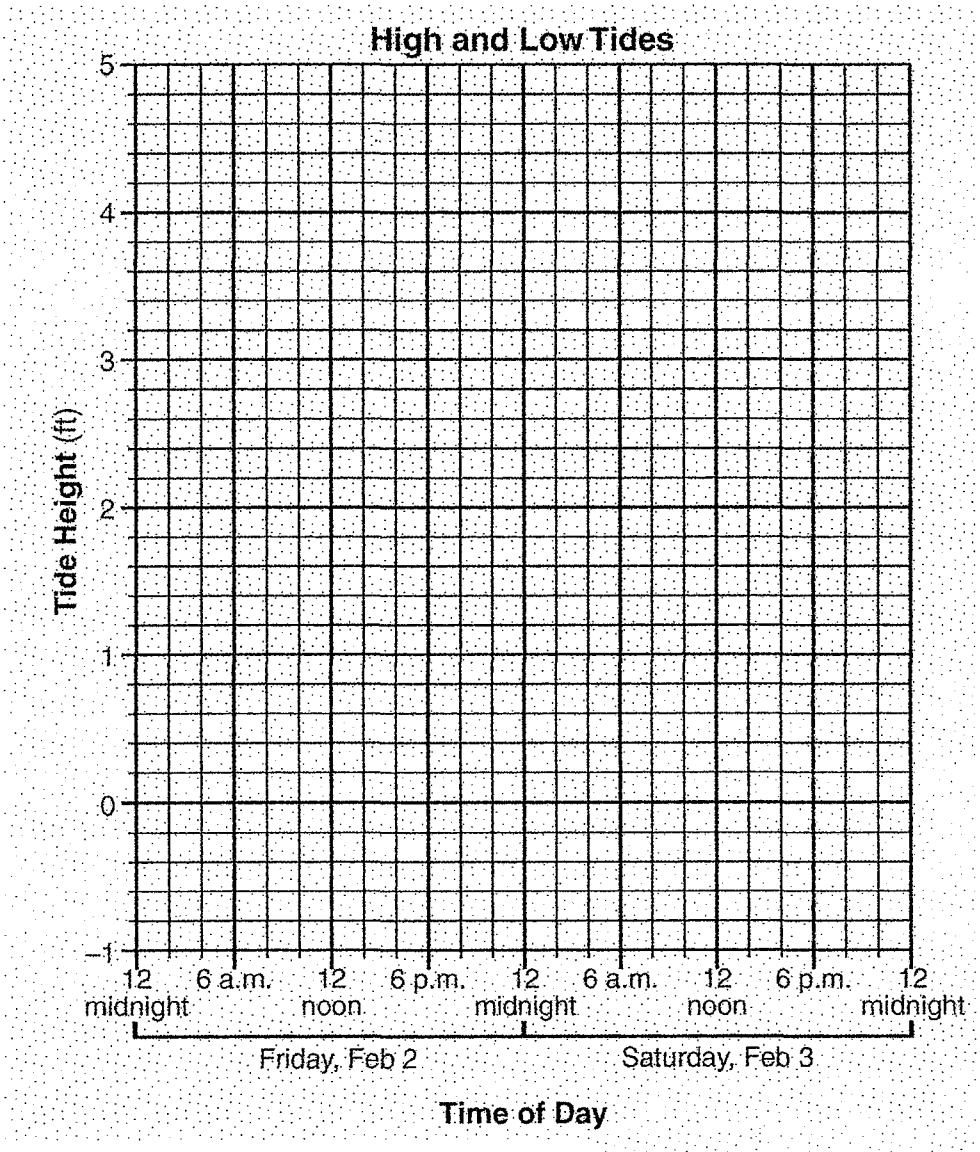
Name Date Period

Earth-Moon Free Response

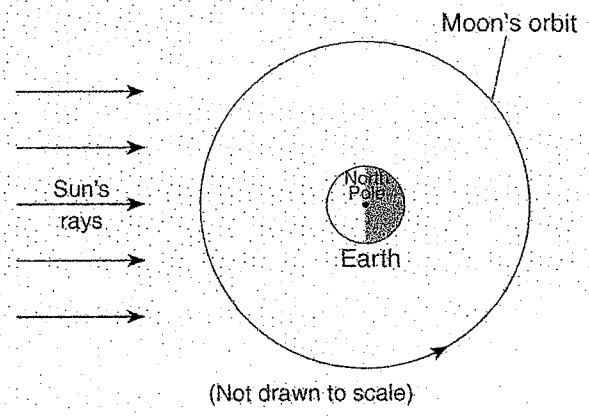
Score _____

1)



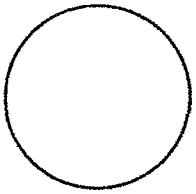
2) _____

3)



4) _____

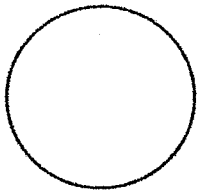
5)



6) _____

7) _____ hours

8)



9)

W

X

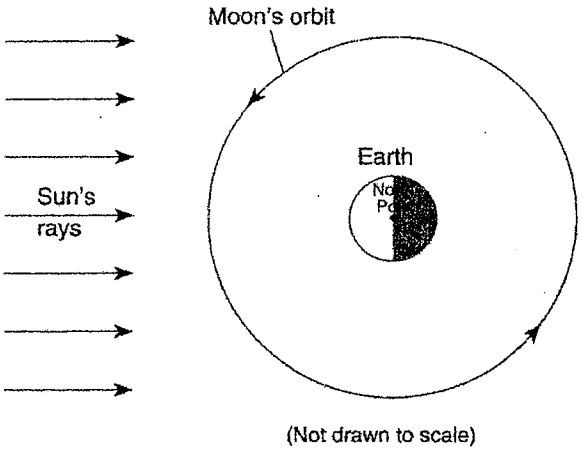
Y

Z

10)

11)

12 & 16

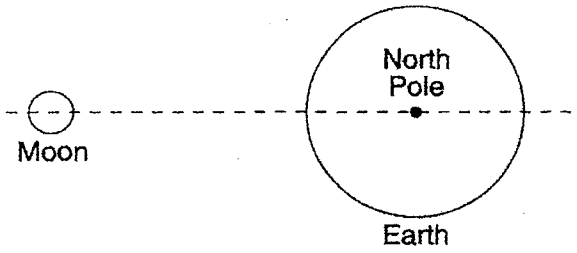


13

14) days

15)

17)

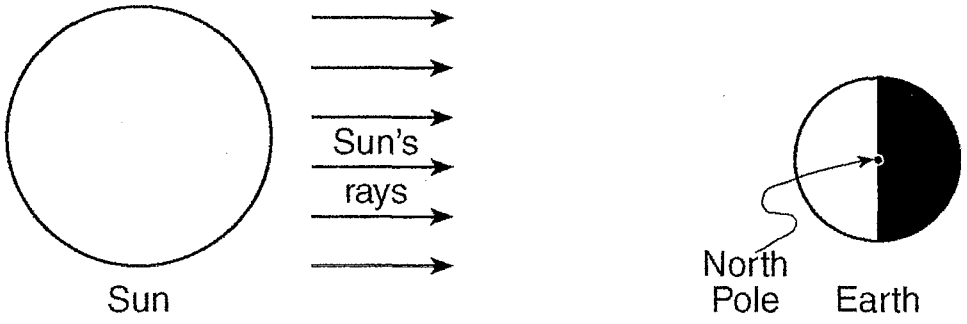


18)

19) Seconds

20)

21)



