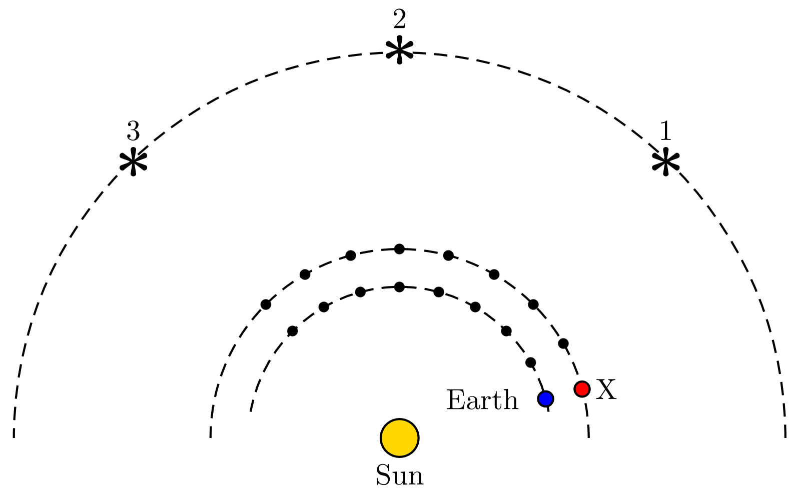
Phys 100
Fall 2023

# Concepts of Physics: Homework 1

Due: 1 September 2023

## 1 Planetary system

Consider a planetary system with an "Earth" and a distant planet, X. The positions of the planets are indicated at intervals separated by one day; they are shown in their positions on the first day. Planet X can be viewed from Earth against distant stars, labelled 1, 2 and 3.




a) Use the diagram to indicate the apparent position of planet X as viewed from Earth on the first day, second day, and subsequent days.

b) On which day will plant X appear in front of star 1? Explain your answer with a diagram.

c) On which day will plant X appear in front of star 2? Explain your answer with a diagram.

d) Does planet X appear to move in one particular direction when viewed from Earth? Explain your answer with a diagram.

## 2 Retrograde motion

The concept of retrograde motion is important for deciding between possible models of the solar system.

a) Briefly describe what retrograde motion is.

b) Describe whether a simple geocentric model can ever predict that retrograde motion will be observed. Explain your answer.

c) Describe whether a simple heliocentric model can ever predict that retrograde motion will be observed. Explain your answer.

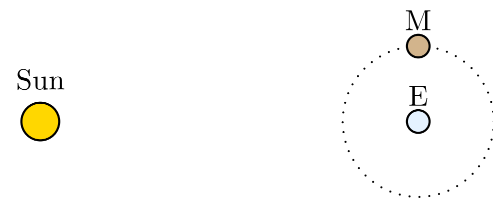
d) Describe a special circumstance in which a heliocentric model would predict that retrograde motion will not be observed.

## 3 Position of the Moon

The Moon orbits the Earth in a circle.

a) Can the Moon ever appear to be close to the Sun when viewed from Earth? When might this occur? Explain your answer with a diagram.

b) Can the Moon ever appear to be far from the Sun when viewed from Earth? When might this occur? Explain your answer with a diagram.




## 4 Position of Venus

The planet Venus appears as the "morning" or "evening" star. It is always seen close to sunrise or sunset. Consider what various models can predict about this.

a) Imagine a simple geocentric model where Venus orbits at a different rate to the Sun. Will it always appear close to sunrise or sunset? Or could it appear at midnight? Explain your answer.

b) Now consider Copernicus' heliocentric model. According to this model will Venus always appear close to sunrise or sunset? Or could it appear at midnight? Explain your answer.

*Hint: For each model, draw schematic diagrams with orbits of these objects at various moments. Use these diagrams to make predictions.*

## 5 Phases of a planet

Planets can display phases, like the Moon does. Consider the planet Jupiter and the phases that it could display.

a) Consider a geocentric model in which Jupiter orbits between Sun and Earth. Sketch three situations where the phase of Jupiter would be "new," "half" and "full." If any of these is impossible, describe why.

b) Consider a geocentric model in which the Sun orbits between Jupiter and Earth. Sketch three situations where the phase of Jupiter would be "new," "half or partial" and "full." If any of these is impossible, describe why.

c) Consider Copernicus' heliocentric model. Sketch three situations where the phase of Jupiter would be "new," "half or partial" and "full." If any of these is impossible, describe why.

d) If you could observe the phases of Jupiter, explain how you could use the observations to decide which model may be correct and which may be incorrect.

