## The Pilgrim Tides

| Earth Science | March Lunar Cycle, 2016 | Mr. Traeger |
|---|---|---|

Name: _____     Period: _____     Date: _____

### Background and Purpose

Most of us have heard the story of the Pilgrims' exodus from England to the New World in the year 1620. The Pilgrims anchored the *Mayflower* at the site of Provincetown (Cape Cod), Massachusetts for almost a month before settling at Plymouth Harbor. Imagine that you are the ship's captain of the *Mayflower II* and you need to know the tidal fluctuations at Provincetown in order to keep the ship from running aground while at anchor. You will use the tide chart given to you to estimate/graph the tidal fluctuations for March, 2016 arrival at Provincetown. In doing so, you will become familiar with the differences in tidal ranges during each phase of the Moon.

### Materials

- Tide chart
- Ruler
- Graph Paper on Back
- Pencil

### Procedure

1. Using a sheet of graph paper, divide the paper lengthwise into 4 separate sections.

2. Plot time of day on the *x*-axis and water level in feet on the *y*-axis for the dates corresponding to the third quarter, new moon, first quarter, and full moon. Be careful to scale your graph correctly and to account for negative tides, which are below mean sea level. The origin for the time axis should be 12:00 A.M. for each graph.

3. Once you have plotted your points, connect the points with a smooth curve. Make sure to label you graphs with a title and units on each axis.

4. Answer the questions that follow concerning your 4 graphs.

### Pre Graphing Questions (Refer to pages 541-543 in your text to do these)

1. Draw the orientation of the Earth, Sun, and Moon for **Spring** tides. Also make sure to draw the tidal bulge of the ocean. See page 542.

2. Draw the orientation of the Earth, Sun, and Moon for **Neap** tides. Also make sure to draw the tidal bulge of the ocean. See page 542.

3. How many high tides and how many low tides are there (usually) per day? Why is this? Drawing a diagram of how the Earth rotates underneath the tidal bulge is required.

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## Provincetown Cape Cod Bay

