

V Sun, Moon, and Tides

Topic 20 The Moon and Tides

The daily rise and fall of the ocean waters are called tides. Like the moon, tides rise 50 minutes later each day (on the average). Tides are unusually large during the new moon and full moon phases. They are unusually small during quarter moon phases. Because of these observations, people have known for many years that the moon and the tides are related.

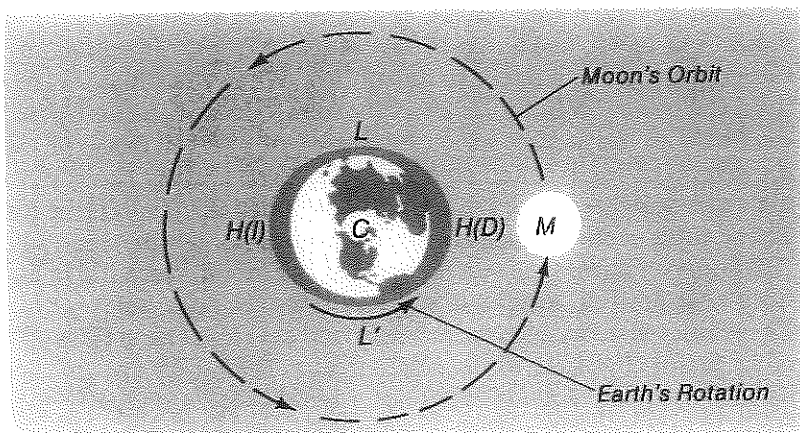
Sir Isaac Newton first explained how the gravity of the moon causes tides. Recall that gravity is stronger when objects are closer together. Because of this, the water on the side of Earth nearest the moon is pulled by the moon more strongly than Earth itself is pulled by the moon. This difference in force causes a bulge in the ocean on the side of Earth near the moon. This bulge is the *direct high tide*. At the same time, Earth's center is nearer to the moon than the water on the side of Earth opposite the moon. Earth itself, therefore, is pulled more strongly by the moon than is the water on the far side of Earth. Earth is pulled away from the water on the far side, leaving a bulge of water behind, which is the *indirect high tide*. Water has been pulled away from the areas that lie between the two high tides. These areas experience low tides.

OBJECTIVES

- A** List the evidences that relate tides to the moon and explain how the moon causes high and low tides.
- B** Describe and explain spring tides and neap tides; define tidal range and identify several factors that influence it.

new
last

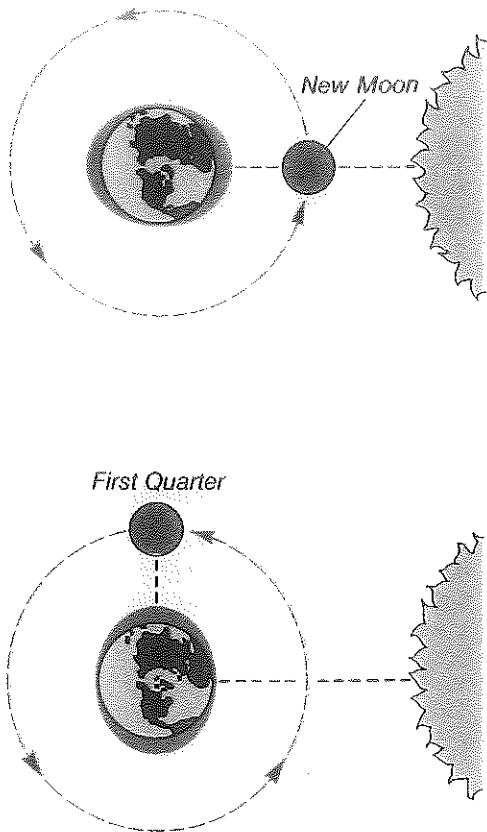
24.18 The moon causes a direct high tide at H(D) and an indirect high tide at H(I). Low tides occur at L and L'.



Topic 21 Rise and Fall of Tides

If Earth and the moon stood still, tides would be in the same places all the time. Earth, however, turns on its axis, and the moon moves around Earth. As Earth rotates, all parts of the oceans pass under the moon in 24 hours and 50 minutes. In one fourth of this time — about 6 hours and 12.5 minutes — the tides change. Each high-tide area gradually rotates to low tide. Each low-tide area gradually rotates to high tide. Six hours and 12.5 minutes later the tides change again.

24.19 (top) At new and full moon phases, sun and moon pull together, causing very high and very low tides called spring tides. (bottom) At quarter moon phases, sun and moon pull against each other, causing a small tidal range, the neap tides.



As Earth and the moon move, the tides continue their regular rise and fall. Each day the cycle starts over again, about 50 minutes later than the previous day. The model timetable that follows gives average times for a day of high and low tides. Actual tides are often much more irregular because the shapes of the ocean basins and ocean floors also influence the tides.

