Halliday/Resnick/Walker
Fundamentals of Physics 8th edition

Classroom Response System Questions

Chapter 37 Relativity

Interactive Lecture Questions
37.1.1. Which one of the following systems is an inertial frame of reference?

a) Space Station Freedom orbits the Earth at an altitude of 350 km.

b) A train is traveling around an unbanked curve at 12 m/s.

c) The space shuttle is accelerating upward at 28 m/s².

d) A carousel rotates uniformly with a period of 25 seconds.

e) A man suspended from a rectangular parachute descends at a constant speed of 8 m/s.
37.1.1. Which one of the following systems is an inertial frame of reference?

a) Space Station Freedom orbits the Earth at an altitude of 350 km.

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c) The space shuttle is accelerating upward at 28 m/s².

d) A carousel rotates uniformly with a period of 25 seconds.

e) A man suspended from a rectangular parachute descends at a constant speed of 8 m/s.
37.1.2. During a practice flight, a Corsair, a World War II fighter plane, is flying at 181 m/s, due west relative to the ground below. The pilot fires his guns and the bullets leave the guns at a speed of 890 m/s, relative to the guns. The velocity of the bullets as they leave the gun, relative to the ground, is

a) 181 m/s, due west
b) 709 m/s, due west
c) 709 m/s, due east
d) 890 m/s, due west
e) 1071 m/s, due east
37.1.2. During a practice flight, a Corsair, a World War II fighter plane, is flying at 181 m/s, due west relative to the ground below. The pilot fires his guns and the bullets leave the guns at a speed of 890 m/s, relative to the guns. The velocity of the bullets as they leave the gun, relative to the ground, is

a) 181 m/s, due west

b) 709 m/s, due west

c) 709 m/s, due east

d) 890 m/s, due west

e) 1071 m/s, due east
37.2.1. Which one of the following statements concerning relativity is true?

a) Light has the same speed for all accelerated observers, regardless of the motion of the source or the observer.

b) No physical experiment can be conducted by an observer within his or her own system that can allow the observer to determine how fast he or she is moving relative to anything outside his or her own system.

c) Depending on the state of motion of your laboratory, experiments within your lab will have different outcomes.

d) The speed of light in all media has the same value, \( c \).
37.2.1. Which one of the following statements concerning relativity is true?

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b) No physical experiment can be conducted by an observer within his or her own system that can allow the observer to determine how fast he or she is moving relative to anything outside his or her own system.

c) Depending on the state of motion of your laboratory, experiments within your lab will have different outcomes.

d) The speed of light in all media has the same value, $c$. 
37.2.2. Is *everything relative* according to the postulates of Special Relativity?

a) No, mass is the same everywhere.

b) No, velocity is not relative.

c) Yes, everything, all physical measurements are relative.

d) No, the speed of light is not relative.

e) No, space is the same everywhere.
37.2.2. Is *everything relative* according to the postulates of Special Relativity?

a) No, mass is the same everywhere.

b) No, velocity is not relative.

c) Yes, everything, all physical measurements are relative.

d) No, the speed of light is not relative.

e) No, space is the same everywhere.
37.2.3. Which one of the following statements concerning the postulates of Special Relativity is true?

a) The postulates have been proven to be true.

b) The postulates have been proven to be false at the sub-atomic scale.

c) The postulates cannot be proven to be true, but they do provide the foundation for Einstein’s Theory of Special Relativity.

d) Einstein did not actually develop these postulates. He borrowed them from others in developing his theory.
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d) Einstein did not actually develop these postulates. He borrowed them from others in developing his theory.
37.4.1. Observer A witnesses two lights flash at the same time. Observer B is moving relative to observer A. What, in general, would observer B see with regard to the two lights?

a) Observer B would also see the lights flash at the same time.

b) Observer B would see the lights flash at different times.

c) Observer B would see only one of the lights flash.

d) Observer B would see neither light flash.
37.4.1. Observer A witnesses two lights flash at the same time. Observer B is moving relative to observer A. What, in general, would observer B see with regard to the two lights?

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b) Observer B would see the lights flash at different times.