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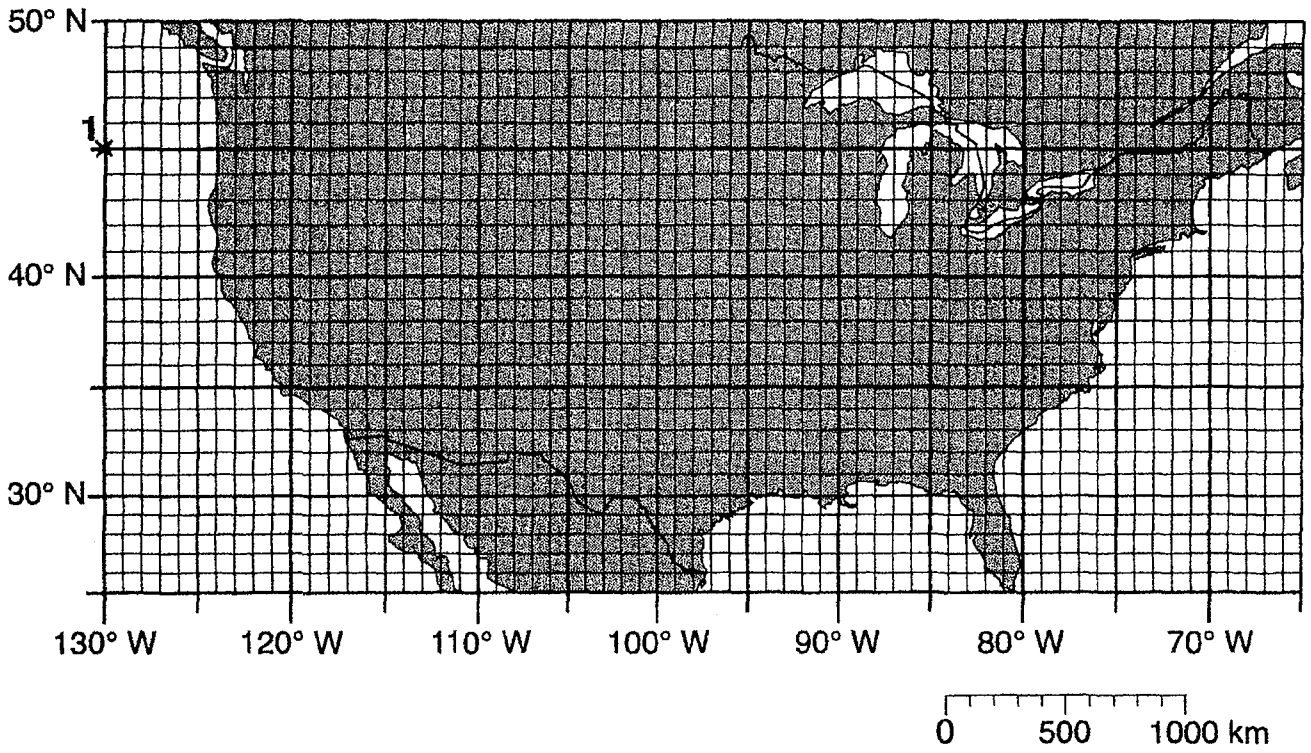
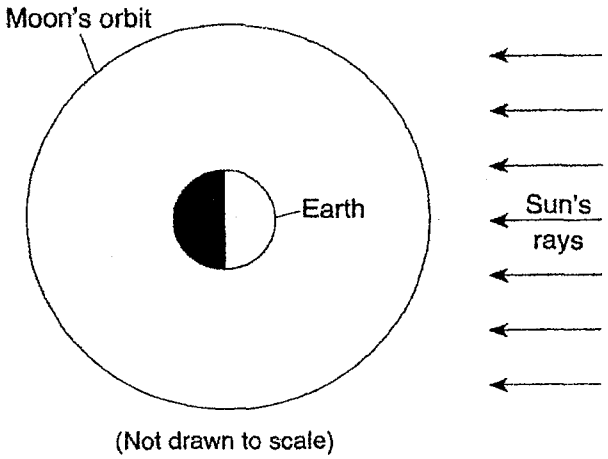
22 & 23)



24)



(Not drawn to scale)

25) _____ &

26) _____ days

27) _____

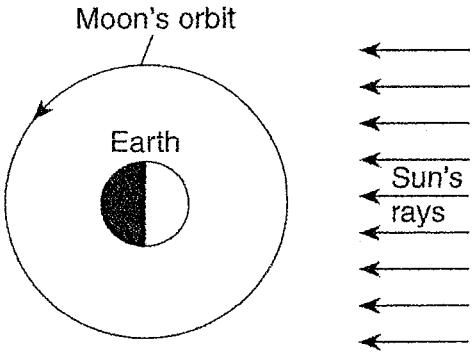
28) Repeat Question - Sorry!

29) _____

30) _____

31)

32)



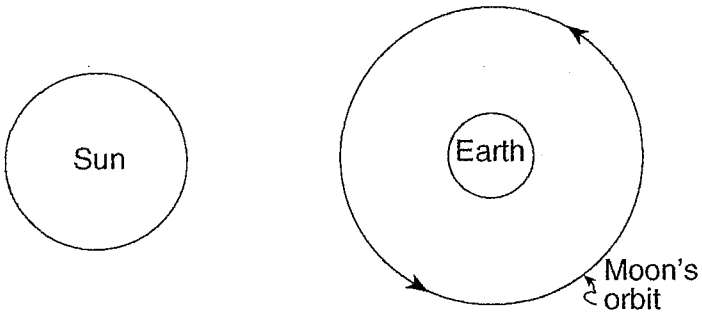
(Not drawn to scale)

33)

34)

35)

36)



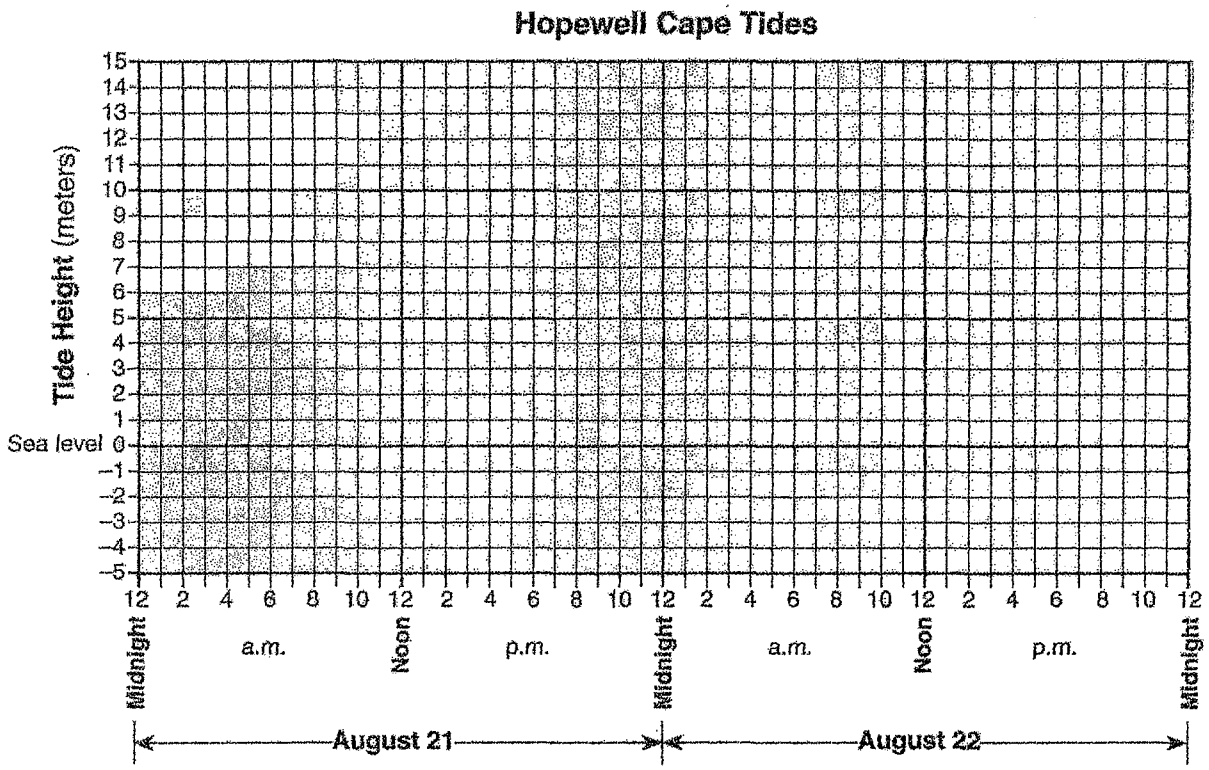
(Not drawn to scale)

37) _____ Revolutions

38)

