

Name: \_\_\_\_\_

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## Computer Laboratory: Calculating the Height of Lunar Features

### Introduction

In the January, 1985 issue of Sky & Telescope magazine, the article "*How High Are Lunar Mountains*" presented BASIC code for creating a calculator of sorts. Based on the length of shadows in a photograph of the Moon, in this case, it is possible to determine the height of the feature casting the shadow. In this laboratory, you will determine the height of a few lunar features using SAOImage DS9 as your measuring tool and the [Height of Lunar Features](#) web page to perform the calculations.

Why the height of features and not the depth? Actually, you are calculating both if the shadow is cast by the crater rim into the crater. In this case, the angle of sunlight and length of the shadow reveals both the depth of the crater and the height of the crater rim. If the feature casting the shadow is not a crater rim, but rather a mountain or central peak, you are calculating the height.

### Procedures

The first step in this process would be to take a photograph of the Moon that captures the region near the terminator. This is where shadows will be most defined. It's also necessary to capture a photograph of the limb (edge) of the Moon using the same settings as the photograph of the terminator. The limb photograph will be used to scale the diameter of the Moon to its actual diameter. Of course, if you use a wide enough field, you can capture both the terminator and the limb in the same photograph.

There are two images included with this laboratory that you will use: the companion image, *Example.jpg*, with guides drawn to assist you and *Moon.jpg*.

1. Launch SAOImage DS9 (ds9). From the "**File**" menu, choose "**Import > JPEG**" and open the *Example.jpg* image. Zoom out so you can see all of the sample guides.
2. From the "**Edit**" menu, select "**Region**".
3. From the "**Region**" menu, select "**Shape > Ruler**". Recall that regions may be selected and removed by pressing the delete key on the keyboard.
4. The example image contains guides to help you get familiar with the process. Click and drag to draw a region that extends from one point along the limb and across a portion of the image to another point along the opposite limb. This is the *chord-line*.
5. Create a second ruler region that is half the distance of the chord-line, but follows the same path (see Image 1). This is the *half-chord* line. The ruler region displays the length of the line in pixels. Record the length of the half-chord.

half-chord = \_\_\_\_\_ pixels

6. Create a new ruler region drawn perpendicular from the limb to the tip of the half-chord line. This is the segment. Record the pixel length of the segment.

segment = \_\_\_\_\_ pixels

7. You will now focus on the shadow cast by the central peak of Piccolomini crater. To ensure an accurate measurement, zoom-in (see Image 2) and follow the path of the shadow with respect to the sun angle. Try not to include any sunlit portion of the feature in the shadow measurement. Make a note of the shadow length.

shadow = \_\_\_\_\_ pixels

8. Pixel distance measurements cannot be used in the calculator since pixel size and number are device dependent. As a result, they have to be converted to millimeters. To perform the conversion, the resolution of the image must be known. Most image viewing applications have an inspector tool or other means of displaying the resolution in pixels per inch. The companion image has a resolution (*DPI*) of 72 pixels/inch, which is converted to millimeters by:  $25.4 \div 72 = 0.35278$  mm/pixel. Convert your half-chord, segment and shadow measurements to millimeters. The measurements you obtained for the companion image should be close to:

Half-Chord = 603.49 pixels = 212.9 mm  
Segment = 292.59 pixels = 103.22 mm  
Shadow = 6.00 pixels = 2.11 mm