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d) Observer B would see neither light flash.
37.4.2. Complete the following statement: According to relativity, the time between two events and the distance between those events,

a) are the same for all observers in all inertial reference frames.

b) cannot be defined because space and time no longer have any meaning.

c) are different in different frames of reference.
37.4.2. Complete the following statement: According to relativity, the time between two events and the distance between those events,

a) are the same for all observers in all inertial reference frames.

b) cannot be defined because space and time no longer have any meaning.

b) are different in different frames of reference.
37.4.3. Two alien spaceships are traveling at 0.95$c$, one directly toward the Earth and one directly away from the Earth. At one instant, both spaceships happen to be the same distance from the Earth and they fire a laser at the Earth. The light from which laser reaches the Earth first according to an observer on Earth?

a) The light from the spaceship moving toward the Earth arrives first.

b) The light from the spaceship moving away from the Earth arrives first.

c) The light from the two ships arrives at the same time.

d) The observer has no way to determine which light reaches the Earth first.
37.4.3. Two alien spaceships are traveling at 0.95c, one directly toward the Earth and one directly away from the Earth. At one instant, both spaceships happen to be the same distance from the Earth and they fire a laser at the Earth. The light from which laser reaches the Earth first according to an observer on Earth?

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c) The light from the two ships arrives at the same time.

d) The observer has no way to determine which light reaches the Earth first.
37.5.1. If one wants to determine the proper frequency of a wave, which of the following statements is true?

a) The proper frequency must be measured in the same frame as the proper length is measured.

b) The proper frequency must be measured in the same frame as the proper time is measured.

c) Choices (a) and (b) are both correct.

d) None of the above answers are correct.
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c) Choices (a) and (b) are both correct.

d) None of the above answers are correct.
37.5.2. Within an alien spaceship there is a room that has a light bulb that flashes one time each day. When the bulb flashes, it sends light out uniformly in all directions. On two opposite walls, there is a light detector that turns on another light as soon as light is detected. Let’s call the wall closest to the forward part of the ship, wall A, and the opposite one, wall B. One day, the aliens decide to test this set up while they are sitting motionless in interstellar space. They activate the system and the central bulb flashes. At the same time, the lights on the two walls light up. The next day when the alien ship is traveling at $0.955c$ through interstellar space, what do they observe when the flash occurs?

a) Lights A and B light up at the same instant of time.

b) Light B lights up a little earlier than A does.

c) Light A lights up a little earlier than B does.

d) Light B lights up much earlier than A does.

e) Light A lights up much earlier than B does.
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d) Light B lights up much earlier than A does.

e) Light A lights up much earlier than B does.
37.5.3. Gax and Zax are intergalactic travelers in two different spaceships. During one interval of their mission, Zax notices that her clock advances 40 minutes while Gax’s clock advances only 20 minutes. What does Gax observe during this same interval?

a) Gax notices that his clock advances only 20 minutes while Zax’s clock advances 40 minutes.

b) Gax notices that his clock advances 40 minutes while Zax’s clock advances only 20 minutes.

c) Gax notices that both clocks advance 40 minutes.

d) Gax notices that both clocks advance 20 minutes.

e) Gax notices that both clocks advance 60 minutes.
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c) Gax notices that both clocks advance 40 minutes.

d) Gax notices that both clocks advance 20 minutes.

e) Gax notices that both clocks advance 60 minutes.
37.5.4. Gax is standing on his home planet as he observes his wife Zax pass their planet at near-light speed. By a strange quirk, at precisely the same instant, their clocks are synchronized at 1:00:00 PM. As Gax continues to observe the clock on his wife’s ship, what does he observe relative to his own clock?

a) His clock reaches 1:00:02 before his wife’s clock does.

b) His clock reaches 1:00:02 after his wife’s clock does.

c) His clock reaches 1:00:02 at the same time as his wife’s clock does.

d) His clock reaches 1:00:02, but his wife’s clock appears to be going in reverse.
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37.5.5. Mick and Rick are twins born on Earth in the year 2175. Rick grows up to be an Earth-bound robotics technician while Mick becomes an intergalactic astronaut. Mick leaves the Earth on his first space mission in the year 2200 and travels, according to his clock, for 10 years at a speed of $0.75c$. Unfortunately, at this point in his journey, the structure of his ship undergoes mechanical breakdown and the ship explodes. How old is Rick when his brother dies?

