

Physics 10293 Lab #7:

Venus

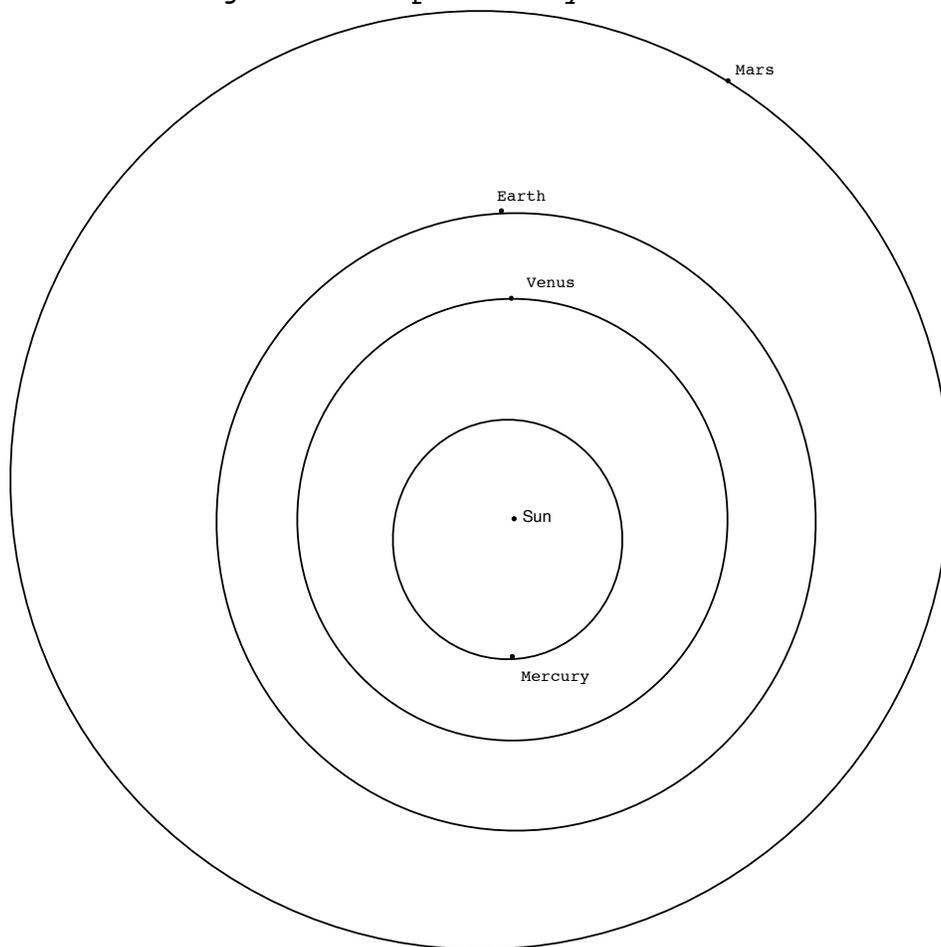
Introduction

Today we will explore the motions in the sky of the brightest planet in our sky: Venus. Because of its brightness and easy visibility near sunrise and sunset, Venus played an important role in the mythologies of many cultures.

Start by opening the Skyguide tab on the sidebar, then select "Unit C: The Planets". Select "C: The Planets". This will open a list of exercises. Within this module, select "C1: The Inner Planets of the Solar System" and "Part 5: Mars". This should give you a bird's eye view of the orbits of the four inner planets.

Conjunctions

Below is an image of the planetary orbits.



This image shows Venus in "inferior conjunction" between Earth and the Sun. It also shows Mercury in "superior conjunction" directly behind the Sun as viewed from the Earth.

Set the date for January 1 of next year. Find the first day after this date that...

Venus at inferior conjunction: _____

Venus at superior conjunction: _____

Venus inferior conjunction (2nd time): _____

To find Venus' synodic period (in days), we need to count the days between inferior conjunctions, but this is difficult using the month and day system. Instead, we will use the Julian calendar, which just counts the days from Jan 1, 4713 BC.

Stop the clock from running and set the date back to the first inferior conjunction of Venus, then use the drop-down menu next to the date display on Starry Night. You will see a menu function "Set Julian Day...". Select this, and a box will appear showing you the Julian date corresponding to this day on the calendar. Don't worry about the fraction after the decimal.

