NAME: SOLUTIONS

BUCKNELL UNIVERSITY
Astronomy 101

Third Hour Exam — 2005 November 16

This exam will be scored on a 100 point scale and has three parts:
1) a multiple choice section containing 6 questions each worth 4 points,
2) a short answer section containing 3 questions each worth 12 points, and
3) a problem section containing 2 problems worth 20 points each.

Below are some relationships you might find useful:

for a circle:	circumference = 2 π radius
	area = π radius^2
for a sphere:	volume = 4/3 π radius^3
for an ellipse:	eccentricity = f/a
Kepler's Third Law:	(Period)^2 = (semi-major axis)^3
acceleration:	acceleration = change in speed per time
	or a = $\frac{\Delta v}{\Delta t}$
for circular orbits:	speed^2 = radius x acceleration
gravitational acceleration:	acceleration = $\frac{G \times mass}{radius^2}$
for constant acceleration:	distance = 1/2 acceleration x time^2
	or d = 1/2 a t^2

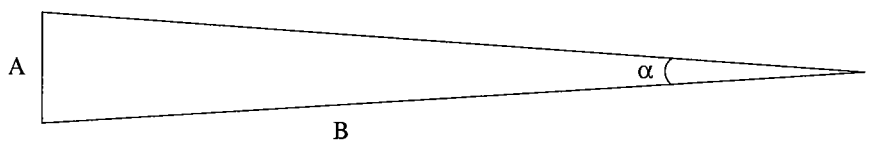
gravitational acceleration at the Earth's surface: 9.8 m/s^2

The lens equation: $\frac{1}{focal\ length} = \frac{1}{source-lens\ distance} + \frac{1}{lens-image\ distance}$

wave speed = frequency x wavelength (i.e., $v = \nu \times \lambda$)

photon energy:	$E_{photon} = \frac{h\ c}{\lambda}$
Wien's Law:	$\lambda_{peak} = \frac{3.0 \times 10^6 \text{K nm}}{T}$
the visible wavelength range:	$\lambda = 400 - 700$ nm (1 nm = 10^{-9} m)
Newton's gravitational constant:	G = 6.67 $\times$ 10^{-11} m^3 / kg s^2
Planck's constant:	h = 6.63 $\times$ 10^{-34} Joule seconds
radius of the Earth:	6.379 x 10^6 m
1 Astronomical Unit (A.U.)	1.496 x 10^{11} m
the speed of light:	c = 3.00 x 10^8 m/s
the speed of sound:	330 m/s

The Observer's Triangle Relation:



$$\frac{\alpha}{57.3^o} = \frac{A}{B}$$

Multiple Choice Questions (4 points each)

MC1. Double-rimmed craters are found on some planetary surfaces, caused by

a) an impactor that encountered a surface with material of different densities.

b) multiple impacts at the same location.

c) pyroclastic flow of molten rock during the impact.

d) erosion of an originally single-rimmed crater.

MC2. The moon Titan has a thick atmosphere, while the planet Mercury has virtually none, because

a) Titan is more massive than Mercury.

b) the Sun's gravity stripped Mercury of its atmosphere.

c) the cold gas in Titan's atmosphere is moving more slowly than the hot gas in Mercury's atmosphere.

d) there's more gas in the outer solar system, so Titan was more easily able to acquire an atmosphere.

MC3. The Magellan spacecraft was able to "see" through the clouds in Venus' atmosphere and map the planet's surface by imaging

a) ultraviolet light.

b) visible light.

c) infrared light.

d) radio light.

e) sound waves.

MC4. Both Earth and Io have active volcanoes. At what other location in the solar system has active vulcanism been observed?

a) Europa

b) Titan

c) Triton

d) Mars

e) Titania

↖ must be current for us to see it

MC5. Which of the following statements regarding Saturn's rings is *not* true?

a) They are composed of a variety of ices.

b) They are likely the material left over from the formation of Saturn and its moons.

c) They extend from the outermost reaches of Saturn out to Saturn's Roche limit.

d) They are only a few hundreds of meters thick.

e) They orbit under the influence of Saturn's gravity.

MC6. We infer that the surface of Venus is geologically young (i.e., 500 million years or so old) based on the fact that

a) volcanoes are currently active on the surface.

b) fault lines indicate plate tectonic motion.

c) the atmosphere has a density 100 times higher than that on Earth.

d) the lithosphere is very thick.

e) there are a small number of craters on the surface.

Short Answer Questions (**12 points each**)

SA1. Should Pluto be considered a planet? Explain why, and provide at least two pieces of hard evidence supporting your claim. (Note: I don't care which side of this argument you take — I'll grade your response based on how well you support your argument.)