Sample Timetable

Tide	Date	Time	Interval Since First High Tide
High	July 4	1:00 A.M.	
Low	July 4	7:13 A.M.	6 h 13 m
High	July 4	1:25 P.M.	12 h 25 m
Low	July 4	7:38 P.M.	18 h 38 m
High	July 5	1:50 A.M.	24 h 50 m

Topic 22 Spring and Neap Tides

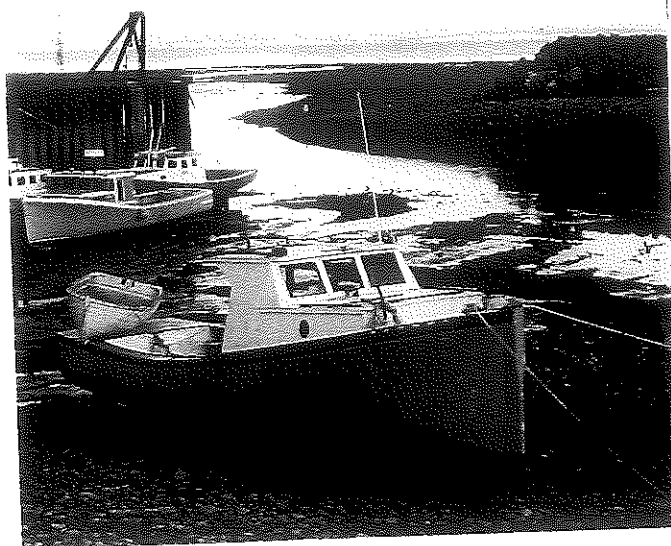
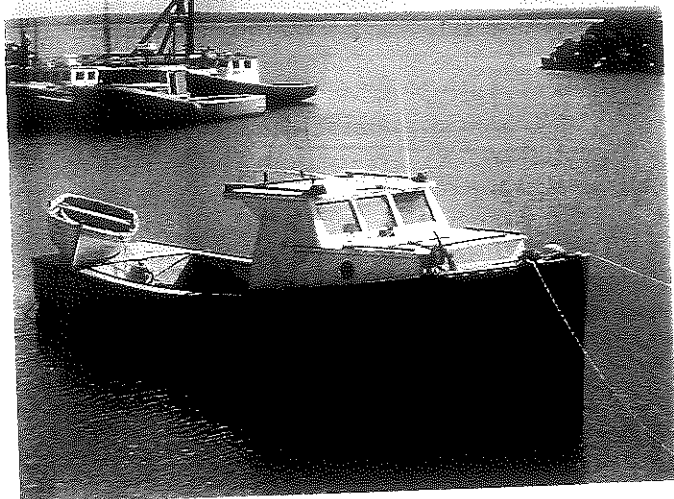
The sun has the same kind of effect on Earth's waters as does the moon. However, because it is so much farther away, the sun's tide-making effect is only about half that of the moon. The sun, however, can strengthen or weaken the moon's effects.

Tides are always high in line with the moon and low midway between the high-tide points. When the sun is in line with the moon and Earth, as shown in Figure 24.19 (top), the sun's entire tide-making effect is added to the moon's. When the sun is 90° away from the moon, as in Figure 24.19 (bottom), the entire effect is subtracted from the moon's effect. At new moon and full moon phases, the effects of the sun and moon add together. During these times, high tides are especially high and low tides are especially low. These tides occur twice a month and are called **spring tides**.

At quarter phases the sun is opposing the moon, resulting in high tides that are not very high and low tides that are not very low. These tides also occur twice a month and are called **neap tides**. One other factor that adds to the tidal effect is the moon's nearness to Earth. When the moon is at perigee, the tidal effect is greater, especially if perigee occurs during the new or full moon phases.

Topic 23 Ocean Basins, Shorelines, and Tidal Range

The **tidal range** is the difference in level between high tide and low tide. Tidal ranges vary widely between bodies of water and tend to be more noticeable near the ocean than near lakes. Small lakes show no tides at all. The largest of the Great Lakes, Lake Superior, has a tidal range of only a few centimeters. In the open ocean the tidal range averages less than one meter.



Tidal ranges on ocean shores are most noticeable, but they also vary greatly. In the Gulf of Mexico, the tidal range may be only half a meter. In the Bay of Fundy on the coast of Nova Scotia, the range can be as great as 20 meters.

What causes these differences? The Bay of Fundy is a long, V-shaped bay. Water from the ocean tide is funneled into the wide end of the V. When the water reaches the narrow end of the V, it piles up high. In the Gulf of Mexico, the opposite occurs. The Gulf has a shoreline much broader than its mouth. As the ocean tide enters the Gulf, its water spreads out over the long shoreline.

24.20 Because it is long and V-shaped, the Bay of Fundy has a very large tidal range.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

20. (a) What observations indicate a connection between the moon and tides? (b) Explain how the moon causes tides. (c) What is the bulge of water toward the moon called? The one away from the moon? (d) Where do low tides occur?
21. (a) Explain why tides rise or fall every 6 hours and 12.5 minutes, on the average. (b) Explain why the tides occur 50 minutes later each day.
22. (a) How does the sun affect tides? Explain. (b) What are spring tides? How and when do they occur? (c) What are neap tides? How and when do they occur?
23. (a) Define tidal range. (b) What is the tidal range of lakes? Of the open ocean? (c) Explain the large tidal range of the Bay of Fundy. (d) Explain the small tidal range of the Gulf of Mexico.