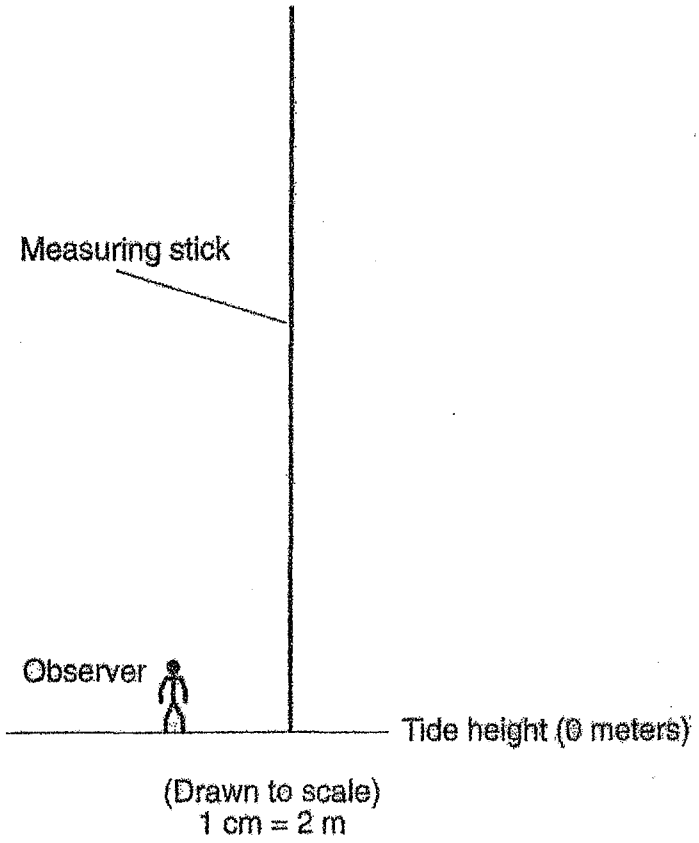
39)

40)

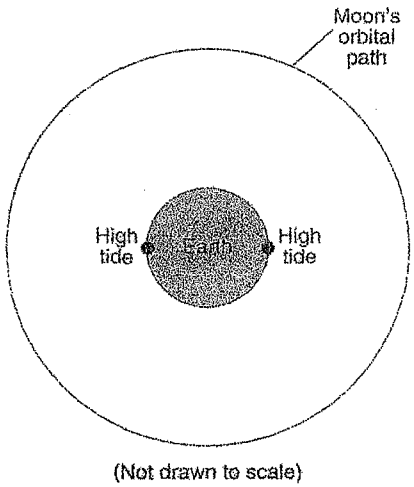


41) _____

42)



43)

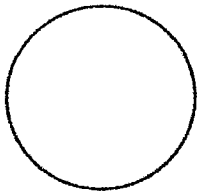


44) _____

45) _____

_____

46)



47)

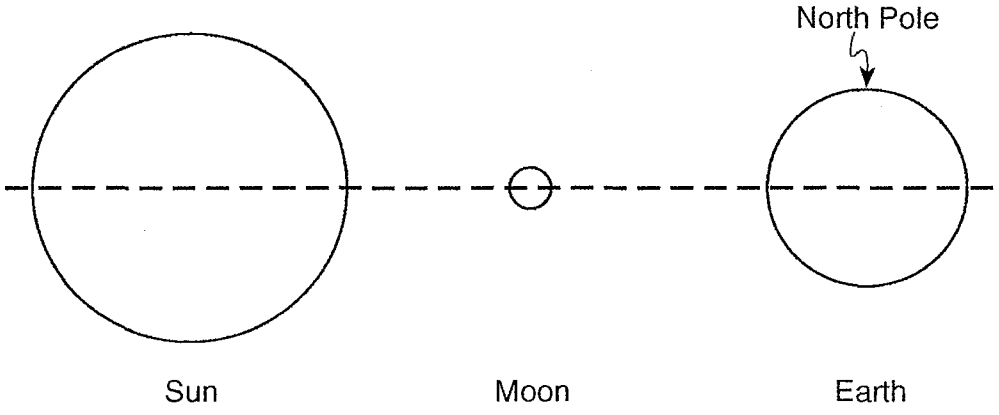
48)

49)

50)

51)

52)



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53) tide

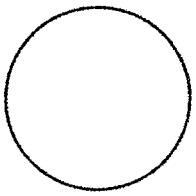
54)

55) _____

_____

_____

56) At Position 7

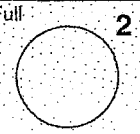
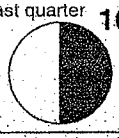
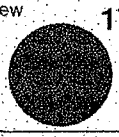
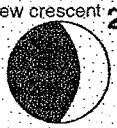


57) _____ &

58) _____

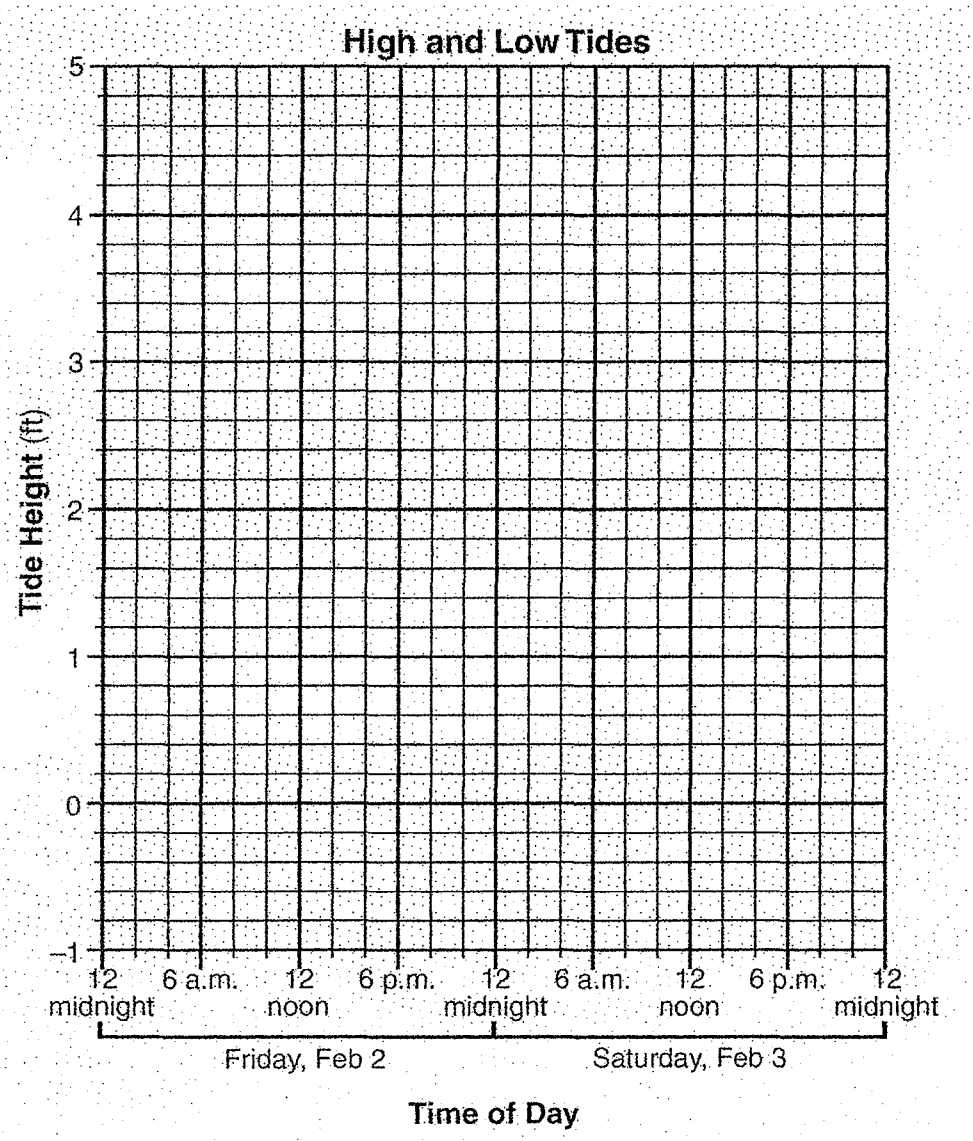
Base your answers to questions **1** through **5** on the calendar and data table below. The calendar shows the month of February 2007, indicating the dates when some lunar phases occurred. February 24 lists only the name of the Moon phase that occurred on that day. The data table shows the highest and lowest tides (in feet) recorded for the Hudson River at Kingston, New York, over a 2-day period in February 2007.

