PHY305A
Exercise Set 1

1. Determine the angular diameter of Sirius, the brightest star in the sky. It's radius is 1.71 times the radius of Sun and distance from Earth is 2.64 pc. Compare this with the angle subtended by Jupiter on Earth when the distance between the two is (i) smallest and (ii) largest. The mean radius of Jupiter is 69,911 Km. It's mean distance from Sun is 778 million Km.

2. How was the mass and radius of the Earth measured historically? What is the best method to measure it at present?

   Historically one of the measurements of the radius of Earth was made by Eratosthenes who lived in Cyrene around 200 BC. He knew that on the summer solstice at noon, the solar radiation is perpendicular to the surface of the Earth in city of Syene, whose modern name is Aswan. At the same instant he measured the inclination of the rays in Alexandria, which is located approximately north of Syene, to be $1/50$ of a complete circle. Knowing the distance between the two he could deduce the radius. The mass was deduced after a measurement of the gravitational constant G by Cavendish in 1797-98. Learn more about this from the internet.

3. How was the mass and radius of Moon and Sun measured historically? What is the best method to measure it at present?

   Historically one of the measurements of the radius of the Moon and the Sun was made by Aristarchus. Learn about these measurements from the internet.

4. Use Stellarium to observe the trajectories of different planets, the Sun and the Moon. Notice that the trajectories of all the planets and the Moon lie roughly in a plane close to ecliptic, the plane of apparent motion of the Sun.

5. Use Stellarium to see the retrograde motion of a planet, such as Mars, as explained in class.

6. Determine the relationship between a sidereal and a solar day. Verify that the mean solar day is approximately 4 minutes longer than a sidereal day.

7. Determine the energy in eV of a radio, visible, x-ray, and γ-ray photon. Assume that their wavelengths are 10 cm, 500 nm, 0.1 nm, and 10^{-5} nm, respectively.

8. The Hubble Space Telescope has a primary mirror of diameter 2.4 m. Determine its angular resolution at a visible wavelength of 500 nm. Determine the resolution of the Very Large Array (VLA) at a wavelength of 2 cm, assuming a baseline of 35 Km. Determine also the resolution of a Very large baseline Interferometer (VLBI), that has a baseline of 1,000 Km at 2 cm wavelength.

9. Verify the conversion of Planck's constant, h, from Kg m^2/s to eV·s:

$$h = 6.6261 \times 10^{-34} \text{ Kg m}^2/\text{s} = 4.1357 \times 10^{-15} \text{ eV} \cdot \text{s} . \tag{1}$$

10. A plane parallel model of the atmosphere is explained in the figure. Show that

$$n_0 \sin \xi = \sin \theta$$

Hence determine the deviation $\delta\theta = \theta - \xi$ approximately. Here n_0 is the refractive index of the layer near the Earth's surface.

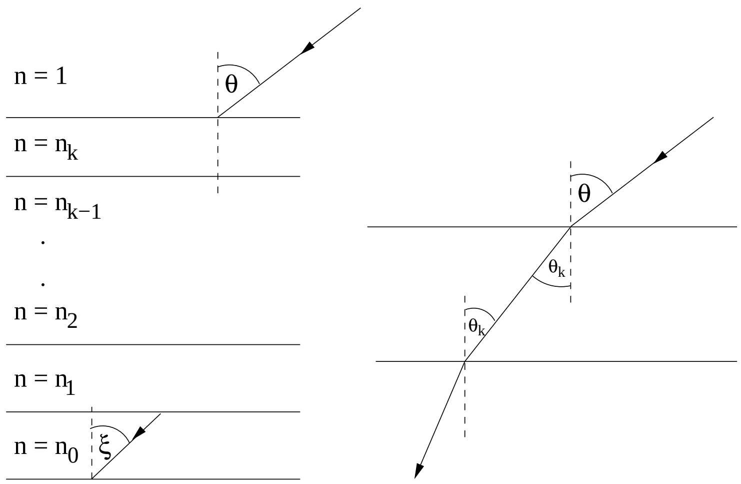

Figure 1: A plane parallel model of the atmosphere. We split the atmosphere into several layers with refractive indices n_0, n_1 ... n_k. Beyond the k$^{\text{th}}$ layer we assume that the refractive index is unity, corresponding to vacuum. A ray of light strikes the top of the atmosphere at an angle θ relative to the normal to the surface. After undergoing refraction through the atmosphere, it strikes the surface of Earth at an angle ξ.