Julian Day for 1st inferior conjunction: _____

Julian Day for 2nd inferior conjunction: _____

Difference = synodic period (in days): _____

Step 2

Recall from our study of Mercury's orbit, there are two places where the planets cross through the Ecliptic plane: the ascending node and the descending node. The descending node is marked with a hollow half-arrow for each planet. This is where the planet is plunging down through the plane of the Ecliptic. On the opposite side of the planet's orbit (on the screen but not shown on paper) is the solid half-arrow which marks the ascending node.

Set the date for January 1 of next year, and run time forward until Venus first reaches a node.

Planetary transits can occur when the planet is at a node at the same time it is lined up with the Earth and the Sun. Below, for the planet Venus, write down which months of the year it is possible to see a transit of this planet from the Earth. This answer doesn't depend on the year.

What are the next two dates on which Venus will be at a node?

_____ and _____

The closest transit to our date occurs from our perspective during the afternoon of June 5, 2012. To view this from TCU, make the following changes to the settings:

- In the top left corner of the menu bar, select "Home", and close the Skyguide tab.
- Change the date and time to 3pm on June 5, 2012
- Scroll around the sky to find the Sun and zoom in until you can see the surface features clearly.
- Right-click on the Sun and select "Centre".
- Open the options sidebar by typing "options" into the search box in the upper right corner.
- Under "Solar System", click on the words "Planets-Moons" to open a dialog box. Near the bottom of this box, click to activate Labels for the planets, then hit "OK" to close the box.
- On the top menu bar, increase the time flow rate to 300x and run time forward until the transit of Venus begins, when the disk of Venus first touches the solid disk of the Sun (not the yellow halo part around the Sun).
- Note the time of this below, to the nearest minute.

Beginning of 2012 Venus transit from TCU: _____

What time is this in "Universal Time"?
(see dropdown menu next to time box): _____

- On the very top menu bar, under "Options", select "Viewing Location". Use this to change your viewing location to Papeete, French Polynesia, also known as Tahiti.
- Again, find and center on the Sun and determine the time (in Universal Time) of the beginning of the transit.

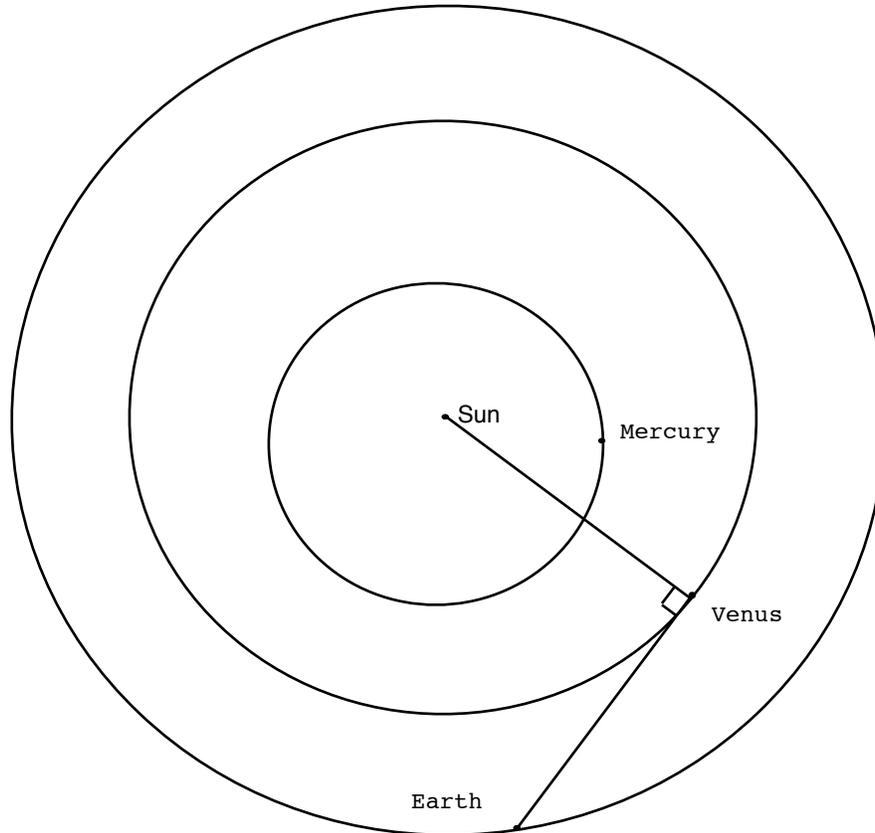
What time is the beginning of the 2012 Venus transit in Papeete, French Polynesia (UT)? _____

