Extended Response

10.1 Postulates of Special Relativity 34.

Explain how Einstein's conclusion that nothing can travel faster than the speed of light contradicts an older concept about the speed of an object propelled from another, already moving, object.

a. The older concept is that speeds are subtractive. For example, if a person throws a ball while running, the speed of the ball relative to the ground is the speed at which the person was running minus the speed of the throw. A relativistic example is when light is emitted from car headlights, it moves faster than the speed of light emitted from a stationary source.
b. The older concept is that speeds are additive. For example, if a person throws a ball while running, the speed of the ball relative to the ground is the speed at which the person was running plus the speed of the throw. A relativistic example is when light is emitted from car headlights, it moves no faster than the speed of light emitted from a stationary source. The car's speed does not affect the speed of light.
c. The older concept is that speeds are multiplicative. For example, if a person throws a ball while running, the speed of the ball relative to the ground is the speed at which the person was running multiplied by the speed of the throw. A relativistic example is when light is emitted from car headlights, it moves no faster than the speed of light emitted from a stationary source. The car's speed does not affect the speed of light.
d. The older concept is that speeds are frame independent. For example, if a person throws a ball while running, the speed of the ball relative to the ground has nothing to do with the speed at which the person was running. A relativistic example is when light is emitted from car headlights, it moves no faster than the speed of light emitted from a stationary source. The car's speed does not affect the speed of light.

35.

A rowboat is drifting downstream. One person swims 20 m toward the shore and back, and another, leaving at the same time, swims upstream 20 m and back to the boat. The swimmer who swam toward the shore gets back first. Explain how this outcome is similar to the outcome expected in the Michelson–Morley experiment.

a. The rowboat represents Earth, the swimmers are beams of light, and the water is acting as the ether. Light going against the current of the ether would get back later because, by then, Earth would have moved on.
b. The rowboat represents the beam of light, the swimmers are the ether, and water is acting as Earth. Light going against the current of the ether would get back later because, by then, Earth would have moved on.
c. The rowboat represents the ether, the swimmers are ray of light, and the water is acting as the earth. Light going against the current of the ether

would get back later because, by then, Earth would have moved on.
d. The rowboat represents the Earth, the swimmers are the ether, and the water is acting as the rays of light. Light going against the current of the ether would get back later because, by then, Earth would have moved on.

10.2 Consequences of Special Relativity 36.

A helium-4 nucleus is made up of two neutrons and two protons. The binding energy of helium-4 is 4.53×10^{-12} J. What is the difference in the mass of this helium nucleus and the sum of the masses of two neutrons and two protons? Which weighs more, the nucleus or its constituents?

a. 1.51×10^{-20} kg; the constituents weigh more
b. 5.03×10^{-29} kg; the constituents weigh more
c. 1.51×10^{-29} kg; the nucleus weighs more
d. 5.03×10^{-29} kg; the nucleus weighs more

37.

Use the equation for length contraction to explain the relationship between the length of an object perceived by a stationary observer who sees the object as moving, and the proper length of the object as measured in the frame of reference where it is at rest.

a. As the speed v of an object moving with respect to a stationary observer approaches c, the length perceived by the observer approaches zero. For other speeds, the length perceived is always less than the proper length.
b. As the speed v of an object moving with respect to a stationary observer approaches c, the length perceived by the observer approaches zero. For other speeds, the length perceived is always greater than the proper length.
c. As the speed v of an object moving with respect to a stationary observer approaches c, the length perceived by the observer approaches infinity. For other speeds, the length perceived is always less than the proper length.
d. As the speed v of an object moving with respect to a stationary observer approaches c, the length perceived by the observer approaches infinity. For other speeds, the length perceived is always greater than the proper length.