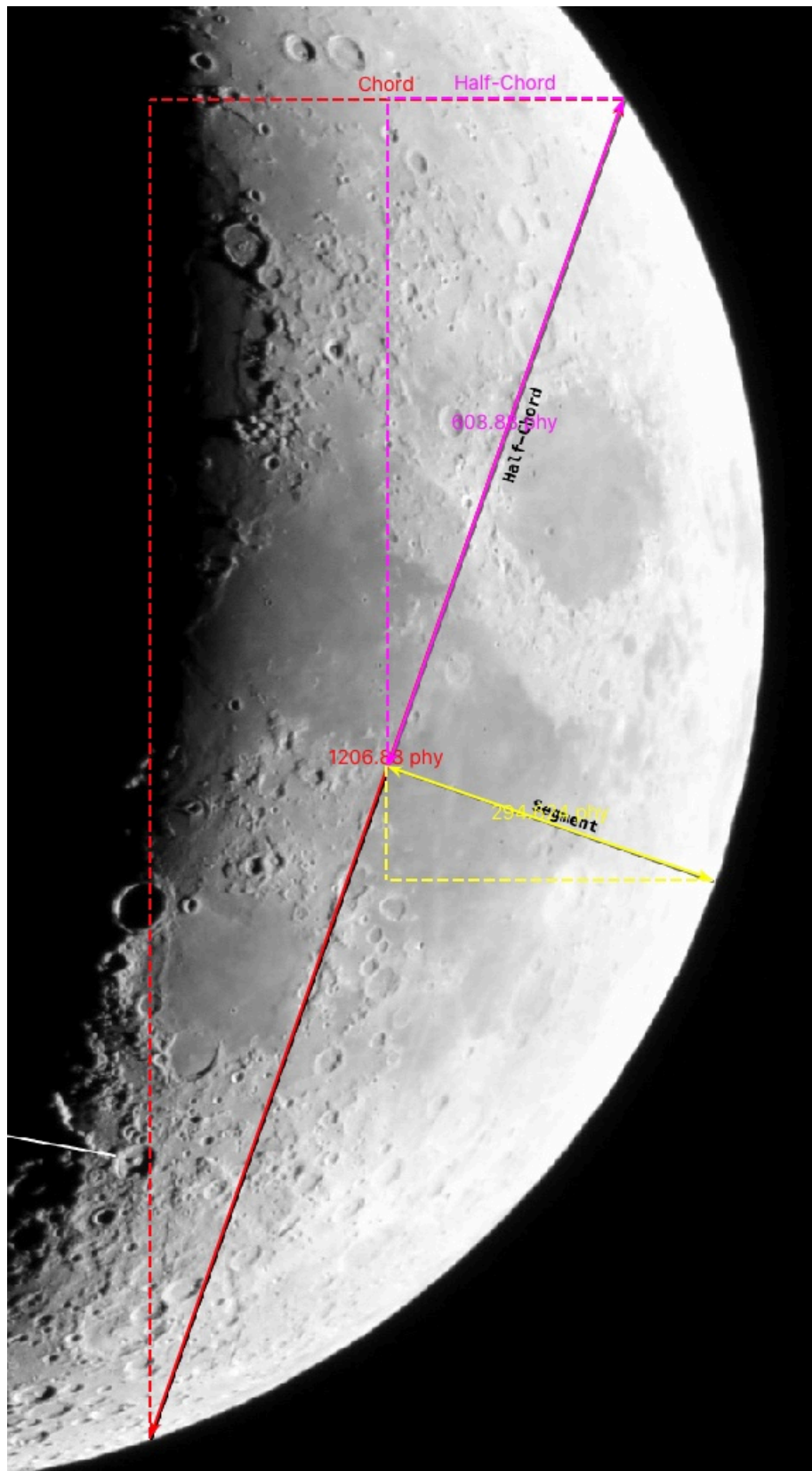
9. Open the [Height of Lunar Features](#) web page. Determine the selenographic coordinates for the feature casting a shadow. Selenographic refers to mapping coordinates on the surface of the Moon just as geographic refers to mapping on the Earth. Below the calculator is a lunar atlas. Locate the feature on the atlas and click on it. This will enter the coordinates in the appropriate fields of the calculator. If you already know the coordinates, you may enter them in decimal format manually.
10. Enter the measurements you've taken into the calculator. First, enter the date of your photograph in universal time (UTC). This is important in order for the calculations to be accurate. The UTC date for the companion image is 2016-03-14T04:08:00. Click the "Calculate" button and the result will appear in green below the calculator.

Feature Height = \_\_\_\_\_ ft ( \_\_\_\_\_ km)

11. Open the *Moon.jpg* image in ds9. You will perform the same steps to obtain the height of the crater, *Maurolycus*, which has been identified in the image.

Image DPI = 100 pixels/inch = \_\_\_\_\_ mm/pixel  
Half-Chord = \_\_\_\_\_ pixels = \_\_\_\_\_ mm  
Segment = \_\_\_\_\_ pixels = \_\_\_\_\_ mm  
Shadow = \_\_\_\_\_ pixels = \_\_\_\_\_ mm  
Feature Height = \_\_\_\_\_ ft ( \_\_\_\_\_ km)

**Image 1: Measuring the Chord Lines Using the "Ruler" region in SAOImage DS9**



***Image 2: Zooming-In to Measuring the Shadow of the Central Peak of a Crater***