February 2007

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	Full 2 	3
4	5	Old gibbous 6 	7	8	9	Last quarter 10 
11	12	13	14	15	16	New 17 
18	19	New crescent 20 	21	22	23	First quarter 24
25	26	27	28			

High and Low Tides for Kingston, New York

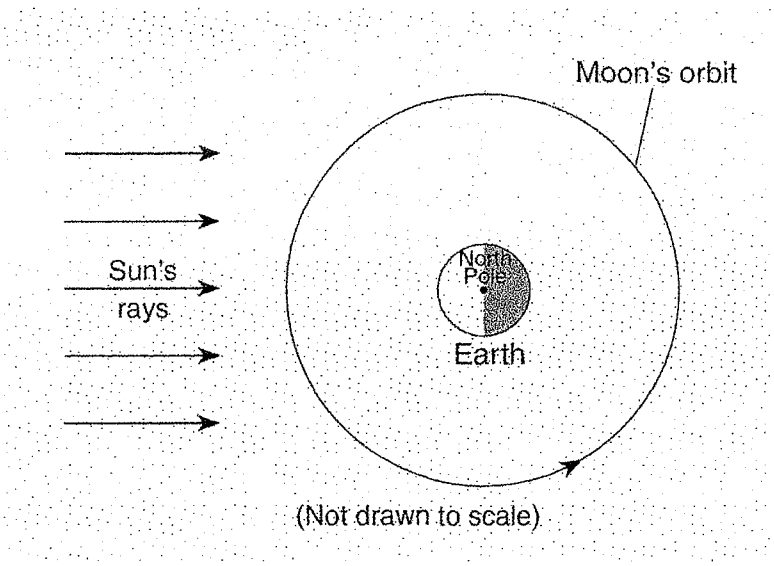
Date	Time of Day	Tide Height (ft)
Friday, February 2	1:30 a.m.	3.5
	7:30 a.m.	−0.2
	1:30 p.m.	4.1
	8:00 p.m.	−0.4
Saturday, February 3	2:00 a.m.	3.6
	8:30 a.m.	−0.2
	2:00 p.m.	4.0
	9:00 p.m.	−0.4



1. On the grid above, plot the tide height for *each* time of day listed in the data table. Connect the plots with a line.

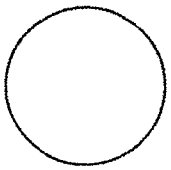
2. Predict the time of the first high tide on Sunday, February 4. Include a.m. or p.m. in your answer.

3. On the diagram below, draw a small circle (**O**) on the Moon's orbit to show the position of the Moon in its orbit on February 2.



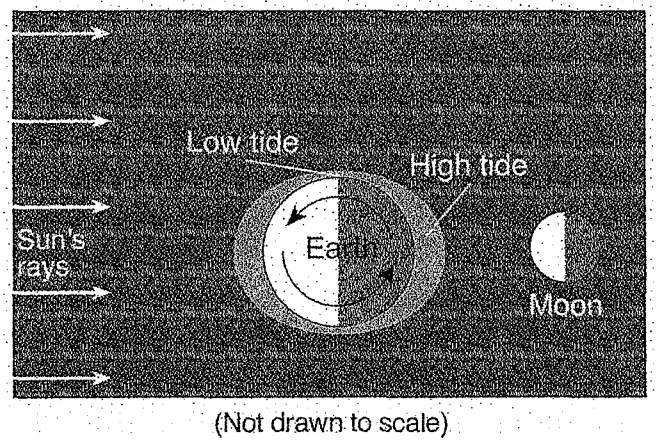
4. State the date of the next full Moon that occurred after February 2.

5. In the circle below, shade the part of the Moon that appeared dark to an observer in New York State on February 24.



Base your answers to questions **6** and **7** on

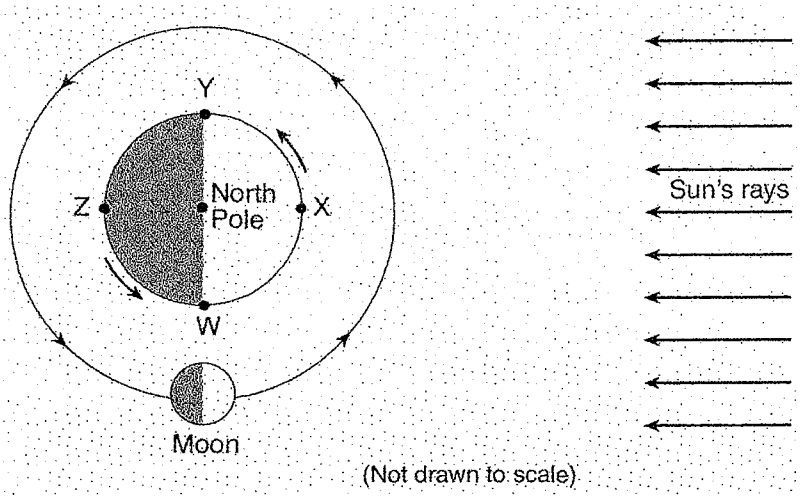
the diagram below, which shows the locations of high and low tides on Earth at a particular time.



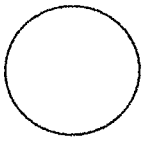
6. Identify the force that causes ocean tides on Earth.

7. Approximately how many hours will pass between high tide and the following low tide?

Base your answers to questions **8** through **11** on the diagram below, which shows one position of the Moon in its orbit around Earth. Letters *W*, *X*, *Y*, and *Z* are locations on Earth's surface.



8. On the diagram of the Moon below, shade the part of the Moon that appears dark to an observer in New York State when the Moon is at the position shown in the diagram above.

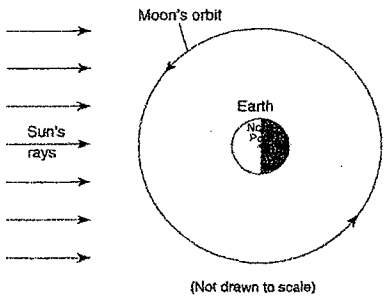


9. Write "high" or "low" to indicate whether a high ocean tide or low ocean tide is occurring at locations *W*, *X*, *Y*, *Z*.

10. What type of tide is this known as?

11. What is the moon phase in the above diagram?

Base your answers to questions **12** through **16** on the diagram in your answer booklet, which shows the Moon's orbit around Earth.



12. On the diagram above, place a small circle (o) on the Moon's orbit at the new-Moon phase where none of the lighted portion of the Moon is visible from Earth.

13. Explain why ocean tides are considered to be cyclic.

14. How long does it take the Moon to complete one revolution around Earth? Express your answer to the *nearest tenth of a day.*

15. Explain why lunar eclipses only occur when the Moon and the Sun are on opposite sides of Earth

16. omit

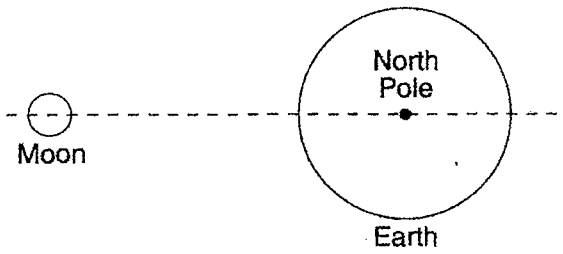
Base your answers to questions **17** through **20** on the passage below.

The Moon Is Moving Away While Earth's Rotation Slows

Tides on Earth are primarily caused by the gravitational force of the Moon acting on Earth's surface. The Moon causes two tidal bulges to occur on Earth: the direct tidal bulge occurs on the side facing the Moon, and the indirect tidal bulge occurs on the opposite side of Earth. Since Earth rotates, the bulges are swept forward along Earth's surface. This advancing bulge helps pull the Moon forward in its orbit, resulting in a larger orbital radius. The Moon is actually getting farther away from Earth, at a rate of approximately 3.8 centimeters per year.

The Moon's gravity is also pulling on the direct tidal bulge. This pulling on the bulge causes friction of ocean water against the ocean floor, slowing the rotation of Earth at a rate of 0.002 second per 100 years.

17. The diagram below shows the Moon and Earth in line with each other in space. On the diagram, place an **X** on Earth's surface to indicate where the direct tidal bulge is occurring.



(Not drawn to scale)

18. Explain why the force of gravity between the Moon and Earth will *decrease* over time.

19. In 100,000 yrs, the rotation of Earth will be slower by how many seconds?

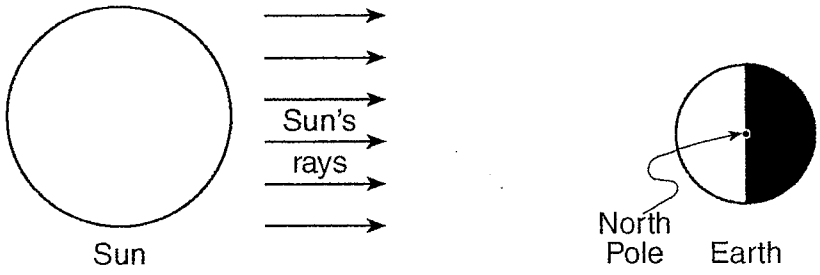
20. Explain why the Moon has a greater influence than the Sun on Earth's tides.

