5th Canadian Astronomy Olympiad 2021

1. ***Satellite.*** Phobos has a radius of 11 km while Mars has a radius of 3390 km. Phobos has a circular orbit around Mars which is inclined at 0° to Mars's equator. The period of Phobos is $7^h\ 40^m$, while the time it takes for Mars to complete a full rotation around its axis is $24^h\ 37^m$.
    a) How many times in a Martian day does Phobos rise above the horizon?
    b) Where on the horizon does Phobos rise?
    c) Suppose Mars was inhabited by Martians. Would it be practical for them to create a calendar using Phobos analogous to the lunar calendars we have on earth? There is no single correct answer, but please justify your opinion with three reasons backed up with calculations.

2. ***Seasons.*** A common misconception is that summer and winter are caused by the changing distance between Earth and the Sun. In reality, however, the seasons are caused by Earth's tilt. For an observer at a latitude of 55°, find the ratio of the solar irradiance at noon of summer solstice to the irradiance at noon of winter solstice due to Earth's tilt (without considering the changing distance). Find the ratio of the irradiances due to Earth's changing distance from the sun (without considering Earth's tilt). Compare the two ratios. What can you conclude?

3. ***Polar night.*** A city has a latitude of 68° 58'. Find the length of the polar night in this city.

4. ***Galaxy.*** Galaxy M96 in Leo has an angular size of 11' by 8' and an apparent magnitude of 10^m. The wavelength of light emitted in the H and K bands is shifted by 10.3 Å. Given that the wavelengths of ionized calcium are 3968 Å (H) and 3934 Å (K), find the galaxy's
    a) radial velocity,
    b) distance to Earth,
    c) linear dimensions,
    d) absolute magnitude, and
    e) luminosity.

5. ***Telescope.*** The photo below shows a picture of the moon taken at the prime focus of a telescope with a CCD chip with dimensions 22.2 by 14.8 mm. The ratio of the sides of the photo is the same as the ratio of the sides of the CCD chip. Find the focal length of the objective lens of the telescope.

6. ***Beginner Astronomer.*** An amateur astronomer (φ = +45°) is observing a galaxy in upper culmination at solar midnight on June 21st (summer solstice). They leave for a late-night snack but end up watching 3 hours of TV instead. When they come back 3 hours later, they look at the galaxy again without repositioning their telescope and of course cannot find it. Not knowing that they should reposition their telescope, they think, "Since Earth moves around the Sun and rotates around its axis, is it possible that an increased distance to the galaxy caused it to become too dim to see?"

Prove this astronomer wrong by calculating the change in apparent magnitude of the galaxy during the time they were watching TV. Also calculate the actual apparent magnitude and find the ratio of the two values. Assume Earth's orbit is circular and the galaxy is stationary relative to the Sun. You may use the following data about the galaxy:

Distance to the Sun (d) = 810 kpc

Surface brightness (μ) = 23.65 mag/arcsec^2

Radius (r) = 12 kpc