NAME:_____

BUCKNELL UNIVERSITY
Astronomy 101

Second Hour Exam — 2005 October 19

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 4 questions each worth 9 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

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

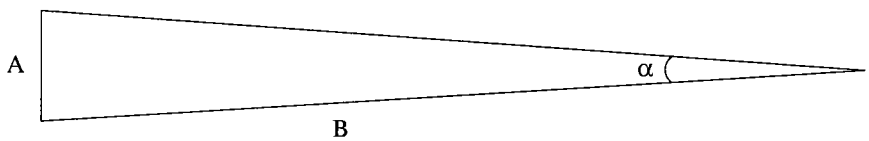
radius of the Earth: 6.379 x 10^6 m

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:



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

Multiple Choice Questions (4 points each)

MC1. Which of the following features of the present-day moon indicates that it might have been formed from the debris ejected when a large planet-sized body crashed into the Earth?

a) The Moon has very little iron in its core.

b) The Moon has a large number of craters.

c) The Moon orbits the Earth in an elliptical path.

d) One side of the Moon always faces the Earth.

e) Lunar maria are made from different material than the highlands.

MC2. The highest high tides will occur

a) when the Sun is directly overhead.

b) when the Moon is New or Full.

c) when the Moon is in First Quarter or Last Quarter phase.

d) when the Moon is farthest from Earth.

e) in spring, when the Sun is directly over the Equator.

MC3. Which of the following is *not* a greenhouse gas?

a) Nitrogen (N_2)

b) Carbon Dioxide (CO_2)

c) chlorofluorocarbons (CFC's) ← In addition to destroying ozone, CFC's are also greenhouse gases. (This was tricky)

d) methane (CH_4)

e) All of the above are greeenhouse gases.

MC4. If I heat a ball bearing to a temperature of about 720 K, it will glow with an orange-y color (this is what I did in class on 28 September). Imagine that I continue to heat the ball bearing until it is roughly twice as hot. What can you say about the ball bearing?

a) The color remains the same, but it glows with an intensity that's about twice as bright.

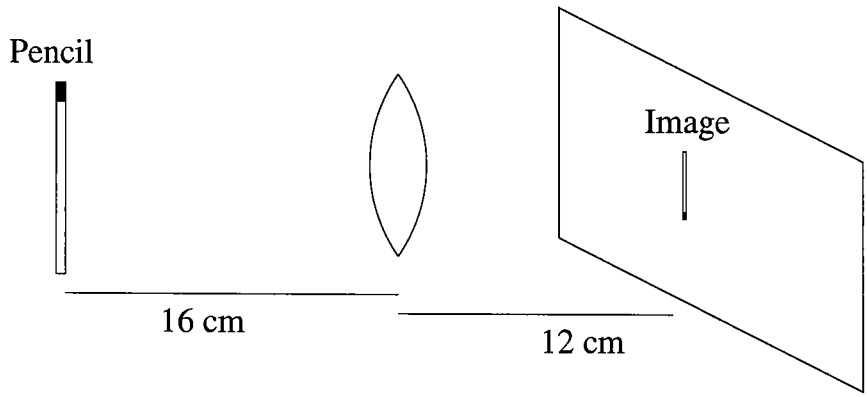
b) It glows white with an intensity that's about twice as bright.

c) It glows white with an intensity that's much more than twice as bright.

d) The color remains the same, but it glows with an intensity that's much more than twice as bright.

e) It glows white with an intensity that's about the same brightness.

MC5. In the diagram below, a pencil is placed a 16cm from a lens, and a sharp image is produced at a distance of 12cm behind the lens.



$\frac{1}{f} = \frac{1}{12} + \frac{1}{16}$

What is the focal length of this lens?

a) 4 cm

b) 6.86 cm

c) 9.04 cm

d) 28 cm

e) 48 cm

MC6. I'm observing the star Altair with one of the Observatory's telescopes. If I decide that I want to observe another object with the same Declination, but a larger Right Ascension, which way will I have to move the telescope?

a) north

b) south

c) east

d) west

Short Answer Questions (9 points each)

SA1. What causes the *aurora borealis*? Be as specific as you can.

Charged particles emitted by the sun (i.e., the solar wind) are deflected by the Earth's magnetosphere toward the polar regions. These particles crash into molecules in the Earth's upper atmosphere. The molecules become excited and emit spectral line radiation producing the aurora borealis, or northern lights.