*Hint: For each model, draw schematic diagrams with various possible arrangements of Jupiter relative to Sun and Earth, both of which you can keep fixed. In each case carefully show the shaded and illuminated sides of Jupiter. Use these diagrams to make predictions.*

## 6 Predictions for the apparent size of planets

The *apparent size* of any object is the size that it appears to be when viewed from a fixed location. Forexample, a baseball when viewed at a distance of one yard *appears* much larger than when viewed at a distance of 100 yards.

The apparent size of any planet as viewed from Earth can be observed with a sufficiently powerful telescope and this can be tracked as the planets orbits. Consider what the simple geocentric model of the solar system and the heliocentric model of the solar system would predict for the apparent size of the planet Mars.

a) Does the geocentric model predict that the distance from Earth to Mars stays constant or not as Mars orbits? Explain your answer.

b) Does the geocentric model predict that the apparent size of Mars will stay the same or change? Explain your answer.

c) Does the heliocentric model predict that the distance from Earth to Mars stays constant or not as Mars orbits? Explain your answer.

d) Does the heliocentric model predict that the apparent size of Mars will stay the same or change? Explain your answer.

e) Explain how you could use this to decide between the two models. What would you have to observe? What are the possible observations and how would they decide between the two models?

## 7 Indirect vs. direct evidence for circular planetary motion.

Consider the motion of the planet Neptune. How do we know that it moves in a nearly circular orbit around the sun rather than about the earth? A direct method for doing this would be to observe the position of Neptune, the Earth and the Sun from a distance during one entire orbit of Neptune. This would require observing the three from a space probe at a significant distance from the Sun. The only candidates for this are the Voyager and Pioneer planetary space probes which reached suitable distances from the sun in the late 1990's. Suppose that these were used to photograph Neptune, the Earth and the Sun, once per week and that these photographs were played back as a movie.

a) Sketch the paths of Neptune, the Earth and the Sun according to the simple geocentric model of the solar system.

b) Sketch the paths of Neptune, the Earth and the Sun according to Copernicus' notion of the solar system.

c) Look up the time taken for Neptune to complete one orbit (a "Neptune year" or the "orbital period") and write this down together with the source of your information. Has there been enough time for these probes to have observed one complete orbit of Neptune? Sketch the approximate portion of Neptune's orbit could that the probes could have observed? Could a hypothetical movie produced by these probes be used to support either the ancient Greek notions or those of Copernicus?

A movie of this type could be regarded as "direct" evidence for Copernicus' notion of the solar system. Such observations were not actually done by these or any other space probes. In fact, the orbits of the planets needed to be known in advance so that the probes could approach various planets closely (they did this successfully).

d) Based on discussions in the class and the text describe evidence for the paths of Neptune, the Earth and the Sun according to Copernicus' notion of the solar system. Would you consider this as "direct" or "indirect" evidence (i.e. does the evidence actually show the paths of the planets or do you have to deduce the possible path from the evidence?)

## 8 Reading exercise: units and scientific notation

Read section 2.4 on pages 40–42. This series of exercises offers examples and exercises that you could construct to check that you understand the content of the text correctly.

a) Measure the length of the longest edge of the textbook for this course using a ruler, measuring in metric units (i.e. in meters, centimeters, . . . ). Write down your result, ensuring that you include the units of measurement that you used.

b) We will now aim to express this in terms on millimeters and kilometers. Read page 41 and consult Table 2.1. Based on Table 2.1, would you expect that the length of the book edge in kilometers will be much larger or much smaller than 1.0? Based on Table 2.1, would you expect that the length of the book edge in millimeters will be much larger or much smaller than 1.0?

c) To rewrite the length in terms of these other metric units, requires using powers of 10. Do Concept Check 8 on page 42 and check whether you got the correct answer.

d) Consider the task of writing your length measurement in terms of meters, if you have not already done so. Based on ideas of shifting decimal points, described on page 41, will you have to shift the decimal point in your number left or right to write the length in meters? If so how many places? Do this to write the length of your book in meters.

e) Now repeat this to write the length of your book in centimeters and, separately, kilometers. Do you get much larger or much smaller numbers in each case (as you had predicted earlier).

f) Try Conceptual Exercise 31 on page 52.