ___the hydrogen can easily be used as rocket fuel ___proves the solar system formed over 4 billion years ago.

The star Betelgeuse has been measured by the Hubble Telescope to have a radius of about 7.5 \( \times 10^8 \) km. What is this in A.U.? About how far out would this extend if Betelgeuse were placed at the center of our solar system?

___2.5 A.U., beyond Mars but not the asteroid belt ___2.5 A.U., beyond the Earth but not beyond Mars
___5 A.U., radius of Mars’ orbit ___5 A.U. radius of Jupiter’s orbit
Very roughly, how long would it take the expanding shell of a supernova to cross the Milky Way? To reach the Andromeda Galaxy? (Assume the shell expands at a constant velocity of .1 c.)

___100,000 years for the Milky Way; 1 million years for Andromeda
___1 million years for the Milky Way; 20 million years for Andromeda
___1 million years for the Milky Way; 20 million years for Andromeda
___10 million years for the Milky Way; 100 million years for Andromeda

A certain telescope can just detect the Sun at a distance of 1,000 pc. What is the maximum distance at which it could detect a supernova with a peak luminosity $10^{12}$ times that of the Sun?

___$10^7$ pc ___$10^8$ pc ___$10^9$ pc ___$10^{10}$ pc

Astronomers have observed what they believe to be neutron stars by what means?

___gravitational lensing due to their strong gravity fields ___`lighthouse' effect due to its rapid rotation
___gravitational redshift of hydrogen spectral lines ___neutrino detectors in mineshafts.

The original shape of the cloud of gas that first formed the Milky Way Galaxy might still be seen in the shape of the

___disk ___halo ___galactic bulge ___spiral arms

The thickness of the Milky Way's disk in the vicinity of the Sun:

___30 pc ___300 pc ___3,000 pc ___30,000 pc

What evidence suggests that much of the matter in the Milky Way is `dark'?

___large regions in the galaxy where no stars are seen ___faint radio emission suggesting large regions of cool matter which would not emit visible light ___the rotation velocity vs. radius of stars as they orbit the center of the Milky Way ___detection of gravity waves.

The motion of stars and gas clouds in the vicinity of the center of the Milky Way suggests that it houses a ___.

___wormhole ___very large star cluster of white dwarf stars ___very massive cloud of gas which is to cool to emit visible light ___supermassive black hole

A certain telescope can see a star like the Sun at a distance of 10,000 pc. The brightest Cepheids are 10,000 times the luminosity of the Sun. How far away can this telescope see these Cepheids?

___$10^5$ pc ___$10^6$ pc ___$10^7$ pc ___$10^8$ pc

Hubble's law relates which two observed properties of a galaxy?

___recessional velocity and luminosity ___distance and recessional velocity ___peak luminosity and distance ___rotation rate and luminosity

What is the approximate distance to Andromeda?

___100 kpc ___10 kpc ___1 Mpc ___10 Mpc

Which of the following is the accepted interpretation of Hubble's law?

___As galaxies move outward, they are replaced with new matter created to take its place.
___The farther away a galaxy is from us, the faster it is moving away, because of the Big Bang, much like an ordinary explosion.
___Galaxies are pulled apart as the intervening space expands over time.
___Galaxies are stationary but over time they evolve and redden, giving the appearance of motion.

What is the `mainstream' explanation for the high redshifts observed in distant objects?

___They are rapidly moving away from us through the background space.
___They are at rest with respect to us, but the light has been gravitationally redshifted.
___Their light has lost energy over time while traveling this distance.
___In the time it took their light to reach us, the Universe expanded and, thus, their wavelengths have increased.

What is the origin of the cosmic microwave background?

___light remaining from the Big Bang ___the combined radiation of all objects too distant to see individually ___billions and billions of stars in the universe ___the total of all the synchrotron sources.

What type of spectrum is the cosmic microwave background?

___black-body ___emission line ___absorption line ___synchrotron

In the early Universe, when most of the energy was tied up in photons, what physical processes would have been common?

___pair creation and annihilation ___nuclear fission of heavy elements ___supernovae ___proton decay.

In the standard Big Bang model, once deuterium forms it is quickly converted into ___.

___helium ___carbon ___iron ___oxygen

At 15 minutes after the Big Bang (and after helium finished forming), what heavy element(s) formed?

___nitrogen ___oxygen ___carbon ___no other heavy elements formed
What is the most common type of galaxy?
___ elliptical
___ barred spiral
___ irregular
___ spherical

What future stages is our Sun likely to pass through as it dies?
___ supernova
___ carbon detonation
___ red giant to white dwarf
___ collapse to neutron star

What is plotted vs. what on an H-R diagram?
___ temperature vs. size
___ temperature vs. color
___ temperature vs. absolute brightness
___ absolute brightness vs. size

What two properties of a Cepheid variable are related to one another in such a way that we can estimate the distance to them?
___ size is proportional to absolute brightness
___ period is proportional to absolute brightness
___ period is proportional to temperature
___ size is inversely proportional to temperature

Very roughly: what is our best estimate for the age of the Earth?
___ 10 billion years
___ 4 billion years
___ 1 billion years
___ 100 million years

What causes sunspots?
___ carbon build-up in photosphere
___ magnetic fields
___ condensation
___ all of these