The reason for this difference is parallax. Because these two places on Earth are separated by thousands of miles, they see this event at different times. This time difference proved to be important in establishing the size scale of our solar system for the first time in 1769, a historical event we will return to later.

Step 3

As with Mercury, we will study the maximum elongations of Venus. Since the orbit of Venus is roughly circular, like Earth's orbit, the maximum elongation angle that Venus experiences does not vary much like Mercury's elongation angle. Also, since Venus is further from the Sun, it can appear further away (in an angular sense) in the sky. Thus, before sunrise or after sunset, Venus can be found much higher in the sky compared to Mercury.

We will now explore some upcoming elongations, times when Venus will be easily visible in the morning or evening. On the next page is an example of a planetary configuration where we on Earth are seeing Venus at a maximum elongation.



Notice at this time, that a line from Earth to Venus forms a right angle with a line from Venus to the Sun. Reopen the skyguide simulation and look for the next occurrence of maximum elongation after June 5, 2012.

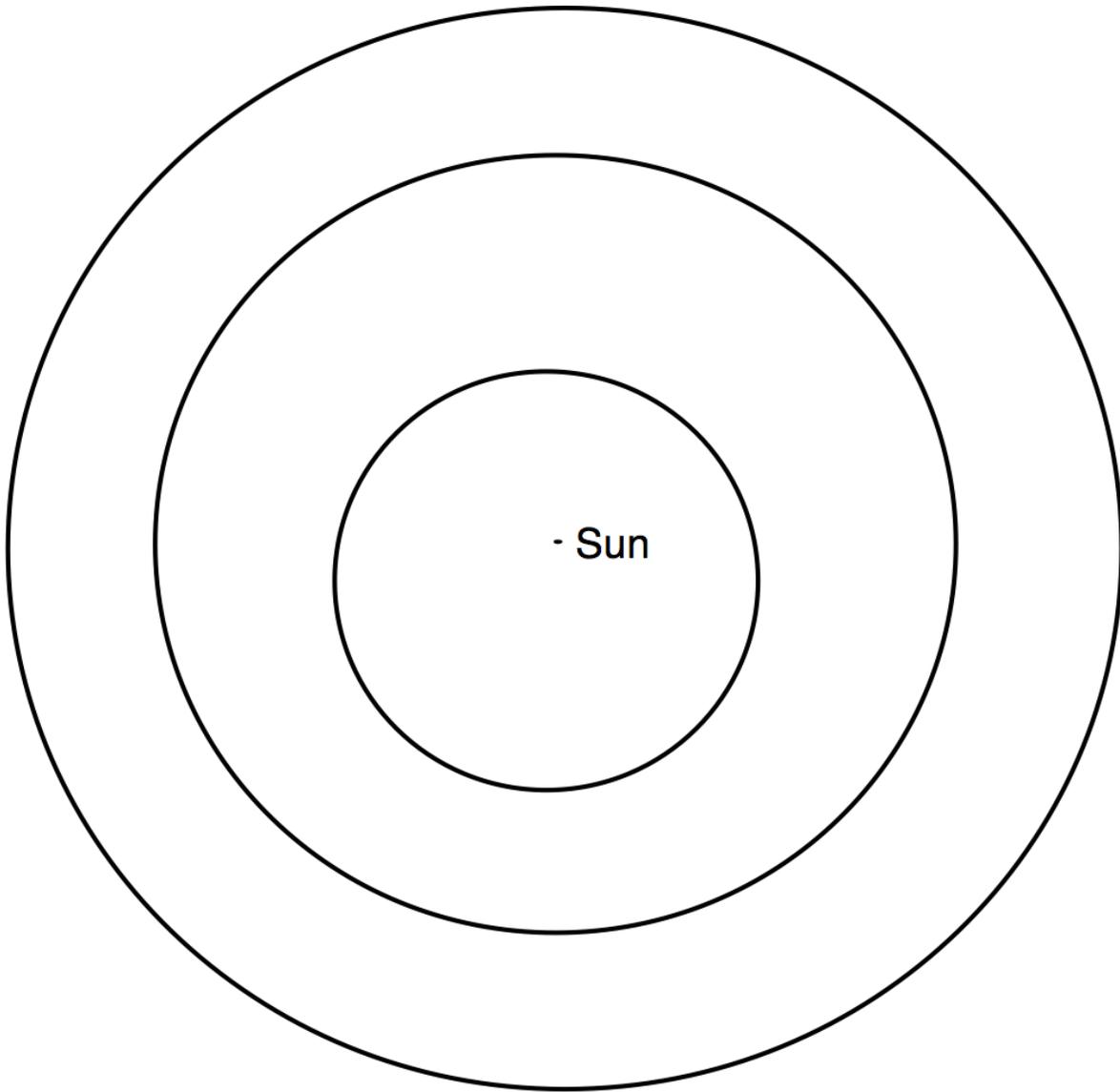
Open the Skyguide tab on the sidebar, then select "Unit C: The Planets" then "C1: The Inner Planets of the Solar System", then "5: Mars"

