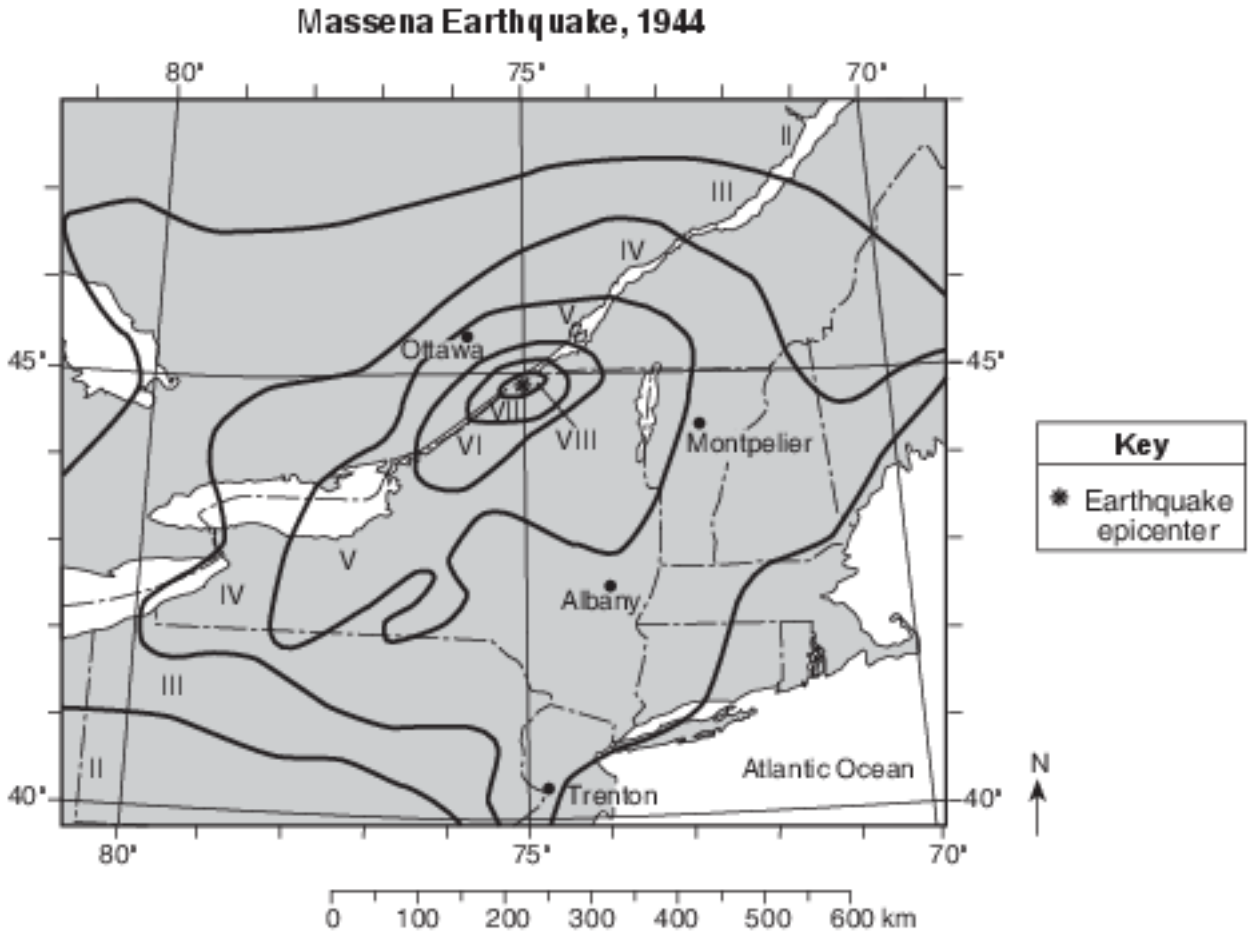
Earthquake P Wave And S Wave Travel Time

Base your answers to questions 1 on the map and table below and on your knowledge of Earth science. The map shows the zones of observed effects reported after a 1944 earthquake that occurred near Massena, New York. The isolines on the map are boundaries between zones of observed effects described in the Modified Mercalli Scale table. Four cities are labeled on the map.



