

Astronomy 301

COMMENTS ON HOMEWORK 1

In many cases the answer to a question is in the text or was discussed in class. These comments are intended to clarify a few points. I generally do not provide answers that may be memorized and then regurgitated in the event (not improbable) that the question or its close relative appears later in the semester.

In general, answers to Part B questions were readily faulted for being too concise – often, the critical points were left unexplained or a few words preceded by a critically placed 'since' or 'because' were provided as a poor substitute for an answer. Take time to think through the explanation requested, and then write it out in your own words. Remember a neatly drawn diagram is often helpful.

Part A

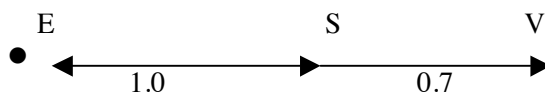
- A1. Venus orbits the Sun at a distance of about 0.7AU, as stated in the book. This estimate is also obtainable from the Figure on page 3.

A note on the use of the word 'about'. What do I mean when I say the AU is about 93 million miles? The length of the AU is now known very accurately: one source gives it as 149.59787 million km. When I qualify the distance as 'about' 93 million miles, I am rounding the number off and am content to convey the impression that it is a huge distance by terrestrial standards.

A different case is presented by the statement that 'the distance from the Sun to the center of the Galaxy is 'about' 25,000 light years. Our estimates of this distance are not very precise. One method may give 24,000 LY and another 27,000 LY, for example. So in this case, 'about' is used because we do not know the true distance more precisely than 1000 LY or so.

Watch out for these different uses of the simple word 'about'.

- A2. The orbits are almost circular. When Earth and Venus are at their maximum distance apart, Venus is on the far side of the Sun from us:



The V-E separation (see diagram) is then $1.0 + 0.7 = 1.7$ AU.

- A3. a.

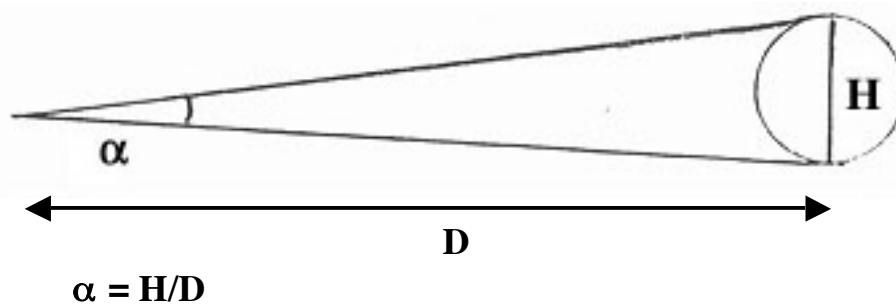
- A4. a.

- A5. Full rotation takes 24 hours and is 360 degrees. Simple math tells us that in 1 hour the rotation is $360/24 = 15$ degrees.

- A6. Also 15° , of course.

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A7. Angular size is proportional to the real size of the object divided by its distance from the observer – as seen in this sketch:



This means we may write the angular size of the Sun as seen from Earth as $\alpha = H/D$. The question tells us that $\alpha = 0.5$ degrees and by definition $D = 1$ AU. Rearranging $0.5 = H/D$ we get $H = 0.5$ if we measure angular size in degrees and distance in AU.

Let the angle subtended on Mercury by β . Distance between Mercury and Sun is 0.4 AU. Then,

$$\beta = \frac{H}{D} = \frac{0.5}{0.4} = 1.25^\circ$$

I think it easier to do this as a proportionality.

Angular diameter of Sun is inversely proportional to distance from the Sun:

Then,

$$\alpha \propto \frac{1}{D}$$

$$\frac{\alpha_M}{\alpha_E} = \frac{D_E}{D_M}, \quad \alpha_M = \alpha_E \frac{D_E}{D_M} = 0.5 \frac{1}{0.4} = 1.25^\circ$$

which gives the same answer of 1.25 degrees.

A8. An essential point is that our Galaxy is a member of the Local Group – that's why we refer to it as 'Local'.