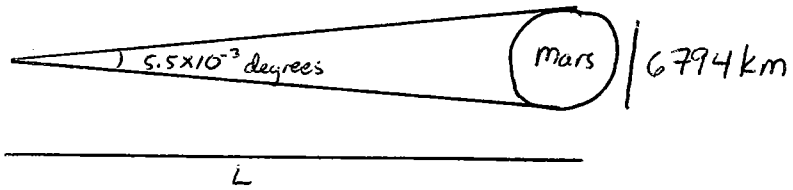
YES

- orbits the Sun
- has a moon
- is differentiated
- was first KBO discovered and remained the only such object for ~50 years
- has an atmosphere

NO

- member of Kuiper Belt (composition, orbit)
- not even largest KBO
- eccentric, inclined orbit
- mass less than all other planets and many moons

SA2. Mars, whose diameter is 6794 km, has an angular size of 5.5×10^{-3} degrees when viewed from Earth this week. How long does it take radio signals from the Spirit and Opportunity rovers on the surface of Mars to reach the NASA scientists here on Earth?



$$\frac{5.5\times10^{-3}}{57.3} = \frac{6794\ \text{km}}{L} \Rightarrow L = 6795\ \text{km}\ \frac{57.3}{5.5\times10^{-3}}$$

$$= 7.08\times10^{7}\ \text{km} \times \frac{1000\ \text{m}}{1\ \text{km}}$$

radio waves are light waves!

$$= 7.08\times10^{10}\ \text{m}$$

use speed of light

$$\text{speed} = \frac{\text{distance}}{\text{time}} \Rightarrow \text{time} = \frac{\text{distance}}{\text{speed}} = \frac{7.08\times10^{10}\ \text{m}}{3.0\times10^{8}\ \text{m/s}} = 236\ \text{s}$$

SA3. Explain why scientists think that environmental conditions were different on Mars some 2 billion years ago. Make sure you explain how things were different as well as what evidence leads us to this conclusion.

evidence: dry channels on surface ⇒ running water in past
extinct volcanoes ⇒ active vulcanism in past.

Running surface water implies that Mars once had a thicker, warmer atmosphere. Active vulcanism provided gaseous input, thickening the atmosphere. With a thicker atmosphere, the greenhouse effect warmed the surface. With higher atmospheric pressure & warmer temps, water can exist in liquid form (e.g. won't evaporate away or freeze)

Problems

Show your work! I will be very generous with partial credit if I can figure out what you're doing!

Here is some information regarding Pluto and it's moon Charon:

Property	Pluto	Charon
Radius	1160 km	635 km
Mass	?	1.8×10^{21} kg
Orbital radius (assume circular orbits)	5.9×10^{9} km	1.96×10^{4} km
Orbital period	7.83×10^{9} s	5.51×10^{5} s

P1. Calculate Charon's average density.

(20 points)

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{Volume} = \frac{4}{3}\pi\,(\text{radius})^3 \qquad r = 635\,\text{km} \times \left(\frac{1000\,\text{m}}{1\,\text{km}}\right) = 635000\,\text{m}$$

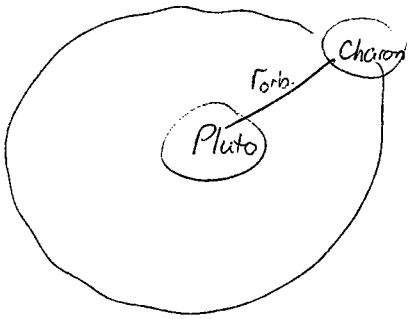
$$= \frac{4}{3}(3.14)(635{,}000\,\text{m})^3$$

$$= 1.07 \times 10^{18}\,\text{m}^3$$

$$\text{Density} = \frac{1.8 \times 10^{21}\,\text{kg}}{1.07 \times 10^{18}\,\text{m}^3} = 1680\,\text{kg/m}^3$$

P2. Calculate Pluto's mass.

(20 points)



speed of Charon $= \frac{2\pi r_{orb}}{P}$ (Charon's orbital properties)

$= \frac{2\pi\,(1.96\times10^{7}\,m)}{5.51\times10^{5}\,s}$

$= 224\ m/s$

acceleration Charon must feel to go in a circle

$$accel_{Charon} = \frac{v^2}{R} = \frac{(224\ m/s)^2}{1.96\times10^{7}\,m} = 2.6\times10^{-3}\ m/s^2$$

acceleration felt by Charon due to Pluto's gravity

$$accel_{Charon} = \frac{G\,M_{pluto}}{R^2} \Rightarrow M_{Pluto} = \frac{accel_{Charon}\,R^2}{G}$$

R = distance between Charon & Pluto

$$= \frac{2.6\times10^{-3}\ m/s^2\ (1.96\times10^{7}\,m)^2}{6.67\times10^{-11}\ m^3/kg\,s^2}$$

$$= 1.5\times10^{22}\ kg$$