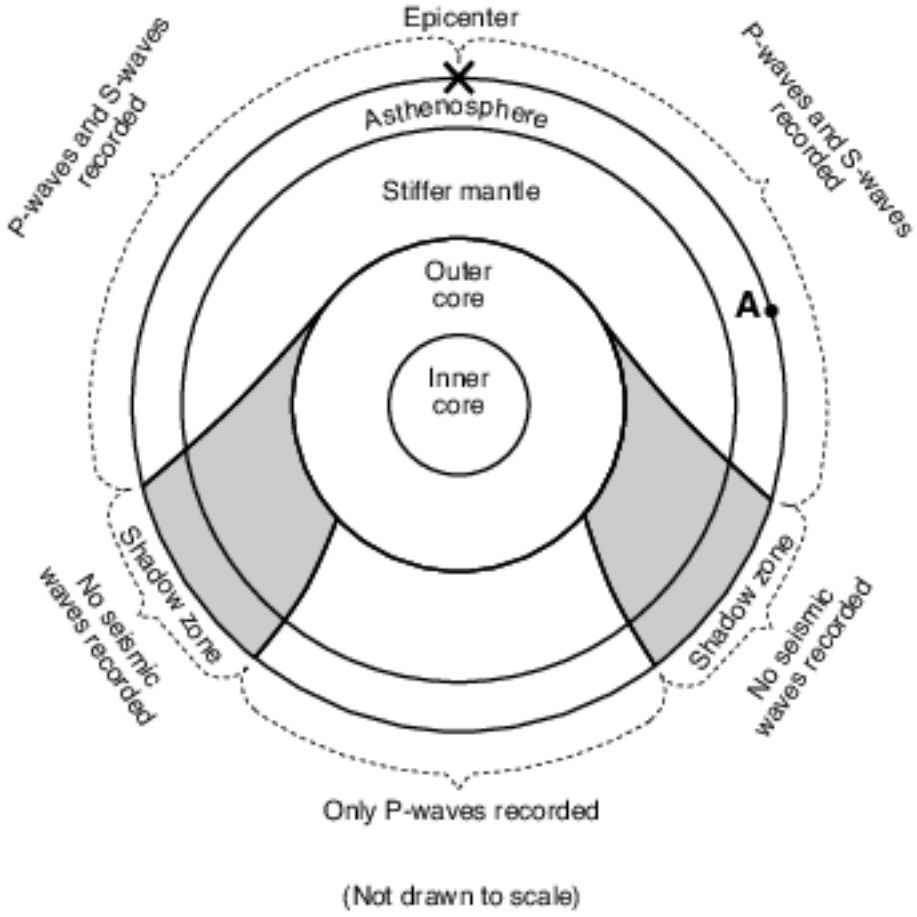
Modified Mercalli Scale

Intensity Value	Description of Observed Effects
I	Usually detected only by instruments
II	Felt by a few persons at rest, especially on upper floors
III	Hanging objects swing; vibration like passing of truck; noticeable indoors
IV	Felt indoors by many, outdoors by few; sensation like heavy truck striking building; parked automobiles sway
V	Felt by nearly everyone; sleepers awakened; liquids disturbed; unstable objects overturned; some dishes and windows broken
VI	Felt by all; many frightened and run outdoors; some heavy furniture moved; glassware broken; books off shelves; damage slight
VII	Difficult to stand; noticed in moving automobiles; damage to some masonry; weak chimneys broken at roofline
VIII	Partial collapse of masonry; chimneys, factory stacks, columns fall; heavy furniture overturned; frame houses moved on foundations

1 How long did it take for the first P-wave to travel from the epicenter of this earthquake to a seismic station in Trenton, New Jersey?

(1) 1 minute 10 seconds
(2) 2 minutes 10 seconds
(3) 3 minutes 20 seconds
(4) 4 minutes 20 seconds

Base your answers to questions 2 on the cross section below, which shows the type of seismic waves recorded at various locations after an earthquake has occurred. Point A is a location on Earth's surface and X is the epicenter of the earthquake.



