ASTRO 100/G – Experiment 1

The use of a computer planetarium

Links to Lectures 2, 3, and 4

Name:
ID:
UPI/Username:

Grade

/10

Astronomers today use programs like this one to produce current and future astronomical maps. The programs can also interface with telescopes, to move them around automatically. In this experiment, you will use such a program to look at the behaviour of the planets over time.

Planets mostly rise and set with the stars; however, they too orbit the Sun and move slowly relative to the background celestial sphere. Jupiter orbits the Sun once every 12 years, so its motion is difficult to see; but for Mercury, Venus and Mars, which are closer to the Sun with orbital periods more like the Earth's (1 year), they do move noticeably relative to the celestial sphere.

At the end of this lab, students will be able to:

- **Qualitatively compare** views of a telescope in equatorial and azimuthal mounts.
- **Estimate** orbital periods of solar system objects using planetarium software.
- **Contrast** the cause of apparent planetary retrograde motion for inner and outer planets.
- **Describe** the difference between synodic and sidereal periods of a planet.

Starting Stellarium

Stellarium is installed by default on all computers in this lab. It can be downloaded at http://stellarium.org/ and installed on your own computer (or you can scan the QR code on the last page). Once installed, go to to Start and search Windows for "Stellarium". Move the mouse to the lower part of the left of the screen and a menu will appear. Click on the top symbol – it looks like a compass rose – to bring up the **Location** window. Make sure this is set to Auckland, New Zealand.

Open up the Date / Time window by clicking the second icon on the left window. Set the time to 21:00:00 (9pm this evening). Advance the time forwards (or backwards) by clicking on the arrows. You should see the sky move, with everything moving at roughly the same speed. This is because of the Earth's rotation, and is the same reason we have a 24-hour day. The stars appear to be fixed relative to one another because they're so far away, but the planets move. This is why they're called planets – it's from the Greek word *planētes*, for 'wanderer'.

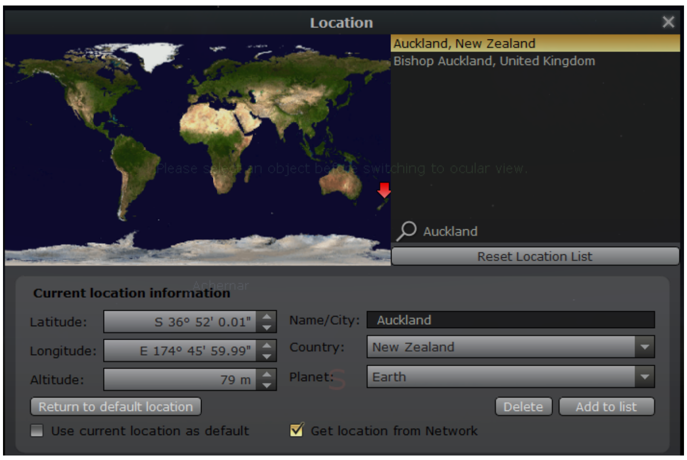


Figure 1: Find and click the location button in the menu and check you are in Auckland, New Zealand.

The 11th symbol on the bottom menu switches you between an equatorial mount and an azimuthal mount. If the symbol is highlighted, the virtual telescope is mounted on an equatorial mount that has an axis parallel to the Earth's rotation axis, with the celestial sphere as the reference frame. Therefore the stars appear fixed while the ground appears to move as you change time. This means that when you advance in time, the stars will not move but horizon will. This setting makes it easiest to see how the planets are moving relative to the background stars. We suggest you attempt this experiment with the telescope **highlighted**.

1. (2 marks) Speed up the simulation by using the fast forward button at the bottom (you may have to click it several times). Experiment with switching between the equatorial and azimuthal mounts for your virtual telescope (Ctrl+M or click 11$^{\text{th}}$ symbol from the left on option buttons, it looks like a telescope). What stays stationary in each view?