---

21. The diagram provided below represents the Sun and Earth as viewed from space on a certain date.

a Using a symbol for the Moon of approximately the size of a dime, draw the position of the Moon on the diagram provided aboveat the time when the fullMoon phase is observed from Earth.

b Draw an arrow on the diagram provided abovethat shows the Earth motion that causes surface ocean currents and surface winds to curve (Coriolis effect).



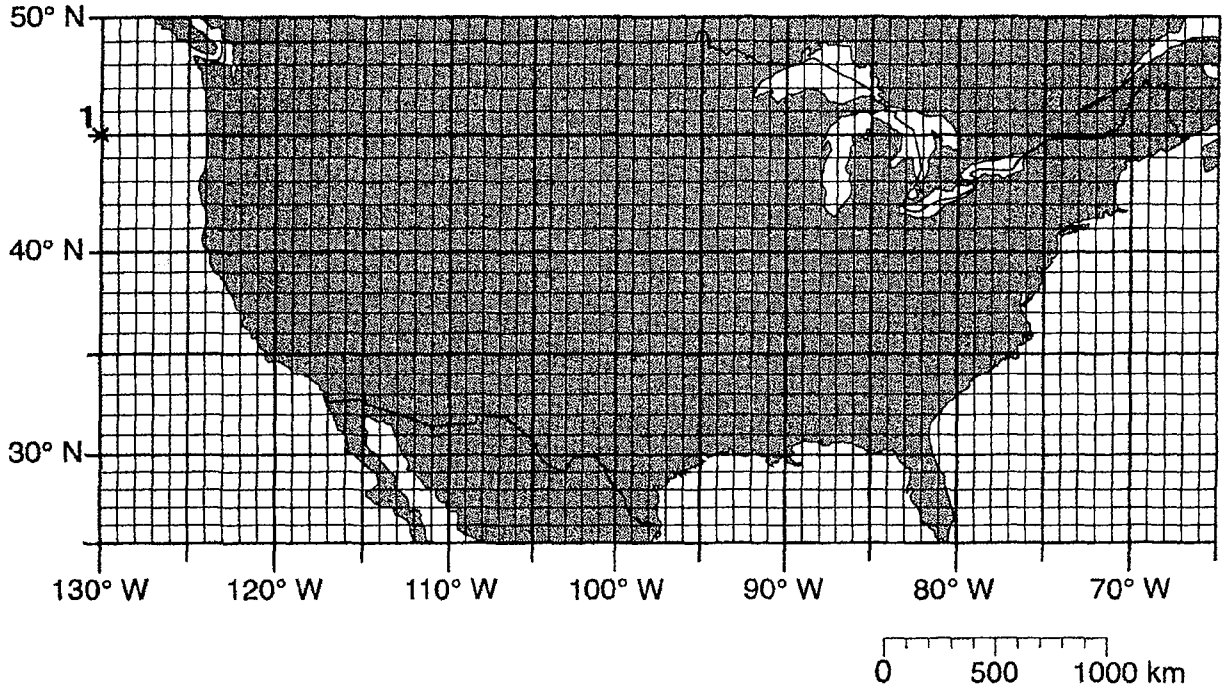
(Not drawn to scale)

Base your answers to questions **22** through **24** on on the information below about a solar eclipse that will occur on August 21, 2017. The latitude and longitude coordinates for the movement of the center of the Moon's shadow across the Earth's surface are given in the table.

Data Table

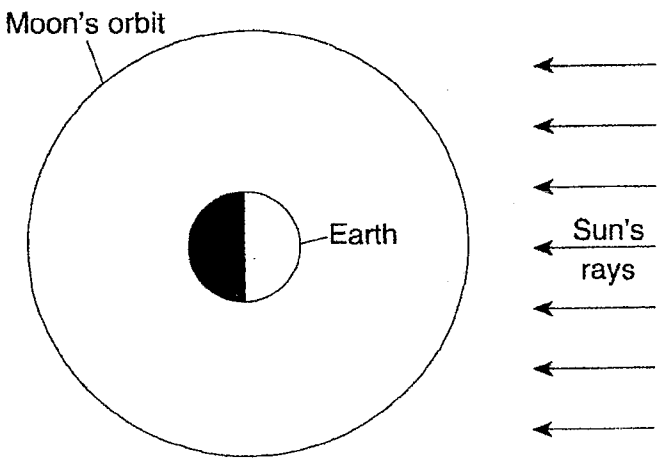
Shadow Position Number	Latitude (° N)	Longitude (° W)
1	45.0	130.0
2	44.0	114.5
3	42.0	103.0
4	39.5	94.0
5	36.0	86.0
6	32.5	78.5
7	28.5	71.0

22. On the graph below, plot with an **X** the path of the center of the Moon's shadow for each position given in the data table. Connect the **X**s with a smooth, curved line. Shadow position number 1 has been plotted on the graph.



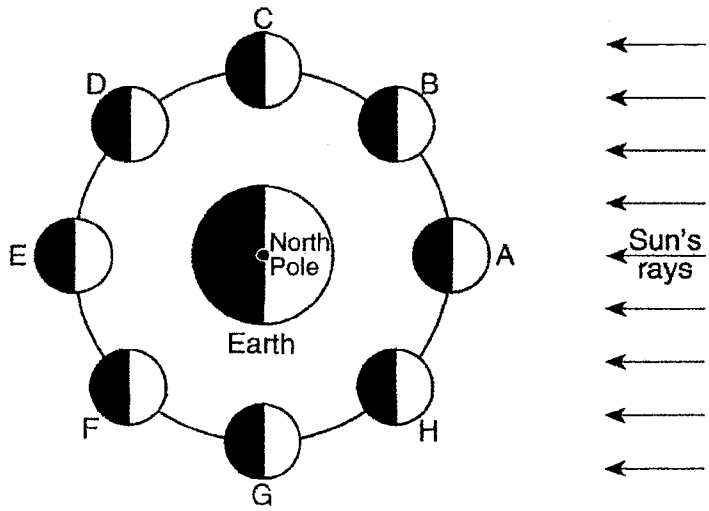
23. The path of the Moon's shadow will be approximately 100 kilometers wide. On the graph now shade the area between positions 1 and 3 to show the width of the Moon's shadow on Earth.

24. On the diagram below, place an **X** on the Moon's orbit to show the Moon's position during a solar eclipse.



(Not drawn to scale)

Base your answers to questions **25** through **29** on the diagram below, which shows the Moon at positions *A* through *H* in its orbit around Earth.



(Not drawn to scale)

25. Which letters represent the *two* positions of the Moon when the *least* difference between the levels of high and low ocean tides occur on Earth?

26. How many days does it take for the Moon to complete one cycle of phases as viewed from Earth?

27. At which Moon position could a lunar eclipse occur?

28. How many days does it take for the Moon to complete one cycle of phases as viewed from Earth?

29. At which Moon position could a solar eclipse occur?

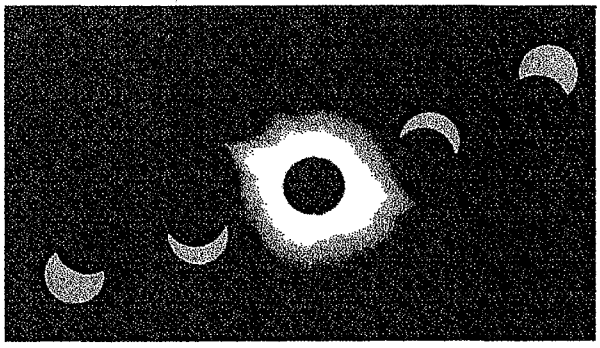
Base your answers to questions **30** through **32** on the data table below and on the graph. The data table shows the maximum altitude and phase of the Moon observed above the southern horizon on certain dates during January and February at a New York State location. The line on the graph shows the altitude of the noontime Sun observed during the same time period at the same New York State location.

Data Table

Date	Maximum Altitude of Moon (°)	Phase of Moon
January 4	26	new
January 13	63	first quarter
January 19	72	full
January 26	35	last quarter
February 3	34	new
February 11	70	first quarter
February 18	60	full
February 25	27	last quarter

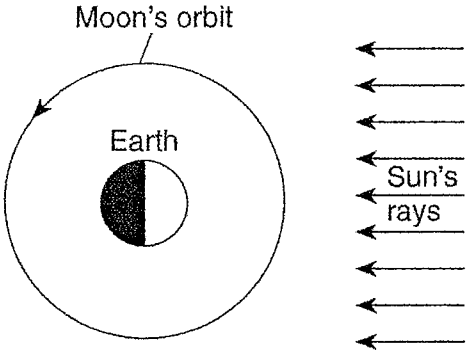
30. Assuming that February had 28 days, on which date in March did the next full Moon occur?