a) 35 years old

b) 40 years old

c) 50 years old

d) 65 years old

e) 95 years old
37.5.5. Mick and Rick are twins born on Earth in the year 2175. Rick grows up to be an Earth-bound robotics technician while Mick becomes an intergalactic astronaut. Mick leaves the Earth on his first space mission in the year 2200 and travels, according to his clock, for 10 years at a speed of $0.75c$. Unfortunately, at this point in his journey, the structure of his ship undergoes mechanical breakdown and the ship explodes. How old is Rick when his brother dies?

a) 35 years old
b) 40 years old
c) 50 years old
d) 65 years old
e) 95 years old
37.5.6. The center of the Milky Way Galaxy is about 26,000 light years from the Earth. By what means could a human being travel to the center of the Milky Way?

a) Even with time dilation, it isn’t possible to travel that far within a normal human lifetime.

b) A person would have to travel at the speed of light, but that isn’t possible.

c) A person would only have to travel very close to the speed of light for it to be possible within a normal human lifetime.

d) A person would only have to travel a little faster than the speed of light for it to be possible within a normal human lifetime.
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37.5.7. Mars rotates about its axis once every 88 642 s. A spacecraft comes into the solar system and heads directly toward Mars at a speed of 0.800c. What is the rotational period of Mars according to the beings on the spaceship?

a) about 53 100 s

b) about 88 600 s

c) about 105 000 s

d) about 148 000 s

e) about 181 000 s
37.5.7. Mars rotates about its axis once every 88 642 s. A spacecraft comes into the solar system and heads directly toward Mars at a speed of 0.800c. What is the rotational period of Mars according to the beings on the spaceship?

a) about 53 100 s

b) about 88 600 s

c) about 105 000 s

d) about 148 000 s

e) about 181 000 s
37.6.1. Gax is standing on his home planet as he observes his wife Zax orbit their planet at near-light speed. Gax and Zax have identical sticks that are one meter long and each are holding them parallel to the direction that Zax is moving. What does Gax observe about the length of the sticks?

a) Zax’s stick is more than one meter long, while his stick is exactly one meter long.

b) Both sticks are still exactly one meter long.

c) Zax’s stick is less than one meter long, while his stick is exactly one meter long.
37.6.1. Gax is standing on his home planet as he observes his wife Zax orbit their planet at near-light speed. Gax and Zax have identical sticks that are one meter long and each are holding them parallel to the direction that Zax is moving. What does Gax observe about the length of the sticks?

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37.6.2. Gax is standing on his home planet as he observes his wife Zax orbit their planet at near-light speed. Gax and Zax have identical sticks that are one meter long and each are holding them perpendicular to the direction that Zax is moving. What does Gax observe about the length of the sticks?

a) Zax’s stick is more than one meter long, while his stick is exactly one meter long.

b) Both sticks are still exactly one meter long.

c) Zax’s stick is less than one meter long, while his stick is exactly one meter long.
37.6.2. Gax is standing on his home planet as he observes his wife Zax orbit their planet at near-light speed. Gax and Zax have identical sticks that are one meter long and each are holding them perpendicular to the direction that Zax is moving. What does Gax observe about the length of the sticks?

a) Zax’s stick is more than one meter long, while his stick is exactly one meter long.

b) Both sticks are still exactly one meter long.

c) Zax’s stick is less than one meter long, while his stick is exactly one meter long.
37.6.3. An alien observer passes the earth at $0.60c$ and measures the length of an American football field while traveling in the direction from one end zone to the other end zone. On the field, the distance from end zone to end zone is 91.4 m. How long does the field appear to be according to the alien observer?

a) 59.6 m
b) 73.1 m
c) 74.6 m
d) 91.4 m
e) 114 m
37.6.3. An alien observer passes the earth at $0.60c$ and measures the length of an American football field while traveling in the direction from one end zone to the other end zone. On the field, the distance from end zone to end zone is 91.4 m. How long does the field appear to be according to the alien observer?

a) 59.6 m

b) 73.1 m

c) 74.6 m

d) 91.4 m

e) 114 m
37.6.4. A perfect cube with 2.00-m sides is constructed in an alien space station. It is then launched from the station. Sometime later, the cube passes the station with a speed $0.800c$, relative to the observers on the station. What is the volume of the cube as measured by the observers on the station?