   Solution: Equatorial Mounts: the stars do not move (1 mark). Azimuthal: the earth does not move (1 mark).

Now go to the bottom edge of the screen (towards the left) and another menu will appear. Make sure the options for cardinal points (so you know where N, S, E and W are), and planet labels (so you can find the planets) are enabled. Turn on the equatorial mount and ensure the program is running in full screen. Make sure you turn **off** ground and atmosphere so that you can see the stars and planets in all directions. The bottom panel should look like the image in Figure 2 (but with a different date!)

Figure 2: The second menu can be found by moving your cursor to the bottom of the screen. Make sure that your menu looks like the one shown above for the remainder of the experiment.

Now we will compare the motions of the Moon, Mercury and Mars. These three objects are different: the Moon orbits the Earth, while Mercury and Mars go around the Sun. Mercury is closer to the Sun than the Earth, while Mars is further away. Therefore, we expect the motions of all three objects to be qualitatively different. First, zoom out and adjust the view until everything appears to move in a circle. Make sure your telescope is set to an **equatorial** mount. You want to be able to see the entire circle without having to adjust the view again.

2. (1 mark) Find the Moon, it should be bright and easy to find. You should find that it appears to move in a circle on the Sky. Measure how long it takes to make a full circle on the sky and give this value in days below.

   Orbit begins on: **Varies** .

   Orbit ends on: **Varies** .

   The period is: **28** days.

   1 mark if "close", 0.5 marks if "not close", 0 marks if student guessed with no justification.

3. (1 mark) Now search for Mars. You should see once every year or so that it stops, moves backwards then forwards again in retrograde motion. This is because it is outside Earth's orbit and from our viewpoint we overtake it. How long does it take for Mars to orbit the Sun? Use this retrograde motion to help you measure this time and give your answer below.

   Orbit begins on: **Varies** .

   Orbit ends on: **Varies** .

   The period is: **770** days.

   Student should measure from retrograde to retrograde. 1 mark if "close", 0.5 marks if "not close", 0 marks if student guessed with no justification.

4. (1 mark) Repeat the previous question for Mercury. This time, instead of being overtaken by Earth in its orbit, Mercury appears to move behind the Sun, and this is the cause of the apparent retrograde motion. Use this to estimate the period of Mercury.

Orbit begins on: **Varies** .

Orbit ends on: **Varies** .

The period is: **113** days.

