Observational Astronomy / NYU, Fall 2013

MIDTERM

1. We studied several coordinate systems, in particular two coordinate systems are the most useful to us. Name them, and describe which is tied to the observer, which to the celestial objects (and what that means). Each system describes the position of an object with a set of two numbers. What are those numbers in each system? You also need 2 reference points. What are those?

2. Sirius is the brightest star in the night sky. Here are Sirius coordinates:

RA 06h 45m 08.9sec Dec -16 42 58.0sec

   1. convert these coordinates from Sexagesimal (the format hh:mm:ss, dd:mm:ss that i gave you) to degrees and fractions of degrees.
   2. given its coordinates: when will Sirius transit (i.e. its meridian will cross the zenith) in the time of our labs (7-9pm). (Have you taken into account daylight saving??)
   3. Will we be able to see it (weather permitting) this semester?

3. The axial tilt of planets is what determines the alternation of seasons on planets. Look up the Solar System planets with the *largest* and *smallest* axis tilt. Note: for the purpose of this exercise you want to describe the axis tilt in the 0-90 degree interval: it does not matter if the spin is prograde or retrograde, it just matters how far the spin axis is from being perpendicular to the orbital plane.
   a. What is the size of the polar circles on those planets.
   b. What is the size of the tropics on those planets.
   c. Speculate on the thermal excursion that should occur on this planet: that, intuitively, is related to the duration of the

day/night cycle. (In reality: the composition of the atmosphere, the presence of internal sources of heat, the circulation of heat patterns which is relate to winds, the magnetic field… all matter: climatology is a complex science!!)

4. Newton's formulated the law of gravity. $F = G \frac{m1*m2}{r^2}$; G is a constant:

$G = 6.67384 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$

so *on the surface* of the Earth your weight is a measure of the *force* with which the Earth pulls on you given: a) your mass, b) the Earth's mass, c) your distance to the center of the Earth. Knowing that, find solar system object where your weight would be roughly the same as it is on Earth. Optional: if you are familiar with any plotting program, or if you can draw it, make a plot of the relevant quantities for the solar system objects you considered.

5. The Greek philosopher Eratosthenes was the first to measure the circumference of the Earth. He noticed the light from the sun would, on a particular day, fall vertically over a well in Syene, a town directly south of Alexandria of Egypt. He noticed that instead the sun appeared at the same time, on the same day of the year, to be at an angle from zenith if he was in Alexandria: an angle of about 7^o 12'. He then had someone walking (or so goes the legend) from Alexandria to Syene to measure the distance between the two: about 925,000 km. With this information (and knowing the sun is very, very, very far away) he was able to get to a fairly correct number for the circumference of the Earth!

   a. Do the same; is your estimate of the circumference of the Earth reasonable?
   b. Could Eratosthene have done it if, instead of Greek, he were for example British, or South African (I do realize neither Britain nor South Africa existed politically at the time, but that is not the answer!)?

6. Remember the rule of small angles we covered in the first lecture. Callisto is the farthest of the four Galilean satellites of Jupiter. Its maximum angular separation from Jupiter occurs when Callisto is at apocenter, AND the earth and jupiter are at conjunction, the closest point they can get to each other in their orbits, (and its orbit is aligned such that the apocenter radius lies perpendicularly to the line of sight -- assume tha that is the case)
    a. Look up the orbital parameters for Callisto. Knowing Callisto's apocenter, and that Jupiter's orbit is 5.2 AU, what is the maximum angular separation between Callisto and Jupiter?
    b. Remember that the human eye has a ~5mm diameter pupil. Do these numbers alone explain why nobody was able to observe Jupiter's satellites before the invention of the telescope? If not, speculate why instead.

7. Some stars appear double in blue light, but they cannot be *resolved* in red light from the same telescope. Why?

8. What is the most common shape for a telescope mirror? Why?

9. What mirror diameter gives 1 arcsec resolution for radiation of λ=2 micrometers wavelength? What electromagnetic regime is that? What would it need to be for λ=2m? (yikes!!) what electromagnetic regime is that? And λ= 100 micrometers?

10. What are the focal plane, the focal length of a telescope?

11. Draw a schematic sketch to show why images seen in telescopes appear flipped on the vertical and horizontal axis

USEFUL FORMULAE:

- small angle approximation:

$$\vartheta \sim \frac{\text{projected size}}{\text{distance}}$$

- conversion from seconds to degrees and radians

x arcsec = x/3600 degree

$$x \text{ degree} = \frac{x * \pi}{180} \text{ radians}$$

1 hour = 15 degrees

- resolving power:

$$\vartheta = \frac{1.22 * \lambda}{D}$$