**Provincetown Cape Cod Bay, Massachusetts**

**March Tide Chart**

**2016**

| DAY | DATE | HIGH | | | | LOW | | | | ☀ | | 🌙 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AM | hgt | PM | hgt | AM | hgt | PM | hgt | rise | set | moon |
| Tuesday | 01 | 4:20 | 8.6 | 4:52 | 7.8 | 10:43 | 1.1 | 10:59 | 1.5 | 6:15 | 5:31 | |
| Wednesday | 02 | 5:11 | 8.6 | 5:48 | 7.7 | 11:37 | 1.2 | 11:53 | 1.6 | 6:13 | 5:32 | |
| Thursday | 03 | 6:06 | 8.6 | 6:45 | 7.8 | 12:34 PM | 1.1 | | | 6:11 | 5:33 | |
| Friday | 04 | 7:03 | 8.9 | 7:42 | 8.1 | 12:50 | 1.4 | 1:31 | 0.8 | 6:10 | 5:34 | |
| Saturday | 05 | 7:59 | 9.3 | 8:37 | 8.6 | 1:47 | 1.1 | 2:26 | 0.3 | 6:08 | 5:36 | |
| Sunday | 06 | 8:53 | 9.8 | 9:28 | 9.2 | 2:41 | 0.6 | 3:18 | -0.3 | 6:07 | 5:37 | |
| Monday | 07 | 9:45 | 10.3 | 10:17 | 9.8 | 3:34 | -0.1 | 4:07 | -0.9 | 6:05 | 5:38 | |
| Tuesday | 08 | 10:35 | 10.8 | 11:04 | 10.4 | 4:25 | -0.7 | 4:55 | -1.4 | 6:03 | 5:39 | |
| Wednesday | 09 | 11:25 | 11.1 | 11:52 | 10.8 | 5:15 | -1.3 | 5:42 | -1.7 | 6:02 | 5:40 | 🔵 |
| Thursday | 10 | 12:15 PM | 11.2 | | | 6:04 | -1.7 | 6:30 | -1.8 | 6:00 | 5:42 | |
| Friday | 11 | 12:40 | 11.1 | 1:05 | 11.1 | 6:55 | -1.8 | 7:18 | -1.6 | 5:58 | 5:43 | |
| Saturday | 12 | 1:29 | 11.2 | 1:57 | 10.7 | 7:46 | -1.7 | 8:08 | -1.2 | 5:57 | 5:44 | |
| Sunday | 13 | 3:20 | 11.0 | 3:52 | 10.2 | 9:40 | -1.4 | 10:01 | -0.7 | 6:55 | 6:45 | |
| Monday | 14 | 4:14 | 10.6 | 4:50 | 9.6 | 10:36 | -0.9 | 10:57 | -0.1 | 6:53 | 6:46 | |
| Tuesday | 15 | 5:12 | 10.2 | 5:52 | 9.0 | 11:36 | -0.4 | 11:57 | 0.4 | 6:51 | 6:47 | |
| Wednesday | 16 | 6:14 | 9.8 | 6:59 | 8.7 | 12:40 PM | 0.1 | | | 6:50 | 6:49 | |
| Thursday | 17 | 7:20 | 9.4 | 8:06 | 8.5 | 1:00 | 0.8 | 1:46 | 0.3 | 6:48 | 6:50 | |
| Friday | 18 | 8:26 | 9.3 | 9:09 | 8.6 | 2:04 | 0.9 | 2:51 | 0.4 | 6:46 | 6:51 | |
| Saturday | 19 | 9:28 | 9.3 | 10:06 | 8.8 | 3:07 | 0.9 | 3:49 | 0.3 | 6:45 | 6:52 | |
| Sunday | 20 | 10:23 | 9.4 | 10:54 | 9.0 | 4:04 | 0.7 | 4:39 | 0.2 | 6:43 | 6:53 | |
| Monday | 21 | 11:10 | 9.5 | 11:36 | 9.2 | 4:53 | 0.5 | 5:22 | 0.2 | 6:41 | 6:54 | |
| Tuesday | 22 | 11:52 | 9.6 | | | 5:37 | 0.3 | 6:01 | 0.1 | 6:39 | 6:55 | |
| Wednesday | 23 | 12:13 | 9.3 | 12:31 | 9.6 | 6:17 | 0.1 | 6:38 | 0.2 | 6:38 | 6:57 | 🟡 |
| Thursday | 24 | 12:49 | 9.4 | 1:08 | 9.5 | 6:56 | 0.0 | 7:14 | 0.2 | 6:36 | 6:58 | 🟡 |
| Friday | 25 | 1:24 | 9.5 | 1:45 | 9.3 | 7:34 | 0.0 | 7:51 | 0.4 | 6:34 | 6:59 | |
| Saturday | 26 | 1:59 | 9.5 | 2:23 | 9.1 | 8:13 | 0.1 | 8:28 | 0.6 | 6:32 | 7:00 | |
| Sunday | 27 | 2:35 | 9.4 | 3:02 | 8.9 | 8:53 | 0.3 | 9:07 | 0.8 | 6:31 | 7:01 | |
| Monday | 28 | 3:14 | 9.2 | 3:44 | 8.6 | 9:34 | 0.5 | 9:49 | 1.1 | 6:29 | 7:02 | |
| Tuesday | 29 | 3:56 | 9.1 | 4:29 | 8.3 | 10:19 | 0.7 | 10:34 | 1.3 | 6:27 | 7:03 | |
| Wednesday | 30 | 4:42 | 8.9 | 5:19 | 8.1 | 11:08 | 0.9 | 11:24 | 1.5 | 6:26 | 7:04 | |
| Thursday | 31 | 5:33 | 8.8 | 6:12 | 8.0 | 12:01 PM | 1.0 | | | 6:24 | 7:05 | |

Tide charts acquired from http://www.boatma.com/tides/Cape-Cod.html

## Making Tide Graphs

Use the following graph sheet to plot your tides. Make sure to make 4 separate graphs, one for each phase of the moon. Plot time of day (hours) on *x* axis and height variation (feet) on *y* axis.