Under the Time control box on the top bar, select "Now".

In the "Options" sidebar, under "Solar System", click on the words "Planets-Moons" and activate "Labels" near the bottom of the dialog box that opens.

Run time forward (1 day time steps) until the next occurrence of maximum elongation (use a piece of paper to help establish when there is a right angle). Sketch the location of the planets on your worksheet and note the date.

On the chart below, mark the locations of Earth and Venus during the next occurrence of maximum elongation.



What is the date of this elongation? _____

Keeping in mind that Earth orbits and rotates in a counterclockwise direction, will Venus be visible before sunrise on this date or after sunset? _____

Now use the "Home" button on the top bar to return to our standard sky view from TCU.

Set the date for the maximum elongation date you already determined and the time to sunrise or sunset, depending on when you think Venus will be visible above the horizon. Now determine Venus' altitude above the horizon by right-clicking on Venus and selecting "Show Info" at the bottom of the drop-down menu.

What is Venus' altitude above the horizon at sunrise or sunset on this date? _____

The next time Venus will have its maximum elongation at this time of day will be one synodic period later. You calculated the synodic period of Venus in step 1. Use the "Julian Day" setting for the date to add one synodic period to today's date and again determine Venus' altitude at sunrise or sunset on this new date.

What is Venus' altitude above the horizon at sunrise or sunset one synodic period after its first maximum elongation? _____

Step 4

You probably found that your two altitude answers weren't quite the same. That's because Venus doesn't follow the same apparent path in the sky at every elongation. It varies because the orbits of Earth and Venus are not exactly circular, and their perihelion points don't quite match up.

The Mayans noticed this, but they also noticed that while the appearance of Venus in the sky differs from year-to-year, there is a point at which it begins to repeat. We are going to try to recreate these observations to deduce when the cycle of Venus repeats itself. This cycle was recognized by not only the Mayans but also several other early cultures, as indicated by their writings and artwork.

Take the following steps to view the motion of Venus in the evening sky.

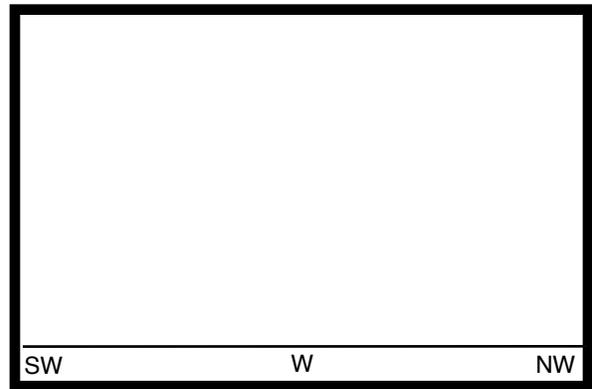
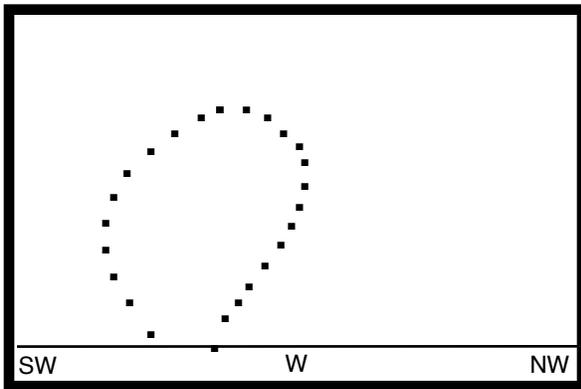
- Scroll around to view the Western horizon

