Gravity and Tides

Tides are caused by the gravitational attraction of the moon and sun. These two large objects pull on the water and cause it to bulge with respect to the Earth's surface. The large gravitational attraction of the Earth holds the water onto the surface, but the other two, more distant objects can tug it onto an oblong shape.

$$F_{grav} = G\frac{m_1 m_2}{d^2}$$

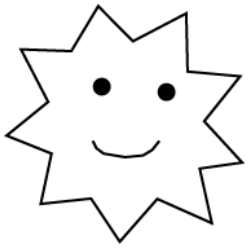
Goal: To understand how the moon and sun influence tides on the Earth, and to recognize the connection between tidal range and the phases of the moon.

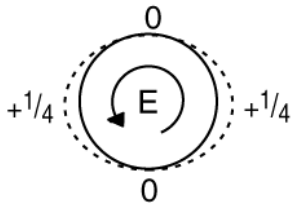
Pre-Activity questions: (refer to pages 109-112 in text)

Gravity pulls the water on the Earth toward foreign bodies (moon and sun). Why is there a tidal bulge on the Earth on the opposite side from the moon or sun?

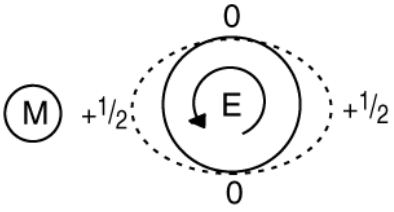
Why does the moon have a greater effect on tides than the sun?

TIDES

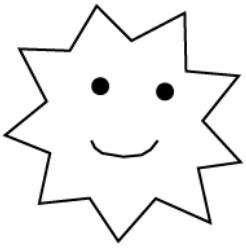




Effect of the sun on tides
(view from above)



Effect of the moon on tides
(view from above)



Sketch the combined effects of the sun and moon on tides.

Figure 1

Procedure:

Part 1 – Graphical representation of tidal variations and phases of the moon

Look at the diagrams in Figure 1 which show the relative effect of the sun and the moon on the Earths tides. The tidal bulges are greatly exaggerated, but the relative size of the deflections caused by the sun and the moon are in the correct proportions.

Sketch in the approximate size and shape of the tidal bulge in the third diagram (bottom of figure 1)

Examine each of the four diagrams in Figure 2 and determine the relative position of the Earth, the sun, and the moon. On each diagram of the Earth/sun/moon, shade in the dark half of the moon and leave the sunny side white. Label each diagram with the phase of the moon (new, waning, full, waxing).

Shade the dark side of the Earth and leave the sunny side white. Determine which letter on the diagrams of the Earth represents dawn, noon, dusk, and midnight.

a =

b =

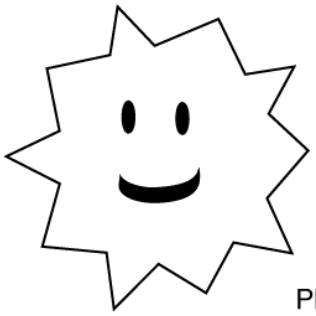
c =

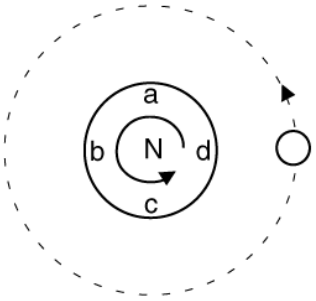
d =

On each diagram, draw in an ellipse **in green** showing the approximate tidal bulges related to the moon's gravity. **In red**, draw in a smaller ellipse representing the sun's tidal bulges. **In blue**, draw in the approximate shape of the water surface that results from the combination of these two bulges.

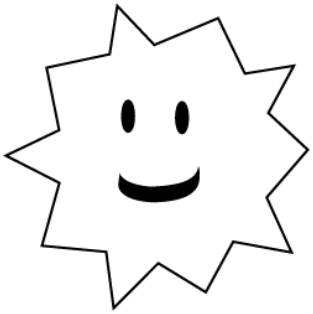
Under what conditions is the tidal range the largest? Explain why. What phase(s) of the moon does this represent?

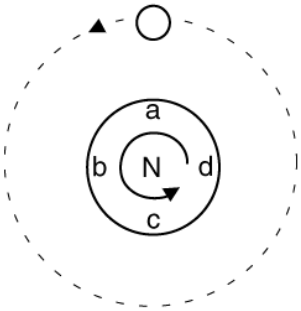
Under what conditions is the tidal range the smallest? Explain why. What phase(s) of the moon does this represent?



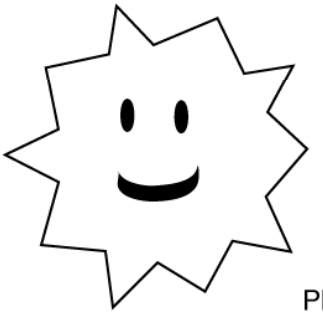


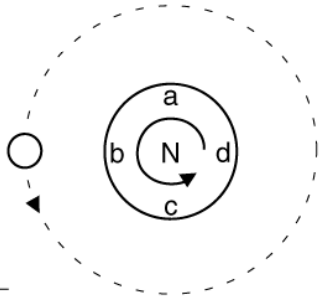
Phase of the moon: _____



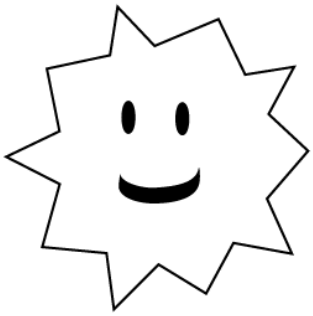


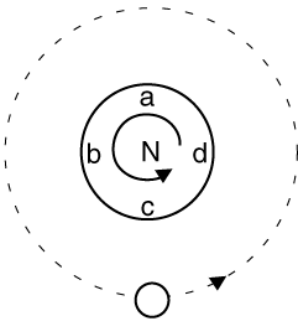
Phase of the moon: _____





Phase of the moon: _____





Phase of the moon: _____

Figure 2 - view is looking down on the North Pole

Part 2 – Numerical model of the phases of the moon, related to time of day

Fill in the chart below showing water displacement (in meters) based on the following assumptions:

1. the bulges facing toward and away from the moon pull the water up about ½ meter above the average.

2. the low areas on the sides of the Earth perpendicular to the moon pull the water down about ½ meter below the average.

3. the bulges facing toward and away from the sun pull the water up about $^1/_4$ meter above the average.

4. the low areas on the sides of the Earth perpendicular to the sun pull the water down about $^1/_4$ meter below the average.

	Station a			**Station b**			**Station c**			**Station d**		
time of day												
	moon	sun	total	moon	sun	total	moon	sun	total	moon	sun	total
full moon												
waning moon												
new moon												
waxing moon												

Post-Activity Questions

How does your numerical data match your observations from Part 1? Do your calculations show the same relationship between the highest/lowest tides and the phases of the moon? How do Spring tides and Neap tides relate to the phases of the moon?

At what time of day do the highest and lowest Spring tides occur? Neap tides?

Does high tide occur at the same time everywhere on Earth? Explain.

The Earth's axis is tilted about 23 ½ ° so the moon and sun are not always in the equatorial plane; sometimes north of the equator , sometimes south. Explain how this will affect the tides.