a) 4.80 m$^3$

b) 6.40 m$^3$

c) 8.00 m$^3$

d) 10.0 m$^3$

e) 13.3 m$^3$
37.6.4. A perfect cube with 2.00-m sides is constructed in an alien space station. It is then launched from the station. Sometime later, the cube passes the station with a speed $0.800c$, relative to the observers on the station. What is the volume of the cube as measured by the observers on the station?

a) 4.80 m³
b) 6.40 m³
c) 8.00 m³
d) 10.0 m³
e) 13.3 m³
37.8.1. You are in a closed room (no windows and closed doors) on a ship that is traveling very close to the speed of light. Which of the following effects would you notice while sitting in this room?

a) My wristwatch seems to be ticking more slowly.

b) My mass has increased.

c) I seem to be skinnier than usual.

d) I seem to be taller than usual.

e) None of the above observations could be made.
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e) None of the above observations could be made.
37.9.1. An observed on Earth sees two rocket ships moving toward each other, each at a speed of \(0.25c\). An observer is located on one of the moving ships. What speed does the observer measure for the approaching ship?

a) \(0.25c\)

b) between \(0.25c\) and \(0.50c\)

c) \(0.50c\)

d) between \(0.50c\) and \(c\)

e) \(c\)
37.9.1. An observed on Earth sees two rocket ships moving toward each other, each at a speed of $0.25c$. An observer is located on one of the moving ships. What speed does the observer measure for the approaching ship?

a) $0.25c$

b) between $0.25c$ and $0.50c$

c) $0.50c$

d) between $0.50c$ and $c$

e) $c$
37.9.2. An observer on Earth sees a large ship chasing a smaller ship. The larger ship is moving at $0.30c$, while the smaller ship is only moving at $0.25c$. What speed does the captain of the smaller ship see the larger ship closing in on him?

a) less than $0.05c$

b) $0.05c$

c) between $0.05c$ and $0.25c$

d) $0.25c$

e) $0.30c$
37.9.2. An observer on Earth sees a large ship chasing a smaller ship. The larger ship is moving at \(0.30c\), while the smaller ship is only moving at \(0.25c\). What speed does the captain of the smaller ship see the larger ship closing in on him?

a) less than \(0.05c\)

b) \(0.05c\)

c) between \(0.05c\) and \(0.25c\)

d) \(0.25c\)

e) \(0.30c\)
37.10.1. The pilot of an airplane flying due south at a constant speed $v$ observes three sources of electromagnetic waves. Each source emits light with the same frequency $f$. Source A is moving due south at a speed $v$, source B is moving due north at a speed $v$, and source C is moving due south at a speed $2v$. Rank the three frequencies of the observed waves in increasing order (smallest first, largest last) according to magnitude.

a) $A = C < B$

b) $A = B < C$

c) $B < A < C$

d) $A < C < B$

e) $B < C < A$
37.10.1. The pilot of an airplane flying due south at a constant speed $v$ observes three sources of electromagnetic waves. Each source emits light with the same frequency $f$. Source A is moving due south at a speed $v$, source B is moving due north at a speed $v$, and source C is moving due south at a speed $2v$. Rank the three frequencies of the observed waves in increasing order (smallest first, largest last) according to magnitude.

a) $A = C < B$

b) $A = B < C$

c) $B < A < C$

d) $A < C < B$

e) $B < C < A$
37.10.2. Hydrogen atoms in a laboratory can emit blue light that has a specific wavelength of $4.34 \times 10^{-7}$ m. Hydrogen atoms in a distant galaxy far from Earth also emit this same light, but to an observer on Earth, the light appears to have a wavelength of $4.64 \times 10^{-7}$ m. What is the relative velocity of this galaxy with respect to Earth?

a) $2.80 \times 10^7$ m/s, toward the Earth
b) $1.44 \times 10^6$ m/s, away from the Earth
c) $4.10 \times 10^5$ m/s, away from the Earth
d) $2.07 \times 10^7$ m/s, away from the Earth
e) $3.00 \times 10^5$ m/s, toward the Earth
37.10.2. Hydrogen atoms in a laboratory can emit blue light that has a specific wavelength of $4.34 \times 10^{-7}$ m. Hydrogen atoms in a distant galaxy far from Earth also emit this same light, but to an observer on Earth, the light appears to have a wavelength of $4.64 \times 10^{-7}$ m. What is the relative velocity of this galaxy with respect to Earth?