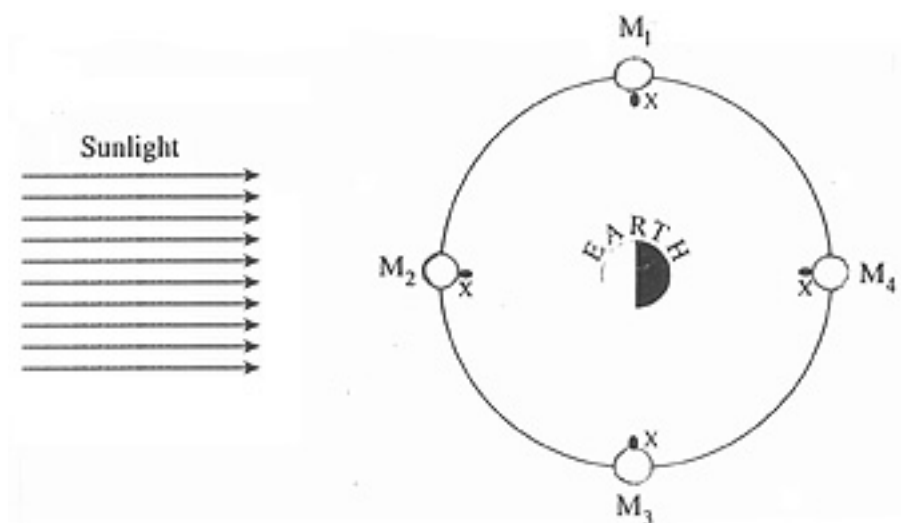
A9. See Chapter 1. Size of galaxy is said to be about 75,000 LY in diameter. This means travel time for the diameter is 75,000 years.

A10. b.

A11. b.

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A12. In the following diagram, I've marked your position by the X; this always gives you a fine view of the Earth.



At M₁ (and M₃) the Earth is seen by X at quarter phase .

At M₂, the Earth is seen as full. At M₄ the Earth is seen as new. Crescent phases occur between M₃ and M₄, and M₄ and M₁. Gibbous phases occur between M₁ and M₂, and M₂ and M₃. One point implicit in the above diagram is the fact that the Moon orbits the Earth keeping the same face towards us. This is why I've marked your position with an X and kept the X facing the Earth. (Does the Moon then spin on its axis? If so, then at what rate?) (Why does the Moon rotate in this way?)

A13. b.

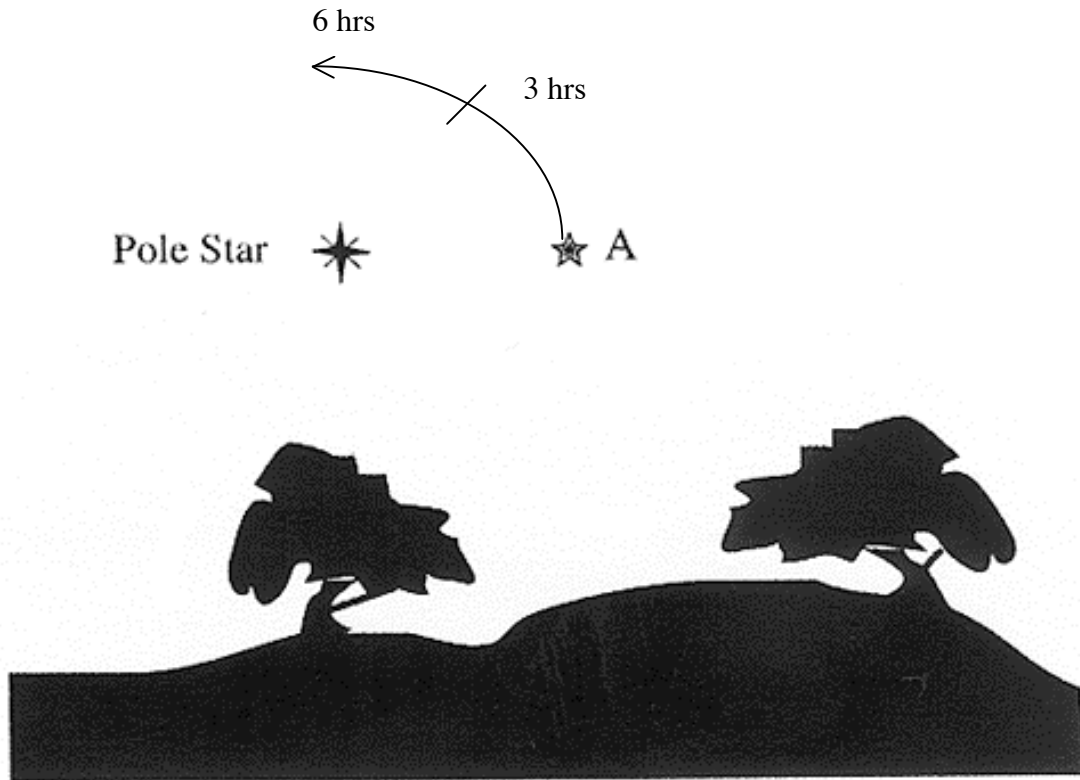
A14. Radius of the Earth is about 6370 kms. The circumference is 2 times pi times the radius = $2\pi R = 40,000$ kms. Speed of light is 300,000 km/s. Then, one trip around takes $40,000 \text{ kms} \div 300,000 \text{ km/s} = 0.13$ secs. In 1 sec, light could make $1/0.13 = 7.5$ trips.

