Galileo Measured a Mountain, and So Can You!

- Alan Hirschfeld, as published in *The Classroom Astronomer*, Fall 2010 (this version © TCA 2010

1. Use the letter-labels in Figure 3 to fill in the blanks below and on your worksheet. Points are indicated by a single letter, line segments always by a pair of letters, and angles always by three letters.

(a) The letter ___ indicates the Moon's center.
(b) Segments ___, ___ and___ are each a radius of the Moon.
(c) Segment ___ represents a mountain whose top is at point **D**.
(d) Segment ___ indicates the beam of sunlight that touches, at point **C**, the boundary between the Moon's light and dark halves – technically, the *terminator* – and illuminates the mountain.

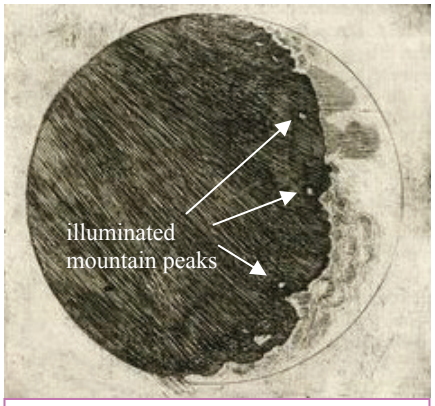

Figure 1. Galileo's sketches of the crescent Moon

2. In Figure 3, Galileo found a right triangle of interest: triangle **ECD**. Again, use the letter-labels in Galileo's diagram to fill in the blanks below regarding statements about triangle **ECD**.
(a) Angle ___ is the right angle.
(b) Side ___ is a lunar radius, about 1,080 miles.
(c) Side ___ is the distance from the terminator to the illuminated mountain peak, as seen from Earth.
(d) Side ___ is the triangle's hypotenuse.

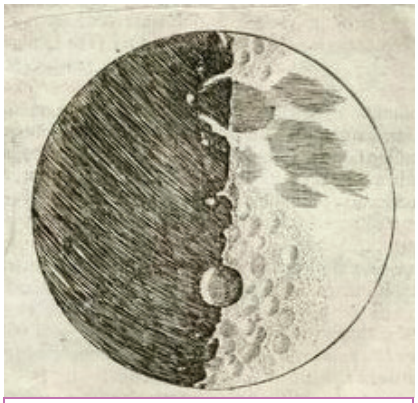

Figure 2. Galileo's sketch of a first-quarter moon.

(e) This hypotenuse encompasses the sum of two segments: another lunar radius, segment ___, plus the height of the mountain, segment ___.

3. In *The Starry Messenger*, Galileo wrote that the illuminated peaks appeared as far as $^{1}/_{20}$ of the Moon's diameter from the terminator. (a) Given that the Moon's diameter is 2,160 miles, compute how far into the Moon's dark side these illuminated peaks were situated, according to Galileo. (b) To which side of the right triangle **ECD** does this answer correspond?

4. Galileo now applied the Pythagorean theorem for right triangles: the square of the hypotenuse is equal to the sum of the squares of the sides, or $(\text{hypotenuse})^2 = (\text{side a})^2 + (\text{side b})^2$. Using your answers to parts 2b, 2c and 2d, write down the Pythagorean theorem for the right triangle **ECD**.

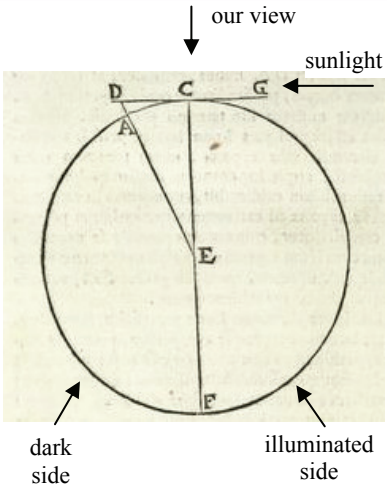

Figure 3. Geometry of an illuminated lunar mountain.

5. Using the numerical values from parts 2b and 3, solve the Pythagorean theorem equation for the hypotenuse of triangle **ECD**.

6. Since the hypotenuse encompasses the sum of a lunar radius plus the height of the mountain, subtract a lunar radius from your answer to part 5 to obtain the height of the mountain itself. In fact, your answer represents the minimum height of lunar mountains; they must be *at least* this tall to poke up into the sunlight.

7. (a) Compare the height of lunar mountains to that of mountains on Earth. Your answer must include a direct number comparison. If you don't know how high mountains on the Earth are, ask your classmates

or look it up. (b) Do you agree with Galileo's stated conclusion that lunar mountains are *several times* taller than the highest mountains on Earth?

8. Having found that the Moon is so rugged, Galileo had to explain why the edge, or *limb*, of the Moon nonetheless appeared round and smooth instead of jagged. He proposed that, when looking at the limb of the Moon, an observer sees successively more distant mountains in the gaps between nearer mountains. Explain how this might make the Moon's limb appear round and smooth. (Galileo also suggested that the Moon's atmosphere blurs the ruggedness of the landscape, making it look more regular than it is. In this he was wrong; the Moon has no atmosphere.)

Worksheet **NAME _____**

1. (a) ____ (b) ____, ____, ____ (c) ____ (d) ____

2. (a) ____ (b) ____ (c) ____ (d) ____, (e) ____, _____

3. (a) _____ miles (b) _____

4.

5.

6.

7.

8.