2 How many kilometers did the seismic waves travel from the earthquake directly to the outside of the outer core?

(1) 800 km
(2) 1400 km
(3) 2900 km
(4) 6400 km

3 A seismic recording station located 4000 kilometers from the epicenter of an earthquake received the first P-wave at 7:10:00 p.m. (h:min:s). Other information that could be determined from this recording was that the earthquake occurred at approximately
(1) 7:03:00 p.m., and the S-wave arrived at this station at 7:12:40 p.m.
(2) 7:03:00 p.m., and the S-wave arrived at this station at 7:15:40 p.m.
(3) 7:17:00 p.m., and the S-wave arrived at this station at 7:12:40 p.m.
(4) 7:17:00 p.m., and the S-wave arrived at this station at 7:15:40 p.m.

4 A seismic P-wave is recorded at 2:25 p.m. at a seismic station located 7600 kilometers from the epicenter of an earthquake. At what time did the earthquake occur?
(1) 2:05 p.m. (3) 2:14 p.m.
(2) 2:11 p.m. (4) 2:36 p.m.

5 The epicenter of an earthquake is located6500 kilometers away from a seismic station.

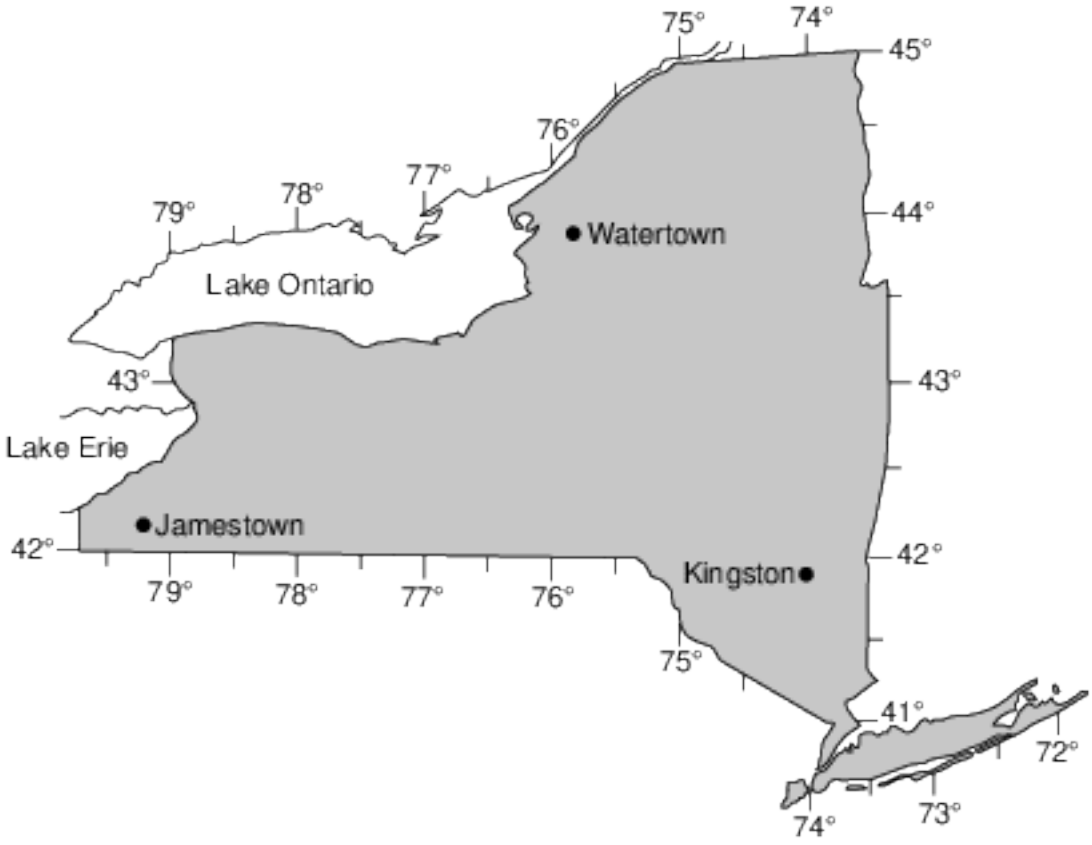
If the first S-wave arrived at this seismic station at 1:30 p.m., at what time did the first P-wave arrive?
(1) 1:20 p.m. (3) 1:38 p.m.
(2) 1:22 p.m. (4) 1:40 p.m.