31. The multiple-exposure photograph below, taken on February 3, shows a total solar eclipse in the middle of the photograph. The maximum altitude of the Sun on this date was 34° above the southern horizon at this New York State location.



Based on the data table, explain why this total solar eclipse occurred on February 3.

32. The diagram shows the Moon's orbit around Earth. Place an **X** on the orbit to represent the Moon's position on February 18.



(Not drawn to scale)

Base your answers to questions **33** through **35** on the data table below, which shows the percentage of the lighted side of the Moon visible from Earth for the first fourteen days of July 2003

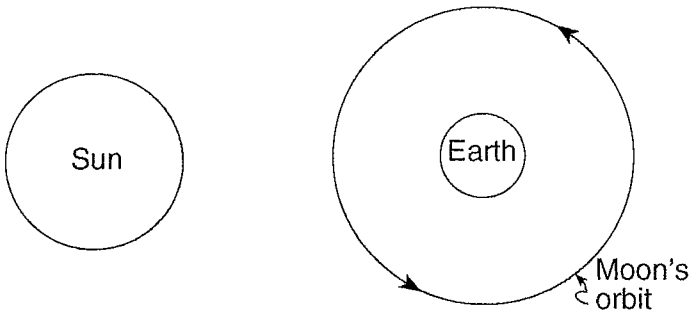
Date	Percentage of Lighted Side of the Moon Visible From Earth (%)
July 1	1
July 2	5
July 3	10
July 4	17
July 5	26
July 6	37
July 7	48
July 8	59
July 9	70
July 10	80
July 11	89
July 12	95
July 13	98
July 14	100

33. What motion of the Moon causes the percentage of the lighted side of the Moon visible from Earth to change from July 1 to July 14?

34. A full Moon phase was observed on July 14. On what day in August was the next full Moon phase observed?

35. Why are the phases of the Moon considered to be cyclic?

Base your answers to questions **36** through **38** on the diagram below. The diagram shows the Sun, Earth, and the Moon's orbit around Earth as viewed from space.



(Not drawn to scale)

36. To represent the Moon's postion in its orbit when a solar eclipse is viewed from earth, draw a circle to represent the Moon's position in its orbit when a solar eclipse is viewed from Earth.

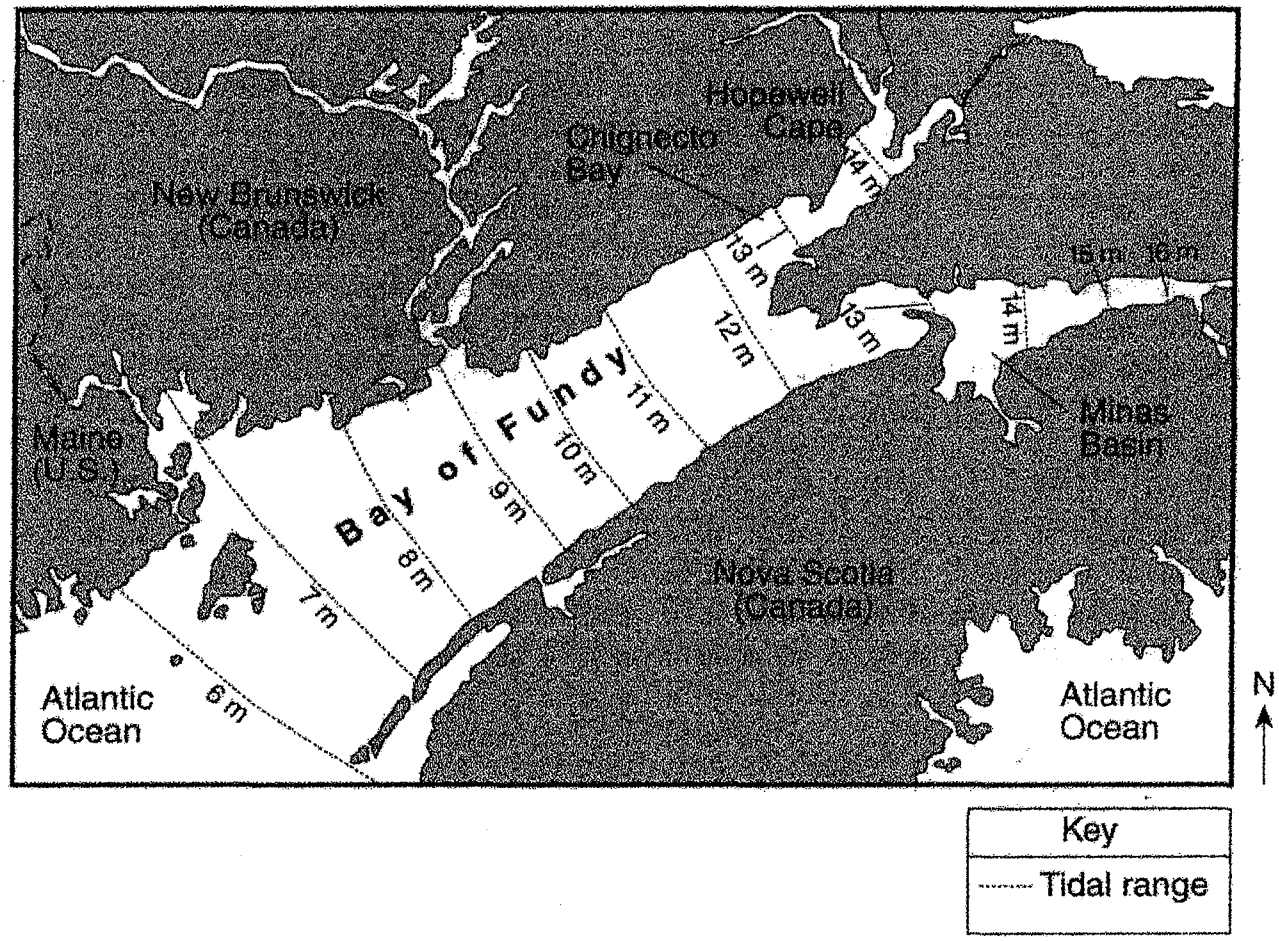
37. Approximately how many complete revolutions does the Moon make around Earth each month?

38. Explain why solar eclipses do not occur every time the Moon revolves around Earth.

Base your answers to questions **39** through **43** on the passage and map below and the tide table. The map shows the tidal range (the difference between the highest and lowest tides) in meters for the Bay of Fundy, Chignecto Bay, and the Minas Basin. The table shows the times of high and low tides for Hopewell Cape for August 21 and 22,. 2005.

The Bay of Fundy has the Highest Tides on Earth

The unique shape of the Bay of Fundy contributes to the extremely high ocean tides experienced there. Frequently described as funnel shaped, the bay gradually becomes more narrow and shallow to the northeast where it splits to form Chignecto Bay and the Minas Basin. The highest tides of the Bay of Fundy are found within these fingers of the bay and are caused by the incoming tides encountering seaward-moving river currents as the bay narrows. The tide height is also affected by the amount of time it takes for high tide to flood the bay. This time is nearly identical from one high tide to the next.