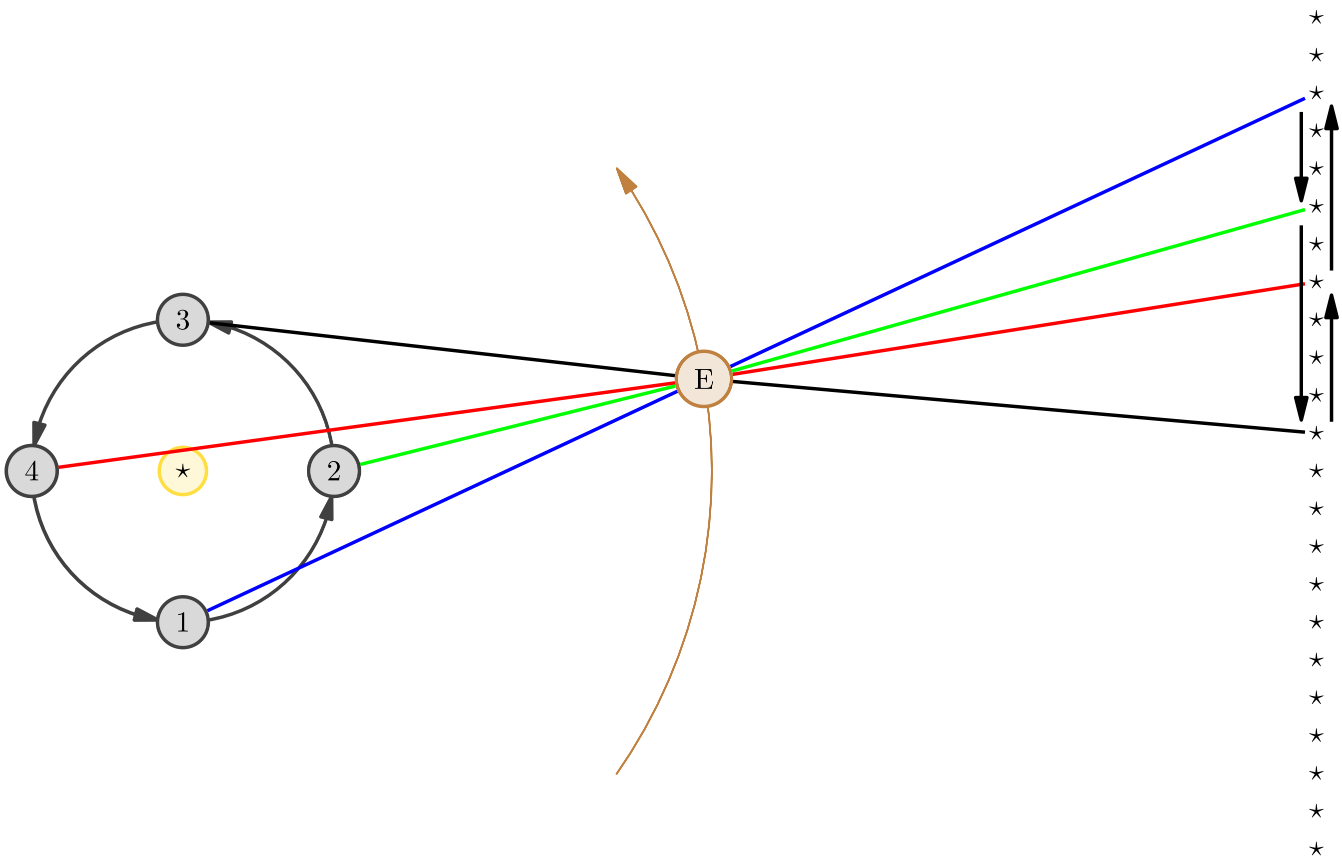
Student should measure from behind/in front of the Sun to behind/in front of the Sun. 1 mark if "close", 0.5 marks if "not close", 0 marks if student guessed with no justification.

5. (2 marks) Now look up the times for the Moon to orbit the Earth, and Mercury and Mars to orbit the Sun. Click on the celestial body in Stellarium, and look on the list of information shown on the left. Are the numbers different from those you found? If so, why?

   Hint: Stellarium lists two different periods. What does each period measure, and which period were you measuring for each? You can look this up online.

   Solution: We measured the sidereal period of the Moon and the synodic periods of the planets. The sidereal time is the time it takes a body to orbit another body (i.e., the time it takes the Moon to complete one orbit around the Earth), whereas the synodic period is the time taken between two successive orbital phenomena (i.e., the time between retrograde motions). The "orbital period" is commonly associated with the sidereal period, not the synodic period, hence the difference between what we measured and what is normally quoted. (1 mark for correct identification of sidereal and synodic periods, 1 mark for identifying they measured synodic for Mars and sidereal for Mercury and Moon).

6. (2 marks) Complete the diagram below to show the apparent retrograde motion of Mercury (gray) as it orbits the Sun (yellow) as seen from Earth (brown). Draw lines from the four positions in Mercury's orbit through the Earth (marked with an E) to the background stars. Add arrows to the background stars line showing the direction of motion from 1 to 2, 2 to 3, 3 to 4, and 4 to 1. The first line is drawn for you in blue.



1 mark for correct lines, 1 mark for correct arrows

You are now finished. Please hand your sheet to the demonstrator for marking.

Stellarium is freeware – you can download it from `http://stellarium.org/`.