6 If it takes a P-wave five minutes to travel from the epicenter of an earthquake to a seismic station, approximately how long will it take an S-wave to travel that same distance?
(1) 15 minutes (3) 9 minutes
(2) 12 minutes (4) 4 minutes

7 What is the approximate time difference between the first P-wave and the first S-wave recorded at a seismic station located 8000 kilometers from an earthquake's epicenter?
(1) 8 minutes 40 seconds
(2) 9 minutes 20 seconds
(3) 11 minutes 20 seconds
(4) 20 minutes 40 seconds

8 If a seismic station is 3200 km from an earthquake epicenter, what is the time needed for an S-wave to travel from the epicenter to the seismic station?
(1) 4 min 40 sec (3) 10 min 40 sec
(2) 6 min 0 sec (4) 11 min 10 sec

Base your answers to questions 9 on the map below and on your knowledge of Earth science. The map shows the locations of Jamestown, Watertown, and Kingston in New York State.



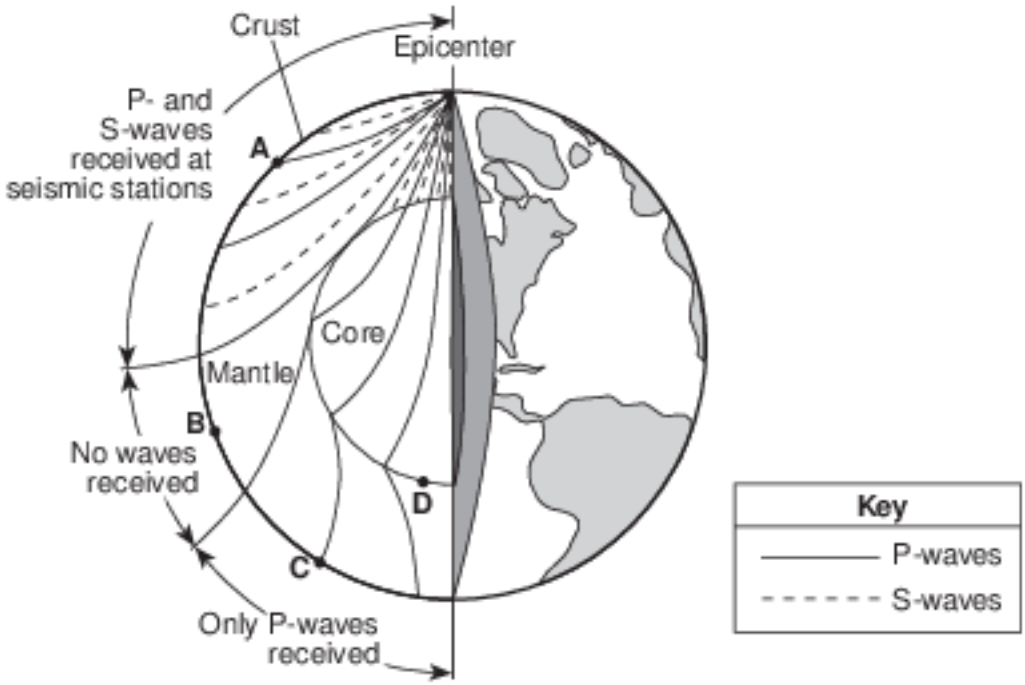
9 Compared to the time of sunrise in Kingston, the time of sunrise in Jamestown would be approximately

(1) 1 hour earlier
(2) 1 hour later
(3) 20 minutes earlier
(4) 20 minutes later

10 What is the approximate P-wave travel time from an earthquake if the P-wave arrives at the seismic station 8 minutes before the S-wave?