**Third Quarter (Plot March 1, 2016)**

**New Moon (Plot March 9, 2016)**

**First Quarter (Plot March 15 , 2016)**

**Full Moon (Plot March 23, 2016)**

**Post Graphing Questions (Refer to pages 541-543 in your text to do these)**

1. Subtract the height value for the lowest low tide from the height value for the highest high tide for each date below. This is called tidal range. Show your mathematical work.

| 3/1/16 (Third Quarter) | 3/9/16 (New Moon) | 3/15/16 (First Quarter) | 3/23/16 (Full Moon) |
|---|---|---|---|
| Highest high tide: <br><br> Lowest low tide: <br><br> Difference (Range): | Highest high tide: <br><br> Lowest low tide: <br><br> Difference (Range): | Highest high tide: <br><br> Lowest low tide: <br><br> Difference (Range): | Highest high tide: <br><br> Lowest low tide: <br><br> Difference (Range): |

2. Which two dates above would be considered as Spring Tides? Which two dates above would be considered as Neap Tides? Use the tidal range to figure this out.

| Dates of Spring Tides | Dates of Neap Tides |
|---|---|
|  |  |

3. Look at the times of the AM high tides for the whole tide chart. By how many minutes does the time advance for each successive day? Why is this?

4. Which has the greatest influence on tides, the Sun or the Moon? Why?

5. Which side of the Earth is more attracted to the moon? The side facing the moon or the side away from the moon? Why?

6. Perigee is on March 10th and the moon is a distance of 359,508 km. Apogee is on March 25th and the moon is a distance of 406,123 km. How does this explain the difference of tidal range between the March 9th New Moon and the March 23rd Full Moon? Draw an orbital diagram to explain this.

7. Look at the following two tide graphs from different locations. Then look at the map on page 708-709 in your book. Explain why the tidal range (size of the tides) is different for each geographic location.



Boston, MA (Atlantic Ocean)



Cedar Key, FL (Gulf of Mexico)
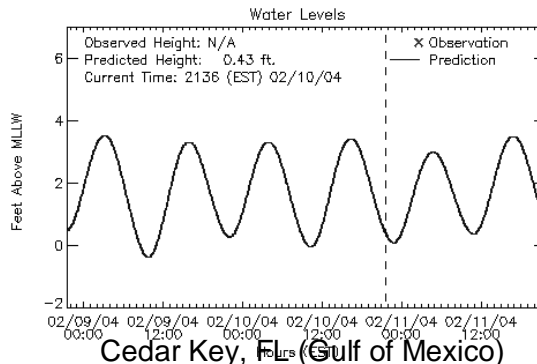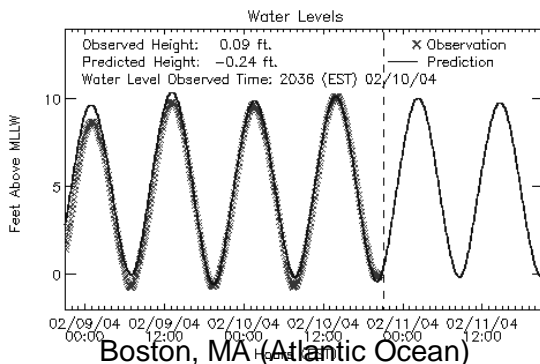
8. Why is it that oceans have larger tides and large lakes have smaller tides? Explain.

9. Predict what might happen on the Earth if we did not have the Moon to influence our tides. Would we still have ocean tides? If so, what other celestial body would cause them?