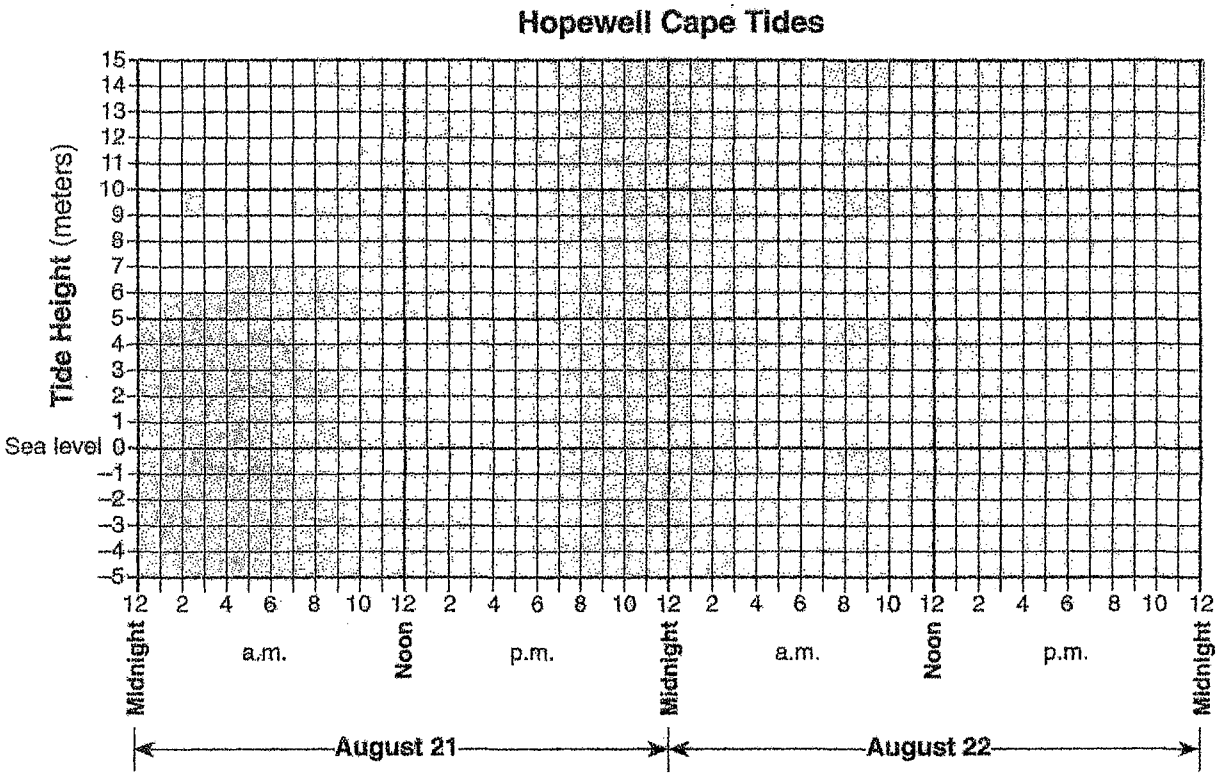


Hopewell Cape
Tide Table, August 2005

Date	Time	Tide Height (m)
21	1:28 a.m.	14.0
21	8:03 a.m.	–0.1
21	1:54 p.m.	13.7
21	8:26 p.m.	0.0
22	2:20 a.m.	14.0
22	8:52 a.m.	–0.2
22	2:46 p.m.	13.8
22	9:16 p.m.	0.0

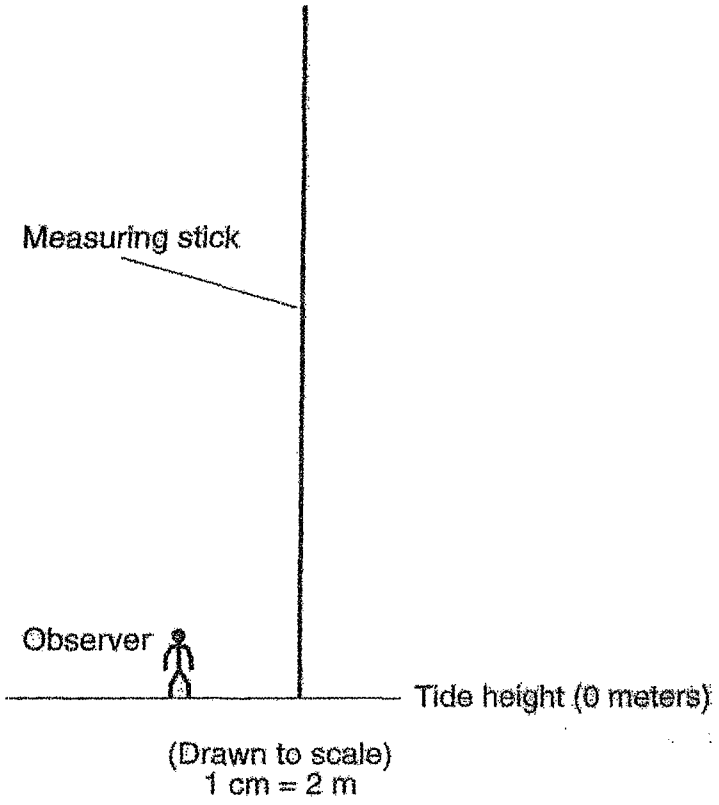
39). Describe *two* characteristics of the Bay of Fundy that cause the extremely high tides to occur at Hopewell Cape.

40. On the grid below, plot with an **X** the height of the water for each time listed on the tide table. Connect the centers of the **X**s with a smooth, curved line.

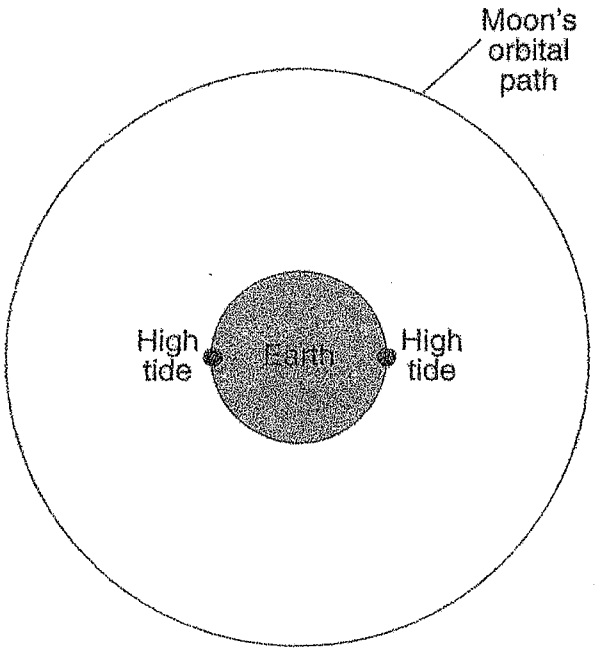


41. Using the tide table for Hopewell Cape, calculate the time difference between two consecutive high tides. Express your answer to the *nearest minute.*

42. The diagram below, shows an observer standing near a measuring stick at the 0-meter tide height location at Hopewell Cape. The diagram is drawn to a scale of 1 centimeter equals 2 meters. On the measuring stick, place an **X** to show the highest tide level shown on the tide table for August 21.

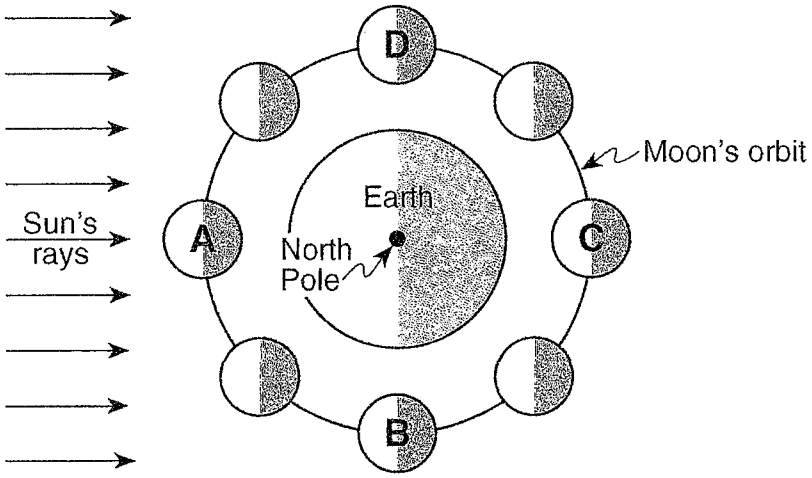


43. The diagram below shows the Moon's orbital path and Earth as viewed from space. The points on Earth indicate two locations where high ocean tides are occurring. Place an **X** on the Moon's orbital path to show where the Moon could be located when these high tides are produced.



(Not drawn to scale)

Base your answers to questions **44** and **45** on the diagram below, which shows the Moon's orbit around Earth. Four positions of the Moon are represented by letters *A*, *B*, *C*, and *D*. Earth's North Pole is labeled. The shaded areas on Earth and the Moon represent night.