- Set the date to the Vernal Equinox (March 21) of this year.
- Set the time to sunset.
- In the options sidebar, under "Local View", click on the words "Local Horizon" to open a dialog box. Near the top of this box, select "Flat" for the horizon style.
- Under "Local View", uncheck "Daylight".
- Under "Solar System", uncheck "Asteroids", "Comets", "Satellites" and "Space Missions"
- Under "Solar System", click on the actual words "Planets-Moons" to open up a dialog box. At the bottom of this box, check to activate "Labels" and also check "Label only planets brighter than" and move the slider to a magnitude of -2 (brightest choice).
- Zoom in or out as necessary until the SW and NW labels on your horizon are at either edge of your screen, with any sidebars (skyguide or options) closed.
- Set the time step to one day.
- If Venus is already visible, take note of its position. If not, run time forward until Venus is visible above the horizon at about sunset.

Your goal here will be to map out the day-to-day location of Venus after sunset. You will find it makes a distinctive path in the sky with each cycle. Below, there are several blank diagrams where you should draw the path of Venus through the sky. One example, showing the path of Venus in the sky starting on Feb 11, 2010, has been done for you. You may wish to check this one yourself to see Venus' motion on the screen and how that translates to your diagram.

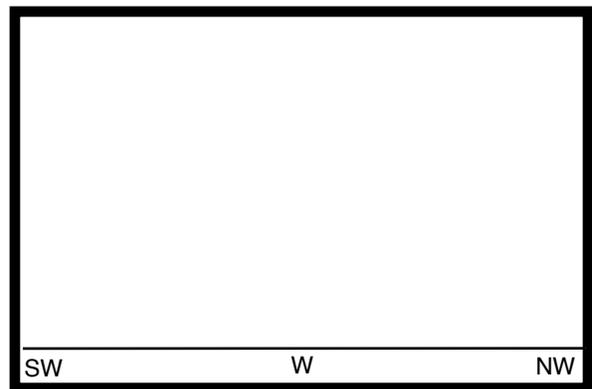
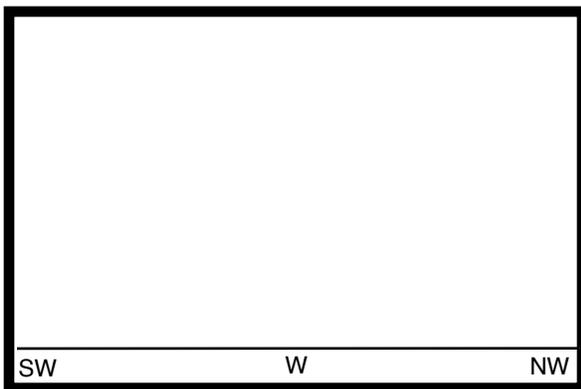
Starting from the next time after Feb 11, 2018 that Venus appears above the Western horizon at sunset, plot the apparent day-to-day path of Venus in the Western sky at sunset until you notice a repetition of the cycle. I recommend a dot on your diagram about every 10 days, then draw a line through the dots when you are done. You should start to notice a repetition before you run out of diagrams! Once you notice a repetition, you only need to draw the first two diagrams of the next cycle.

On the diagrams below, plot the day-to-day path of Venus in the Western sky at sunset. The first one has been done for you. Below each diagram, note the start date for your path. These dates should be roughly one synodic cycle apart.



