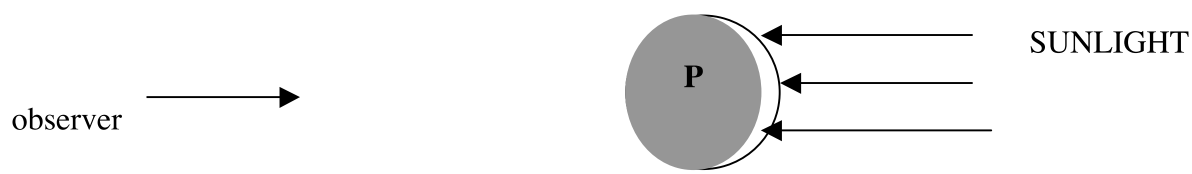
COMMENTS ON HOMEWORK 2

Part A

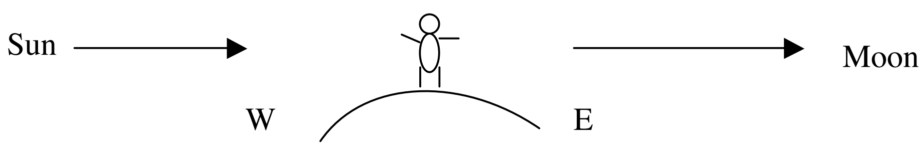
A1. An easy question. All that is needed to answer this are the relations $1° = 60'$ and $1' = 60''$.

A2. This calls for an understanding of why phases occur. When a planet is seen as a crescent, only a very small portion of the sunlight half is facing the observer, see this diagram:



When the observer is directly behind the Planet P, the dark side is facing the observer. In a strictly technical sense, the planet is not visible. At small angles either side, the planet is seen as a thin crescent. This shows that planets *closer* to the Sun than Mars may appear as a crescent to the Martian observer. These are Mercury, Venus, and Earth.

A3. Full moon calls for Sun-Earth-Moon in a straight line.



A4. This called for a couple of sentences about the tilt of the Moon's orbit around the Earth relative to the Earth's orbit around the Sun. And a diagram!

A5. The two-week interval is half of the Moon's orbital period, i.e., the interval between full and new moon.

Can you tell from the tables whether a solar eclipse always precedes a lunar eclipse or vice versa?

A6. To answer this adequately, you must describe how the Moon's orbit about the Earth is tilted at about 5° to the Earth's orbit about the Sun. And then go on to explain why this gives eclipse seasons spaced 6-months apart. It is almost necessary to include a diagram like the one I provided in the overheads:

A7. a.

A8. b.

A9. P is the time taken for the planet to complete an orbit about the Sun. Technically, it is the sidereal period

A10. a is the semi-major axis of the ellipse.

A11. A simple exercise in $P^2 = a^3$. First, be sure you understand what we mean by **P** and **a**. Note that we may consider all orbits to be circular and then **a** is the radius of the orbit instead of the semi-major axis of an elliptical orbit.

In this case P = 1000 years, and
$a^3 = P^2 = 1000 \text{ x } 1000$
$a = \sqrt[3]{1000 \times 1000}$
$= 10 \text{ x } 10 = 100$ AU.

A12. The direct approach to answering this question is to look up Pluto's orbital period. It is 248 years. Since Pluto and the comet must satisfy $P^2=a^3$, and P(comet) is less than P(Pluto), it follows that a(comet) is less than a(Pluto), and so comet belongs to the inner solar system.

Alternatively, $P^2=a^3$ for the comet and then,

$$a^3 = 50 \text{ x } 50 = 2500$$

and a = 13.6 AU, which is much smaller than a for Pluto (see, for example, Seeds, Figure 1.7).

A13. a.

A14. If both masses are tripled, the force is increased **nine** fold.

Recall the expression

$$F = G\frac{M_E M_M}{R^2{}_{EM}}$$

where F is the force on the Moon **and** also the force on the Earth. If M_E is tripled to $3M_E$, and M_M to $3M_M$, F is increased 3 x 3 = 9 times.

As a simple piece of algebra, we would write

$$F_{new} = G\frac{3M_E 3M_M}{R^2{}_{EM}}$$

$$= G\frac{9M_E M_M}{R^2{}_{EM}} = 9F$$

A15. THE SAME.

A16. 81 TIMES STRONGER.

If on A15 and A16 you chose an incorrect answer (probably a for A15 and d for A16), reread Seeds and my Classnotes 5.

Part B

In general, a weakness of the answers was (i) a reluctance to write a paragraph or two in your own words; (ii) a resistance to providing an explanation instead of an assertion. Often, a diagram can be helpful but only if it is linked to the words.

B1.a. After describing what Galileo found from observing Venus (a complete set of phases with Venus decidedly of larger angular diameter when new/crescent than when full/gibbous), go on to show that (i) Ptolemy's model requires Venus to show <u>only</u> new-crescent phases, (ii) Copernican model requires full set of phases with change of angular diameter with phase.

B1.b. Ptolemy and friends looked for shifts of the nearby stars relative to more distant ones. No shifts were seen. They concluded that the Earth did not move.

In the interview, you must clearly argue that there is an alternative conclusion: the Earth indeed moves but the shifts that result are too small to be detected with the crude "equipment" used by Ptolemy and friends. You should then explain how the large distance to the stars **relative** to the size of the Earth's orbit about the Sun ensures that the shifts are ***very*** small. You might tell Ptolemy that this shift was not, in fact, first measured until 1838. Even today and after a space-borne telescope designed for precise measurement of the shifts, detectable shifts have been measured for only a few thousand stars.

B2.a. The material needed is in the textbook. The strongest evidence is i) the observed phases of Venus, and ii) the motions of the Jovian satellites around the planet.

You were asked not only to explain why the observations supported the Copernican solar system, but also why the observations were demonstrably inconsistent with the Ptolemaic model.

Note that a set of observations (or measurements) may not always rule out all competing models, theories, or explanations.

B2.b. Why gradual acceptance and not instant acceptance? See Seeds – B2 was his question.

A scientific factor is traceable to Copernicus's instance that orbits were circular. This limited his ability to predict accurately the positions planets would assume in the future. It seems that the accuracy was not much superior to that of a Ptolemaic model with its many epicycles.

But within a few years, Galileo with his telescope provided the vital observations damning the Ptolemic model. And Kepler showed orbits were elliptical and so greatly improved the ability to predict the paths of planets across the sky.

Several answers referred to 'simplicity and elegance' of the Copernican idea. These are fair descriptions but you should explain what is simple and elegant about this idea. See our discussion in class.

B3. a) Seeds, Fig 3-10.
b) The key items are:
: A lunar eclipse is visible from anywhere on the Earth's nightside.
: A lunar eclipse may last 1 to 2 hours.
: A total solar eclipse is visible only from a thin (100-200 mile wide) strip across the Earth's surface.
: At a given place on this strip, the eclipse lasts less than 7 minutes.
Give diagrams!

I have been asked whether I would agree that the tragedy of the scientist is that he is able to bring about great advances in our knowledge, which mankind may then proceed to use for purposes of destruction. My answer is that this is not the tragedy of the scientist; it is the tragedy of mankind.

Leo Szilard
1898-1964

Asked, on his arrival in Europe, what he thought of Western civilization, Gandhi said, "I think it would be an excellent idea."

Beautiful are the things we see,
More beautiful those we understand,
Much the most beautiful those we do not comprehend.

Niels Steensen (Steno)
17th Century polymathematician