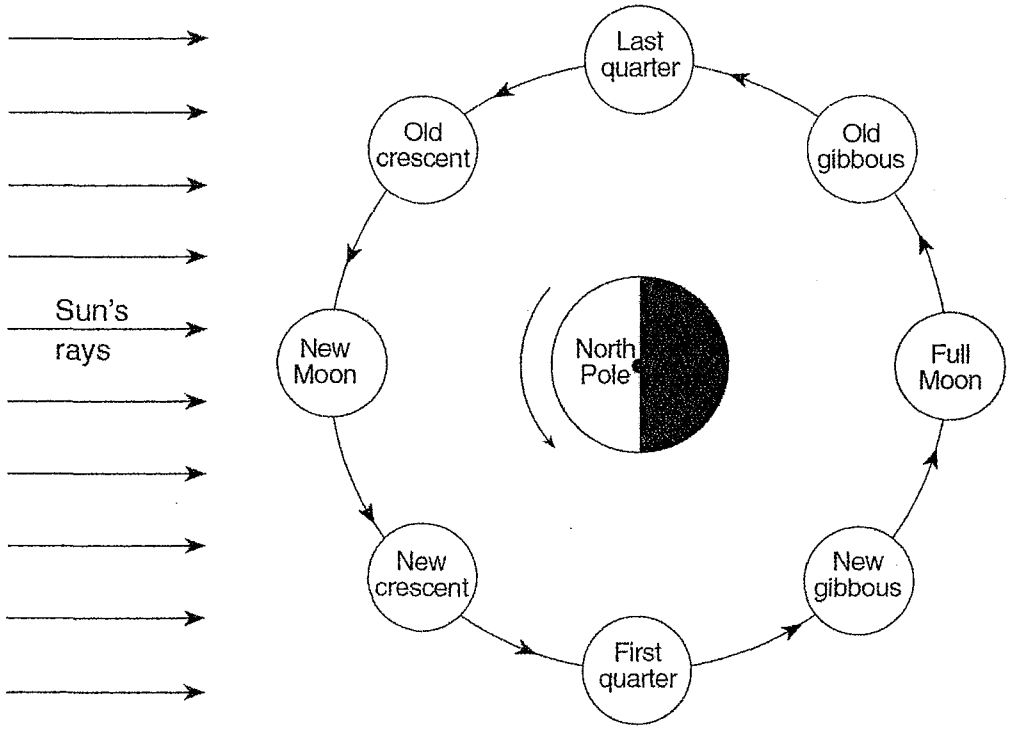


(Not drawn to scale)

44. What motion of the Moon results in the Moon phases as viewed from Earth?

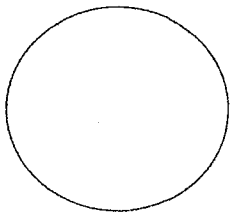
45. A total solar eclipse sometimes occurs when the Moon is at position *A*. Explain why a total solar eclipse does *not* occur every time the Moon is at position *A*.

Base your answers to questions **46** through **49** on diagram below, which shows Earth as viewed from above the North Pole. The nighttime side of Earth has been shaded. The Moon is shown at eight positions in its orbit around Earth. The name of each Moon phase is indicated at each Moon position. The dark portion of each Moon position has not been shaded.



(Not drawn to scale)

46. On the diagram below, shade the portion of the Moon that is in darkness to show the last quarter phase as viewed from New York State.



47. Explain what causes the Moon's phases when viewed from Earth.

48. Which Moon phase occurs approximately one week after the New Moon phase?

49. Explain why the same side of the Moon always faces Earth.

Base your answers to questions **50** and **51** on the reading passage below and on your knowledge of Earth science.

The Blue Moon

A "Blue Moon" is the name given to the second full moon in a calendar month. Because there are roughly 29.5 days between full moons, it is unusual for two full moons to "fit" into a 30 or 31 day month (and impossible to fit into a 28 or 29 day month, so February can never have a Blue Moon). The saying "Once in a Blue Moon" means a rare occurrence, and predates the current astronomical use of the term, which is quite recent. In fact, Blue Moons are not all that rare, on average there will be one Blue Moon every 2.5 years. After 1999, the next Blue Moons will be in November 2001; July 2004; and June 2007. The last one before 1999 was in July 1996.

The term Blue Moon is believed to have originated in 1883 after the eruption of Krakatoa. The volcano put so much dust in the atmosphere that the Moon actually looked blue in color. This was so unusual that the term "once in a Blue Moon" was coined.

"The Blue Moon"
David R. Williams
nssdc.gsfc.nasa.gov/planetary/lunar/blue_moon.html

50. What is the greatest number of full-Moon phases, visible from Earth, that are possible in a span of 1 year?

51. Draw the relative positions of Earth, the Moon, and the Sun, as viewed from space, so that a full-Moon phase would be visible to an observer on Earth. Label Earth, the Moon, and the Sun in your drawing.

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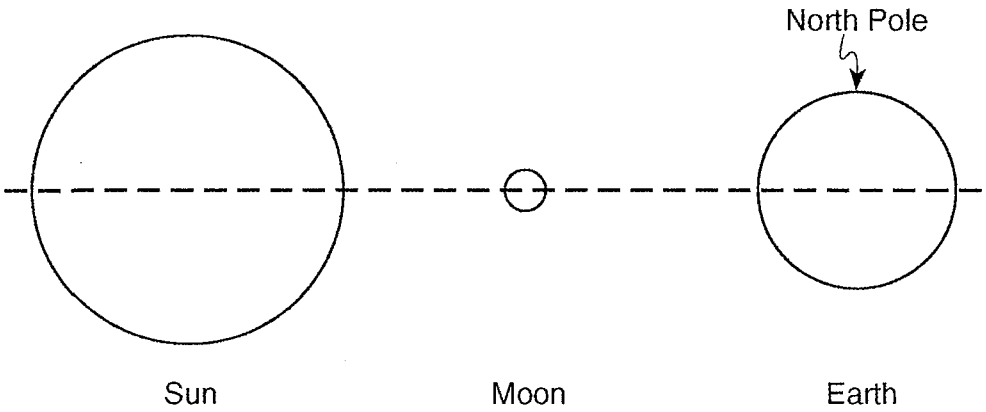
52. The diagram provided below shows the Sun, the Moon, and Earth in line with one another in space. On the diagram, draw *two* dots (•) on the surface of Earth to indicate the locations where the highest ocean tides are most likely occurring.



(Not drawn to scale)

53. What type of tide is shown in the diagram above?

54. Which moon phase is shown in the diagram above?

55. In a complete sentence, explain why the high tides during this phase are much higher than the high tides during a waxing quarter moon phase?

Base your answers to questions **56** through **58** on the diagrams below. Diagram I represents the Moon orbiting the Earth as viewed from space above the North Pole. The Moon is shown at 8 different positions in its orbit. Diagram II represents phases of the Moon as seen from the Earth when the Moon is at position 2 and at position 4.

Diagram I

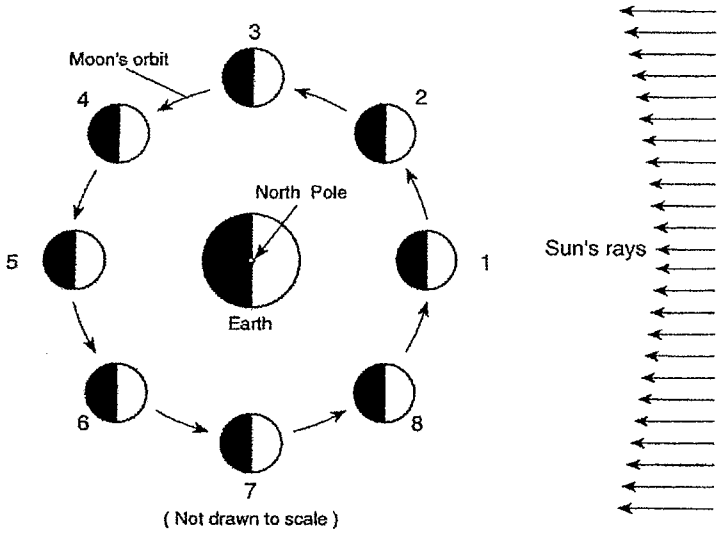
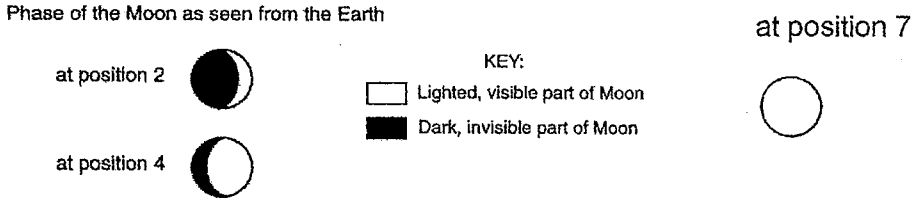


Diagram II



56. Shade the circle provided to illustrate the Moon's phase as seen from the Earth when the Moon is at position 7.

57. State the two positions of the Moon at which an eclipse could occur.

58. State the approximate length of time required for one complete revolution of the Moon around the Earth.