

## Critical Thinking Items

### 10.1 Postulates of Special Relativity 6.

Explain how the two postulates of Einstein's theory of special relativity, when taken together, could lead to a situation that seems to contradict the mechanics and laws of motion as described by Newton.

- a. In Newtonian mechanics, velocities are multiplicative but the speed of a moving light source cannot be multiplied to the speed of light because, according to special relativity, the speed of light is the maximum speed possible.
- b. In Newtonian mechanics, velocities are additive but the speed of a moving light source cannot be added to the speed of light because the speed of light is the maximum speed possible.
- c. An object that is at rest in one frame of reference may appear to be in motion in another frame of reference, while in Newtonian mechanics such a situation is not possible.
- d. The postulates of Einstein's theory of special relativity do not contradict any situation that Newtonian mechanics explains.

7.

It takes light  $6.0 \times 10^{-8}$  minutes to travel from the sun to the planet Venus. How far is Venus from the sun?

- a.  $18 \times 10^6$  km
- b.  $18 \times 10^8$  km
- c.  $1.08 \times 10^{11}$  km
- d.  $1.08 \times 10^8$  km

8.

In 2003, Earth and Mars were the closest they had been in 50,000 years. The two planets were aligned so that Earth was between Mars and the sun. At that time it took light from the sun 500 s to reach Earth and 687 s to get to Mars. What was the distance from Mars to Earth?

- a.  $5.6 \times 10^7$  km
- b.  $5.6 \times 10^{10}$  km
- c.  $6.2 \times 10^6$  km
- d.  $6.2 \times 10^{12}$  km

9.

Describe two ways in which light differs from all other forms of wave energy.

- a. Light travels as a longitudinal wave.
- b. Light travels through a medium that fills up the empty space in the universe.
- a. Light travels as a transverse wave.

- b. Light travels through a medium that fills up the empty space in the universe.
- a. Light travels at the maximum possible speed in the universe.
- b. Light travels through a medium that fills up the empty space in the universe.
- a. Light travels at the maximum possible speed in the universe.
- b. Light does not require any material medium to travel.

10.

Use the postulates of the special relativity theory to explain why the speed of light emitted from a fast-moving light source cannot exceed  $3.00 \times 10^8$  m/s.

- a. The speed of light is maximum in the frame of reference of the moving object.
- b. The speed of light is minimum in the frame of reference of the moving object.
- c. The speed of light is the same in all frames of reference, including in the rest frame of its source.
- d. Light always travels in a vacuum with a speed less than  $3.00 \times 10^8$  m/s, regardless of the speed of the source.

## 10.2 Consequences of Special Relativity 11.

Halley's Comet comes near Earth every 75 years as it travels around its 22 billion km orbit at a speed of up to 700, 000 m/s. If it were possible to put a clock on the comet and read it each time the comet passed, which part of special relativity theory could be tested? What would be the expected result? Explain.

- a. It would test time dilation. The clock would appear to be slightly slower.
- b. It would test time dilation. The clock would appear to be slightly faster.
- c. It would test length contraction. The length of the orbit would appear to be shortened from Earth's frame of reference.
- d. It would test length contraction. The length of the orbit would appear to be shortened from the comet's frame of reference.

12.

The nucleus of the isotope fluorine-18 ( $^{18}\text{F}$ ) has mass defect of  $2.44 \times 10^{-28}$  kg. What is the binding energy of  $^{18}\text{F}$ ?

- a.  $2.2 \times 10^{-11}$  J
- b.  $7.3 \times 10^{-20}$  J
- c.  $2.2 \times 10^{-20}$  J
- d.  $2.4 \times 10^{-28}$  J