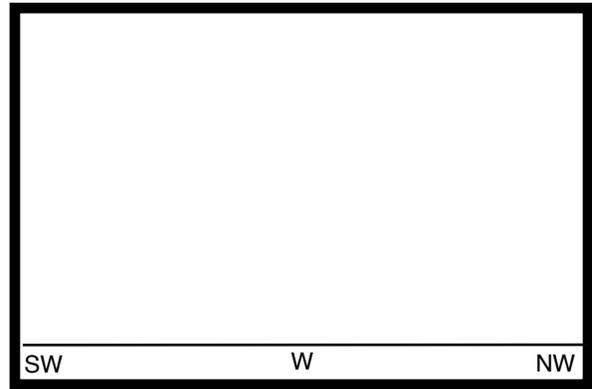
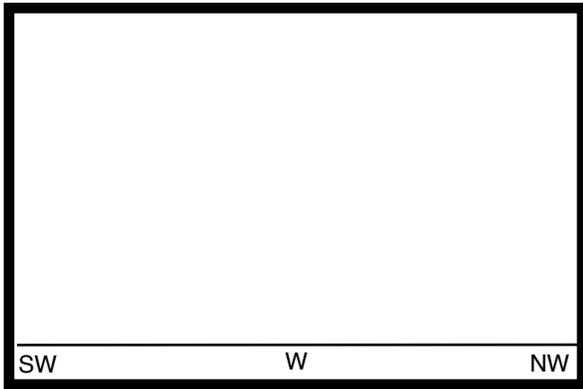
Start date: Feb 11, 2018

Start date: _____



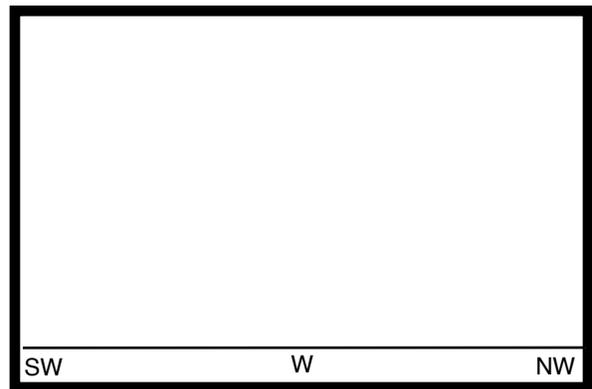
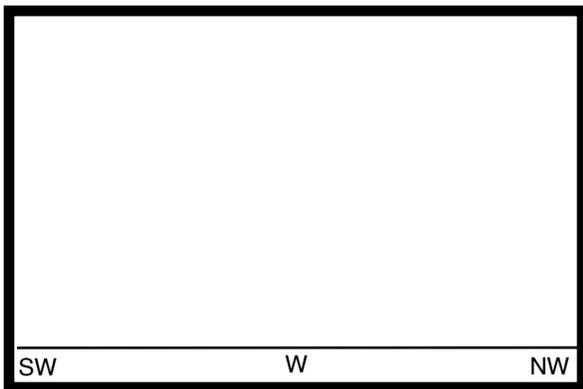
Start date: _____

Start date: _____



Start date: _____

Start date: _____



Start date: _____

Start date: _____

Based on your charts, how many times does Venus appear before its path cycles back to the first path in the cycle? _____

How many years passes between the beginning of these two cycles? _____

How many days are in this number of years? _____

How many synodic cycles is this (previous answer / 584)? _____

Step 5

Like Mercury, Venus shows phases. When Galileo first noticed this through his telescope, he used it to bolster his argument that the planets orbit the Sun rather than the Earth. If you would like to center and zoom in on Venus at some point in its motion in the sky, you can see these phases for yourself as Galileo saw them through his telescope.

Later, Johannes Kepler would expand on this idea, as well as the work of Nicholas Copernicus and Tycho Brahe, to formulate his Three Laws of Planetary Motion. For the first time, planetary motions were starting to make sense to scientists and, most importantly, they were predictable through mathematics with remarkable precision.

The final piece of the planetary motion puzzle, the actual distance between the planets, was established with the help of Captain James Cook's observation of a transit of Venus in 1769. Google "James Cook Venus Transit" and read the first article that comes up (from NASA Science News) to answer the questions below for this final section of the lab.

If Cook's mission had failed in 1769, when would the next transit of Venus have occurred? _____

Explain why it is difficult to precisely determine the time of the beginning (or the end) of the Venus transit.

Did Cook make it back to England? What happened to his crew?