IntroAstro 2012-2013

Homework Set 1-B Solutions

1. The apparent daily rotation of the sky from East to West is a result of Earth's spin about its axis from West to East. This would thus remain unchanged. The sidereal day is the time it takes Earth to spin once about its axis. This too does not depend upon orbital motion so would not change. A Solar day is the (average) time from Noon to Noon, and differs from the sidereal day due to the Earth's orbital motion. Since the Earth orbits to the East, in the same sense as it rotates, our Solar day is 4min *longer* than a sidereal day (this is the 1/365 additional rotation needed to make up for the Earth's orbital motion during the day). If the Earth were to orbit to the West, a Solar days would be 4min *shorter* than the sidereal day. This would make them 8min shorter than they are now. The Sun's motion around the celestial sphere is also a result of Earth's orbital motion. If Earth were to orbit to the West, Sun would appear to move to the West around the celestial sphere, once a year.

   The answer here is **C**.

2. Regulus, which has RA 10h 8m, will be at the Zenith for optimal viewing when sidereal time is 10h 8m. On March 21, sidereal time differs from local time by 12h (the Sun, overhead at Noon, is at RA 0h at the Vernal equinox). April 21 is about 30 days after March 21, and since a sidereal day is 4min shorter than a Solar day, sidereal time will now be ahead of local time by approximately $12\,\mathrm{h} + 30 \times 4\,\mathrm{m} = 12\,\mathrm{h} + 120\,\mathrm{m} = 14\,\mathrm{h}$. ST of 10h will thus correspond to local time $10 - 14 = -4 \sim 20$ or **8pm**.

   The answer here is **D**.

   Remember that all of this is approximate. In particular, 4min per day is an approximation. To avoid accumulating errors, select as a starting point for the calculation the annual event closest to the date in question. The four events are March 21, June 21, September 21, and December 21, on which sidereal time is ahead of Solar time by approximately 12h, 18h, 0h, and 6h respectively.

3. Seasonal variations are due to the Earth's tilt. The higher the tilt angle the more extreme the variations. In the extreme case of a 90° tilt as is (approximately) the case on Uranus, the equator doubles as the arctic/antarctic circle. Except on the

equator every point experiences 24h darkness in winter (for at least one day) and 24h daytime in summer. At the same time, the entire planet is in the *tropics*. Every point except equator and poles will experience two days during which Sun will be directly at Zenith.

The answer here is **C**.

4. The Moon achieves its maximal altitude for the day (or night) when it crosses our meridian. At that point its Zenith angle is the difference between our latitude and the Moon's declination. So the maximal altitude will occur at meridian crossing when the Moon's declination is as close to 42°. How close does it get?

   The Moon's orbit is tilted 5° to the ecliptic. It can thus be found, at various times, on the ecliptic, or as much as 5° North or South of the ecliptic. The ecliptic, in turn, is tilted 23.5° to the celestial equator, so lies between declination 23.5° and $-23.5°$. The Moon's declination is thus closest to 42° when it is 5° North of the ecliptic at the ecliptic's northernmost point, at declination 28.5°. When it crosses the meridian that day (or night) it will lie $42 - 28.5 = 13.5°$ South of the Zenith. Its altitude will thus be $90 - 13.5 = 76.5°$. Rounding this to two significant digits we have 77° so the answer to be entered is **77**.

5. If the Moon is full when observed at this altitude, we know that at the moment of this observation full Moon is the point of maximal Northern deviation from the ecliptic along the Moon's orbit. The New Moon thus lies 5° South of the ecliptic, and eclipses will not occur.

   Eclipses will occur when the Full and New Moon lie along the *line of nodes*, where the tilted lunar orbit meets the ecliptic. This is the situation in which Sun, Earth, and Moon can lie on a line. The line of nodes precesses, relative to the Earth-Sun line, completing a full rotation once every *eclipse year* of 346.6 days.

   In the situation described, the line of nodes is perpendicular to the Earth-Sun line. It will next coincide with this line - along which lie the Full and New moon points, in one-quarter of an eclipse year or about 86.65 days. Around that time will be the next *eclipse season*.

   A lunar eclipse will occur during an eclipse season at full Moon. Since we start at full Moon, this will occur after an integer number of synodic months of 29.5 days.

The third full Moon after the one observed when our problem starts will occur in $3 \times 29.5 = 88.5$ days. Falling only two days after the center of the eclipse season, this full Moon will almost certainly be eclipsed. Of the answers provided, the one matching this calculation is **89** days.

The answer here is **D**.