A15. a.

Part B

- B1. a. The angular distance between star A and the Pole star is maintained during the night. The Pole Star maintains a fixed position in the sky. In 3 hours, star A rotates anticlockwise through 45° . In 6 hours, 90° .

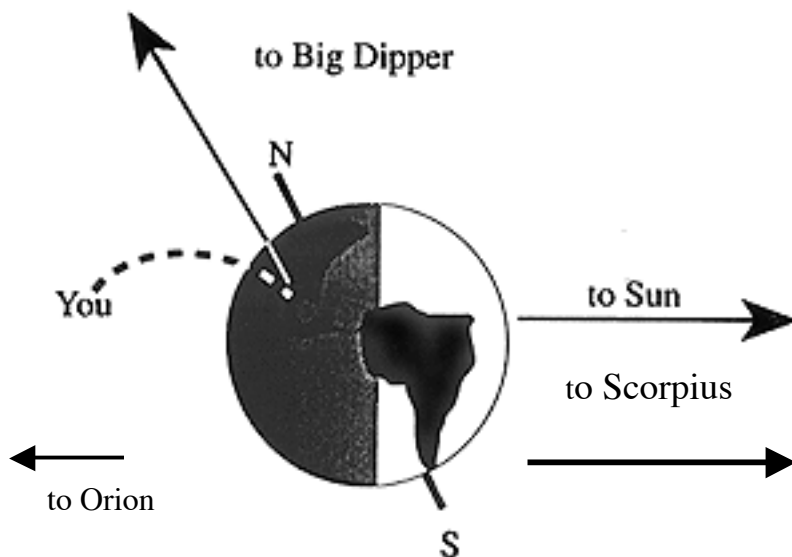
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b. and c. See Figure 2-9 and appropriate text. Orion is near the ecliptic between Taurus and Gemini. A key point is that Orion is near the celestial equator and ecliptic. There is then a time (summer) in the year when the Sun and Orion are in very similar directions: Orion is lost in the day sky. About 6 months later (winter) Orion is opposite the Sun and so easily seen in the night sky and so in the early fall sky near dawn.

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Figure 2-9 gives the Earth on such a small scale that that it may be difficult to appreciate some key points.



In this diagram, it is northern winter (ok?). Orion is visible at night but Scorpius is above our horizon at the same time as the Sun.

In our summertime, the Earth is on the opposite side of the Sun. Scorpius is now visible at night and it is Orion that is above the horizon at the same time as the Sun.

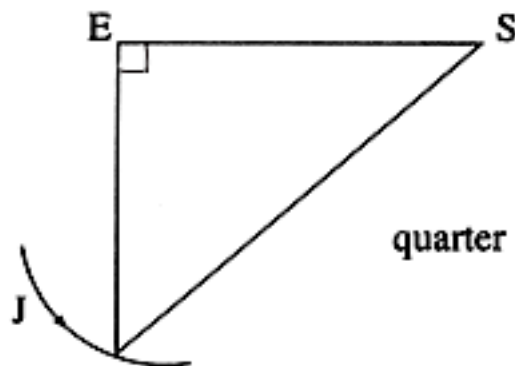
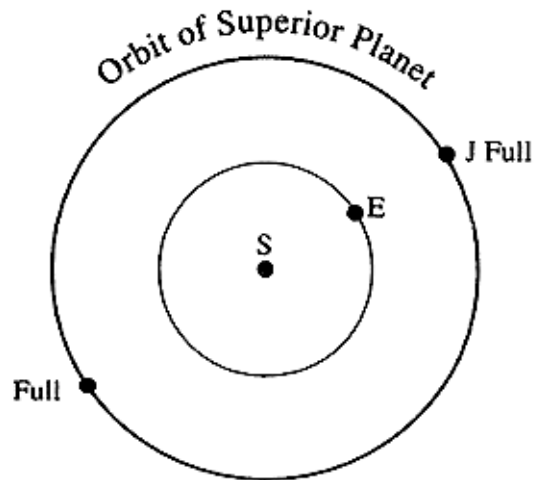
The Big Dipper near the Pole star is well away from the ecliptic. It is above our horizon all the time (day and night, 365 days a year).

- B2. The answers to these questions may be found readily in Seeds. I do expect you to use your own words. Do not copy directly from Seeds. A diagram is essential for part d. It is NOT sufficient to say 'Sun is N of celestial equator for 6 months and S for 6 months' This is merely a rephrasing of the words 'the ecliptic is not coincident with the celestial equator.'
- B3. a. Crescent phase must occur when Venus is between us and the Sun. Full phase occurs when it is on the far side of the Sun from us. At the former position it is closer to us and, hence, appears larger.