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d) $2.07 \times 10^7$ m/s, away from the Earth

e) $3.00 \times 10^5$ m/s, toward the Earth
37.11.1. One electron is traveling due east at 0.9950c and another electron is moving due west, away from the other electron, at 0.9798c. The rest mass of an electron is 0.511 MeV. What is the total relativistic momentum of these electrons?

a) 2.50 MeV/c, due west
b) 5.08 MeV/c, due east
c) 7.58 MeV/c, due east
d) 5.36 MeV/c, due west
e) 2.58 MeV/c, due east
37.11.1. One electron is traveling due east at 0.9950$c$ and another electron is moving due west, away from the other electron, at 0.9798$c$. The rest mass of an electron is 0.511 MeV. What is the total relativistic momentum of these electrons?

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b) 5.08 MeV/$c$, due east

c) 7.58 MeV/$c$, due east

d) 5.36 MeV/$c$, due west

e) 2.58 MeV/$c$, due east
37.12.1. Why is it that objects that have mass cannot travel at the speed of light?

a) because an infinite amount of work is not available

b) because the maximum energy the object can have is limited to $mc^2$

c) because the maximum momentum of the object is limited

d) because the object’s mass increases to infinity

e) because the force of gravity slows the object
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b) because the maximum energy the object can have is limited to $mc^2$

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d) because the object’s mass increases to infinity

e) because the force of gravity slows the object
37.12.2. Space and time are intertwined when considering relativistic effects. Which of the following pairs are also intertwined for relativistic objects?

a) mass and momentum
b) mass and kinetic energy
c) force and inertia
d) linear and angular momenta
e) momentum and energy
37.12.2. Space and time are intertwined when considering relativistic effects. Which of the following pairs are also intertwined for relativistic objects?

a) mass and momentum

b) mass and kinetic energy

c) force and inertia

d) linear and angular momenta

e) momentum and energy
37.12.3. Gax is standing on his home planet as he observes his wife Zax zoom past him along the horizon of their planet at near-light speed. Before she left the planet, the length of her ship was 100 m and the mass of her ship (not including fuel) was 10 000 kg. As she moves past him, Gax observes the length and mass of her ship. What does he observe?

a) The mass of her ship is still 10 000 kg, but its length is somewhat smaller.

b) The mass of her ship is still 10 000 kg, but its length is somewhat longer.

c) The mass of her ship is somewhat larger than 10 000 kg, but its length is somewhat smaller.

d) The mass of her ship is somewhat larger than 10 000 kg, but its length is somewhat longer.

e) The mass of her ship is somewhat less than 10 000 kg; and its length is somewhat smaller.
37.12.3. Gax is standing on his home planet as he observes his wife Zax zoom past him along the horizon of their planet at near-light speed. Before she left the planet, the length of her ship was 100 m and the mass of her ship (not including fuel) was 10 000 kg. As she moves past him, Gax observes the length and mass of her ship. What does he observe?

a) The mass of her ship is still 10 000 kg, but its length is somewhat smaller.

b) The mass of her ship is still 10 000 kg, but its length is somewhat longer.

c) The mass of her ship is somewhat larger than 10 000 kg, but its length is somewhat smaller.

d) The mass of her ship is somewhat larger than 10 000 kg, but its length is somewhat longer.

e) The mass of her ship is somewhat less than 10 000 kg; and its length is somewhat smaller.
37.12.4. An electron (rest mass = 0.511 MeV) has a total energy of 10.00 MeV. What is the speed of this electron?

a) 0.9959c
b) 0.9987c
c) 0.9991c
d) 0.9995c
e) 0.9999c
37.12.4. An electron (rest mass = 0.511 MeV) has a total energy of 10.00 MeV. What is the speed of this electron?

a) 0.9959c
b) 0.9987c
c) 0.9991c
d) 0.9995c
e) 0.9999c
37.12.5. Determine the speed at which the kinetic energy of an electron is equal to twice its rest energy.

a) 0.45c
b) 0.63c
c) 0.87c
d) 0.94c
e) 0.99c
37.12.5. Determine the speed at which the kinetic energy of an electron is equal to twice its rest energy.

a) $0.45c$

b) $0.63c$

c) $0.87c$

d) $0.94c$

e) $0.99c$