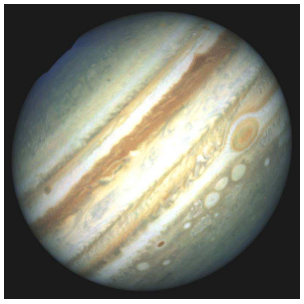
Your name: _____ **TA name: _____**

Written HW 7: Planets
(due Tues, Apr 28, 2009 at 5 PM)

Turn in this written homework in the appropriate slot in the brown Homework Cabinet at the entrance of the HelpRoom, Duane G2B90. Please STAPLE pages together, and **put your name and TA name at the top of every page!**

In all written homework, you will be graded on the clarity and completeness of your answer. ***No credit*** *will be given for an answer in a calculation without a derivation, even if the answer is correct. A calculation without units is also incorrect.*

The primary optical element of the Hubble Space Telescope (HST) is 2.4 m in diameter and has a focal length of is 57.6 m. The telescope is aimed at Jupiter and the collected light is focused onto a sensitive Charge Coupled Device (CCD) detector, similar to what is in a digital camera. Each pixel in the detector is a 21 μm × 21 μm square, and the full CCD is 1024×1024 pixels. Thus the CCD is about one square inch in size. The HST is in orbit very close to the Earth (compared to other distances in the Solar system).



a) Is the image real or virtual? Magnified or reduced? Upright or inverted?

b) Look up the size of Jupiter and the distance to Jupiter when it is closest to Earth. Use the lens formula to determine the magnification of the image. How many pixels in diameter is Jupiter's image on the CCD? How large a square on the surface of Jupiter does one pixel in the image represent?

c) Estimate the total amount of light energy collected by one pixel in a 10 second exposure, as follows: Each square meter of the surface of Jupiter radiates about 20 watts of visible light due to the sun's illumination. First find the total power radiated by an area on the surface of Jupiter that corresponds to one pixel in the image. That power is spread out across the entire hemisphere whose radius is the distance to the earth. Determine the power that is collected by the telescope optics from that piece of Jupiter's surface and assume all of that power is focused onto the pixel in question. Note: the smallest detectable energy from visible light (one **photon**) is about 4×10^{-19} Joules. Roughly how many photons of visible light are collected by the pixel in a 10 second exposure?

d) Repeat your analysis for part (b) for Pluto. Explain why additional optics are needed between the primary mirror and the CCD array to form a useful image of Pluto and its moon Charon.