SA2. A particular transition of an excited iron atom liberates 2.4×10^{-20} Joules of energy in the form of a single photon. Calculate the wavelength of this photon, and comment on whether it would be visible to us.

$$E_{ph} = \frac{hc}{\lambda}$$

so

$$\lambda = \frac{hc}{E_{ph}} = \frac{(6.63 \times 10^{-34}\ \text{J s})(3 \times 10^{8}\ \text{m/s})}{2.4 \times 10^{-20}\ \text{J}}$$

$$= 8.28 \times 10^{-6}\ \text{m}$$

$$8.28 \times 10^{-6}\ \text{m} \times \left(\frac{10^{9}\ \text{nm}}{1\ \text{m}}\right) = 8287\ \text{nm}$$

This wavelength is not in the optical range (400-700nm), so it is not visible to our eyes.

SA3. The planet Zork has a radius of 3800 km, and a mass of 1.4×10^{24} kg. Calculate the average density of this planet.

Density = MASS/Volume

Volume = $\frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi (3800\ km)^3$

$= 2.3 \times 10^{11}\ km^3$ (or $2.3 \times 10^{20}\ m^3$)

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{1.4 \times 10^{24}\ kg}{2.3 \times 10^{11}\ km^3} = 6.09 \times 10^{12}\ kg/km^3$$

(or $6090\ kg/m^3$)

SA4. Give two separate reasons why the Moon has no atmosphere.

1) There's no current internal heat source within the Moon, and no molten core. Consequently, there's no convective motion to drive plate tectonics and vulcanism to liberate gases into an atmosphere.

2) Because of it's small mass, the Moon has a weak gravitational pull and this pull is not sufficient to hold gases in an atmosphere.

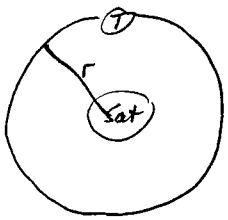
Problems

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

P1. Saturn's moon Titan orbits the planet in a circular path with radius of 1.22×10^9 m. Its orbital period is 15.9 days ($= 1.37 \times 10^6$ seconds).

a) Calculate the speed of Titan in its orbit.

(8 points)



$$\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{P}$$

$$= \frac{2\pi\,(1.22\times10^{9}\,\text{m})}{1.37\times10^{6}\,\text{s}} = \underline{5595\ \text{m/s}}$$

b) From this information, calculate the mass of Saturn.

(12 points)

for circular motion $\quad \text{acceleration} = \frac{v^2}{R}$

$$= \frac{(5595\ \text{m/s})^2}{(1.22\times10^{9}\,\text{m})} = 0.026\ \text{m/s}^2$$

for gravitational attraction $\quad a = \frac{GM}{R^2}$

so

$$M = \frac{aR^2}{G} = \frac{(0.026\ \text{m/s}^2)(1.22\times10^{9}\,\text{m})^2}{6.67\times10^{-11}\ \text{m}^3/\text{kg s}^2}$$

$$= \underline{5.7\times10^{26}\ \text{kg}}$$

P2. The asteroid Pallas orbits the Sun with a period of 4.62 years, and an eccentricity of 0.233.

a) Calculate the semi-major axis of Pallas' orbit.

(8 points)

$P^2 = a^3$ if and only if P in years, and a in A.U.

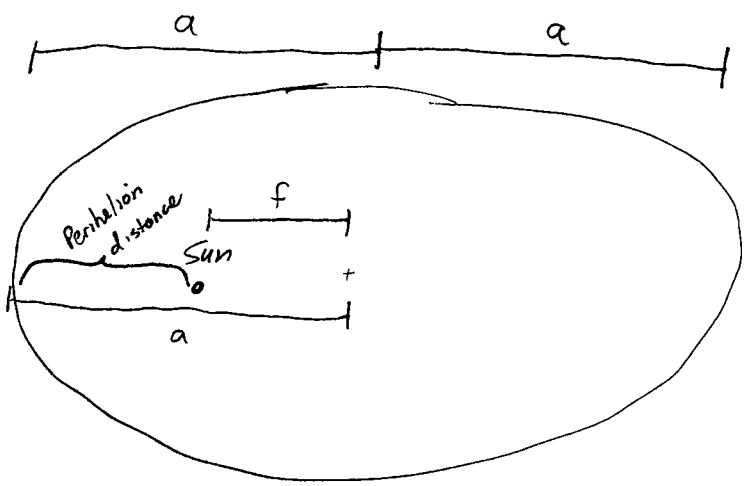
$(4.62)^2 = a^3$

$\sqrt[3]{4.62^2} = a = 2.77$ A.U.

b) In the space below, draw a diagram indicating the orbit of this comet, the semi-major axis of its orbit, and the position of the Sun.

(10 points)

1) elliptical orbit
2) Sun at a focus
3) semi-major axis is one-half the major axis



c) Calculate the perihelion distance (i.e., the distance of nearest approach to the Sun) for this asteroid.

(2 points)

$f = ea$

$= (0.233)(2.77)$

$= 0.64$

Perihelion distance $= a - f$

$= 2.12$ A.U.