The change in angular size is related to the change in distance from Earth. Venus as a crescent is close to its minimum distance from us, that is $1.0 - 0.7 = 0.3$ AU. Full phase is when Venus is at its maximum distance from us, that is $1.7 + 0.7 = 2.4$ AU. Venus's angular size as a crescent is then $2.4/0.3 \approx 8$ times larger than at full phase.

- b. The superior planets cannot show the full cycle of phases; for example, they cannot show the phases near new 'moon' because they can never be positioned between us and the Sun.

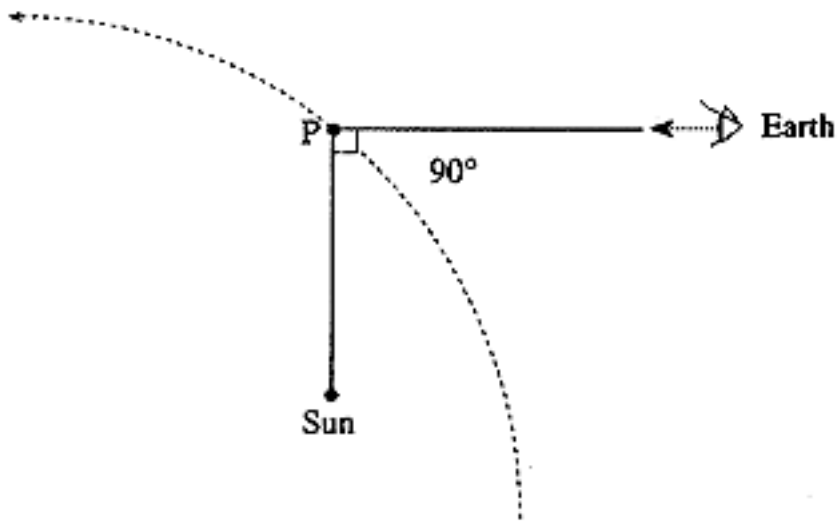
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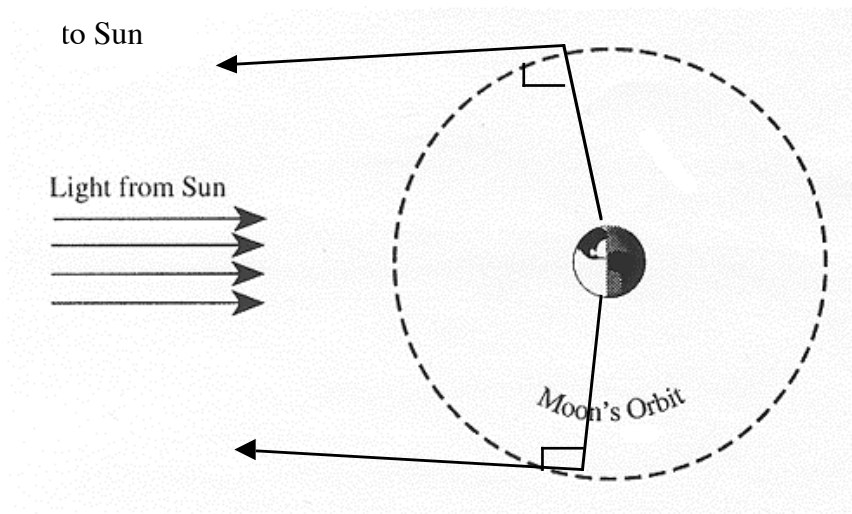
We can consider the relative positions of Earth (E), Jupiter (J), and the Sun (S) by supposing E to be fixed in the above diagram. When J is opposite the E from the S, it is full. As J moves around, E sees a little less than the full phase (*gibbous* is the technical phrase). The visible face of Jupiter decreases from full until the S-E-J angle is 90° . (Do *not* confuse this 90° *at the planet* which is required to give the quarter phase.) When the S-E-J angle is 90° the angle *at Jupiter* between S and E is much less than the 90° required for a quarter phase. Therefore, Jupiter cannot show a quarter phase – only phases near full phase. After this the phase increases back to full.

Here is an alternative proof. To show a quarter phase, the S and the E *at the planet* P must make a right angle as shown here. All planetary orbits are very nearly circular. Thus the distance P – Sun is the radius of P's circular orbit. A part of the circular orbit of P is shown. Clearly P must pass *between* E and S, i.e. it must be an inferior planet and cannot be a superior planet like Jupiter.

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c.



The angle at the Moon between Sun and Earth must be 90° for quarter phase.

Note: Since the Moon at about 250,000 miles is much closer to us than the Sun at nearly 200 million miles, the angle at the Earth is almost 90° too at lunar quarter phase.