(1) 4 minutes 20 seconds
(2) 6 minutes 30 seconds
(3) 10 minutes 0 seconds
(4) 11 minutes 20 seconds

Base your answers to questions 11 on the diagram below and on your knowledge of Earth science. The diagram represents a cut-away view of Earth's interior and the paths of some of the seismic waves produced by an earthquake that originated below Earth's surface. Points A, B, and C represent seismic stations on Earth's surface. Point D represents a location at the boundary between the core and the mantle.



11 Seismic station A is 5000 kilometers from the epicenter. What is the difference between the arrival time of the first P-wave and the arrival time of the first S-wave recorded at this station?

(1) 2 minutes 20 seconds

(2) 6 minutes 40 seconds

(3) 8 minutes 20 seconds

(4) 15 minutes 00 second

Base your answers to questions 12 on the passage and photograph below and on your knowledge of Earth science. The photograph shows the coastal area of Crescent City, California.

Tsunami Capital

The tsunami capital of the continental United States is Crescent City, located on the coast in northern California. Since 1933, thirty-one tsunamis have been observed there. Crescent City is vulnerable to tsunamis because of the low elevation of the land and the shape of its shoreline. The wave energy from a tsunami is funneled into a narrow stretch of shoreline. This causes the wave height to grow very tall, fl ooding more land. The largest and most destructive tsunami to hit Crescent City occurred in March 1964, killing eleven people. The epicenter of a very large earthquake, located at 60° N and 147° W, caused this destructive tsunami.

12 The distance from the epicenter of the March 1964 earthquake to Crescent City is 2600 kilometers. How long did it take the fi rst P-wave to reach Crescent City?

(1) 3 minutes 20 seconds
(2) 4 minutes 10 seconds
(3) 5 minutes 0 seconds
(4) 9 minutes 10 seconds

13 An earthquake occurs at 10:05 a.m. At 10:09 a.m., the first P-wave from this earthquake is detected at a seismic station. Approximately how many kilometers (km) from the epicenter is this seismic station located?

(1) 1000 km
(2) 2000 km
(3) 2600 km
(4) 5600 km

Base your answers to questions 14 on the information below and on your knowledge of Earth science.

Adirondack Earthquake

On October 7, 1983, a magnitude 5.3 earthquake occurred in New York State's Adirondack region. The earthquake's epicenter was at Blue Mountain Lake, which is located approximately 32 miles (50 kilometers) southwest of Mt. Marcy.

14 Determine how long it took the first P-wave to travel from Blue Mountain Lake to a seismic station1200 kilometers away. [1]
_____ min _____ s

Base your answers to questions 15 on the modified Mercalli scale of earthquake intensity below, on the map of Japan in image provided, and on your knowledge of Earth science. The modified Mercalli scale classifies earthquake intensity based on observations made during an earthquake. The map indicates the modified Mercalli scale intensity values recorded at several locations in Japan during the March 11, 2011 earthquake, which triggered destructive tsunamis in the Pacific Ocean.

Modified Mercalli Scale of Earthquake Intensity

Intensity Value	Description of Effects
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Parked cars may rock slightly. Vibrations similar to the passing of a truck.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Parked cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage minimal in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage with partial collapse in ordinary substantial buildings. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures tilted. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Most masonry and frame structures and foundations are destroyed. Train rails bent.
XI	Few, if any, structures remain standing. Bridges destroyed. Train rails bent greatly.
XII	Damage total. Objects thrown into the air.

15 Describe one way the P-waves and S-waves recorded on seismograms at Ishinomaki and Nagano were used to indicate that Ishinomaki was closer to the earthquake epicenter than was Nagano. [1]

Answer Keys

1 1

2 3

3 2

4 3

5 2

6 3

7 2

8 3

9 4

10 3

11 2

12 3

13 2

14 Allow 1 credit for any value from 2 min 30 s to 2 min 40 s.

15 Allow 1 credit. Acceptable responses include, but are not limited to:

- — P-waves arrived earlier at Ishinomaki than at Nagano.
- — The difference in arrival times was less at Ishinomaki.
- — The P-wave and S-wave arrival time interval was greater at Nagano.
- — The amplitude/magnitude of seismic waves was greater/bigger/stronger at Ishinomaki.
- — There is less time difference between the P- and S-waves at the closer location.
- — P- and S-waves were closer together.