Astrophysics/Astronomy Problems

Every question counts as a single point, except starred problems (*) which count as 2 points. Double starred problems (**) also count as 2 points, and will be used to decide in the case of a tie.

1. **(**)**History changed on October 4, 1957, when the world's first artificial satellite, Sputnik I, was successfully launched. It was about the size of a basketball, a sphere of 580 mm in diameter with a mass of 83.6 kg and a 2 mm thick surface of highly polished aluminium alloy. The Russian word "sputnik" means "companion" ("satellite" in the astronomical sense). Sputnik I had an elliptical orbit - at perigee, just after launch, it was 227 km from the Earth's surface, and 945 km at apogee. It remained in orbit until January 4, 1958.

   Estimate (with necessary figures and calculations), whether was it possible to observe the satellite with the naked eye.

2. **(*)**Make an estimate of the number of moon rises /moon sets visible in one year.

3. You are a polar bear sitting on the north pole of the earth. Estimate the duration of sunrise.

   Also, assume that a penguin, sitting on the south pole, and the bear were talking on the phone during the sunrise for the bear. Describe what the penguin is observing at that instant, and a few minutes before and after that instant.

4. **(**)**Scientists were observing a small flashing object in the sky. A few months of observations and tracking the object led the scientists to believe that the object resided in our solar system, in the asteroid belt. It had a size similar to Ceres. More observations showed scientists that the surface of the asteroid was covered with completely with black cats, all staring in random directions. Moreover, all the cats blinked in unision, leading to the flashing effect observed. Estimate the magnitude of the object as observed from earth.

5. **(*)**What is the conversion between square degrees and steradians?

   What is the area of a sphere in square degrees?

   What is the ratio of area covered by the summer triangle in the sky w.r.t. the area of the entire celestial sphere?

6. Why does NASA have it's space launches from the east coast of USA rather than the west coast?

(*)Can you make an estimate of the magnitude of difference in the two cases (energy, money or by any other measure)?

7. The image of the moon on the 21st of march of a particular year is as shown. Estimate it's right ascension.

8. In some versions of greek mythology, Zeus threw down Hephaestus, the god of the blacksmith's fire, down from heaven in a fit of rage. Legend says that Hephaestus fell for nine days and nine nights, and he landed on the island of Lemnos. If this was indeed true, then how high up is heaven?

Hesoid, a greek poet, also collaborates with this story when talking of falling anvils. he claims not only that the anvil would take 9 days and 9 nights to reach earth, as mentioned above, but he also says that if the anvil fell into a deep hole in the earth, then it would take 9 more days, and 9 more nights before reaching Tartarus, a part of the greek underworld. How deep is Tartarus?

9. Some people say that if clocks were invented in Australia, then they would all run counter-clockwise. Why? What does the direction of rotation of a clock have to do with where it was invented?

10. **(*)**How much brighter does the 'full' Earth appear from the Moon, as compared to the full moon from the earth?

11. What is the minimum number of geosynchronous satellites I need to be able to

completely acces any point on earth? Can i even achieve this? What if I only want to access every point on the equator of the earth?

(**)In the case that i want to access only every point on the equator of the earth, what is the highest latitude i can go to to ensure un-interrupted service through out that latitude?

12. The brightest star Sirius has a declination of about 16.5 degrees S. How much time it will remain above horizon for an observer at Kanyakumari (8. degrees N)?

13. I have a very bright torch with a wavelength around 500nm. I shine it far ahead in the distance and see it reflecting of something, which I was later told is a cat. Intrigued, i took out my 4 inch telescope and tried to observe it. How close must the cat have been for me to be able to resolve the reflected light as coming from 2 separate eyes, as opposed to reflecting of a single reflecting source?

14. Sirius is at a distance of 2.7 kpc and moving towards us at 8kms/s. In how many years will its brightness be doubled?

15. Should we launch a spaceship to Mercury during the day or night?

16. The orbital velocity of the sun around the centre of the Milky Way is 220 Km/s at a distance of 8.5 kpc. Find the mass of the Galaxy using Kepler's laws. Should Kepler's laws be used in this calculation?

17. Why can radio astronomers observe during the day, whereas optical astronomers are (for the most part) limited to nighttime observing?

18. Let us consider that observer is sitting on a planet of Sirius. Which object is brighter one in his sky: Our Sun or the stars of the Big Dipper?

    From Sirius, what will the angle between the Sun and Megrez(a star of the Big Dipper) be?

19. From a location at 45degrees latitude, how many stars can i see throughout the duration of a year? Assume that in the entire celestial sphere a human can see upto 6000 stars.

20. A martian rover has only the capability to see upto 20 metres ahead of it. Assuming that it has no autonomous control, and it must be controlled from Earth, then estimate the maximum safe velocity the rover can travel at.

21. By appoximately how many degrees would Pluto have shifted since the time of it's discovery?

22. What is the limit on the size of an asteroid, from which an astronaut can jump off and escape permanently?

23. **(*)**Surprisingly, the friction due to the upper layers of an atmosphere can actually increase the velocity of the satellite, rather than decrease it. Justify using energy arguments how this is possible.

24. Assume the earth was suddenly stopped in it's orbit by some supernatural means. At time t=0, it starts falling towards the Sun. In approximately how much time will it fall entirely into the Sun.

25. **(*)**An asteroid with properties similar to Ceres falls onto the surface of the Earth on Kanpur. Assume that the loss in mass due to friction with the earths atmosphere was negligible, and the velocity at the time of impact was roughly 20 kmps. Estimate the depth of the crater formed due to the impact.

26. **(**)**Assuming that there are about 6000 stars of 6th magnitude or lesser, and that stars are uniformly distributed in space, estimate the number of stars with magnitude less than 0.

27. What is the smallest possible time period of revolution of a neutron star with M=Msun, and R=30km?

28. Estimate the mass of saturns rings.

29. **(*)**There are two photos of the Moon taken by the same camera mounted on the same telescope (the telescope is placed on the Earth). The first photo has been made while the Moon was near its perigee and the second one - near the apogee. Find from these data the value of the Moon's orbit eccentricity.

30. If the earth stopped rotating, would we still have day and night? How would they change?

31. **(*)**If the surface of the moon was changed from how it currently is, to a perfectly reflecting one, then how would it look like from earth? Describe the phases and all other related lunar phenomena.

32. There are 365.24 mean solar days in a year. How will this number change if the rotation of the Earth were happening with the same period, but in the reverse direction?

33. How could astronomers in the pre-spaceflight epoch determine the reflective properties (albedo) of the Earth?

34. **(*)**Observations showed that the angular diameter of the Crab nebula increases by 0.4" every year. At the same time the double spectral lines are observed with the distance between the lines $\Delta\lambda/\lambda$=0.008. Why do we see a double line instead of a single line? Estimate the distance to the nebula.

35. Suppose that around each star there is a planet with Jupiter's mass and orbital period. Determine at a star of what mass it is easier to discover the presence of a planet if one measures:

    a) angular displacement of a star,

    b) variation in a radial velocity of a star.