Key Area 5 – Special Relativity

Multiple Choice Questions 1 → 10

1. A spaceship, sitting on a launch pad, is measured to have a length L. This spaceship has a speed of $2{\cdot}5 \times 10^8$ ms^{-1} as is passes a planet.

   Identify which row in the table describes the length of the spaceship as measured by the pilot in the spaceship and an observer on the planet.

	length measured by the pilot in the spaceship	length measured by the observer on the planet
A	L	less than L
B	L	greater than L
C	L	L
D	less than L	L
E	greater than L	L

2. A spaceship is moving with a constant speed of 0·6c towards Earth. The spaceship emits a beam of light towards the Earth. An astronaut in the spaceship and an observer on Earth both measure the speed of the emitted light.

   Identify which row in the table shows the speed of the emitted light as measured by the astronaut and by the observer.

	speed of emitted light as measured by the astronaut in the spaceship	speed of emitted light as measured by the observer on Earth
A	0·4c	1·6c
B	c	c
C	c	1·6c
D	1·6c	0·4c
E	1·6c	c

3. A spaceship passes by a planet at a speed of $2{\cdot}1 \times 10^8$ ms^{-1}. The time interval measured by the spaceship for this to occur is time Δt.

   Identify which row in the table describes the time interval as measured by the pilot in the spaceship and an observer on the planet.

	time interval measured by the pilot in the spaceship	time interval measured by the observer on the planet
A	Δt	less than Δt
B	Δt	greater than Δt
C	Δt	Δt
D	less than Δt	Δt
E	greater than Δt	Δt

4. A spacecraft travels at a constant speed of 0·70c relative to Earth. A clock on board the spacecraft records a flight time of 3·0 hours.

   Calculate the flight time according to clock on Earth.

   A 1·6 hours

   B 2·1 hours

   C 4·2 hours

   D 5·5 hours

   E 5·9 hours

5. A river flows at a constant $1{\cdot}0$ ms^{-1} towards the North, relative to the river bank. A canoeist rows a canoe at a constant speed of $2{\cdot}0$ ms^{-1} South, relative to the river.

   Determine the velocity of the canoe, relative to the river bank.

   A $1{\cdot}0$ ms^{-1}

   B $1{\cdot}0$ ms^{-1} North

   C $3{\cdot}0$ ms^{-1} North

   D $3{\cdot}0$ ms^{-1} South

   E $1{\cdot}0$ ms^{-1} South

6. An airport moving walkway moves with a constant velocity of 0·6 ms^{-1} towards the East, relative to the ground. A woman walks East across the walkway at 0·9 ms^{-1}.

   Determine the velocity of the woman, relative to the ground.

   A 1·5 ms^{-1}

   B 1·5 ms^{-1} East

   C 0·3 ms^{-1} East

   D 0·3 ms^{-1} West

   E 1·5 ms^{-1} West

7. A star is estimated to have a lifetime of 20 billion years. The star is moving away from Earth at a speed of 0.75c.

   Calculate the estimated lifetime of the star according to an observer on Earth.

   A 10 billion years

   B 13 billion years

   C 20 billion years

   D 30 billion years

   E 40 billion years

8. A spacecraft is travelling at 0·50c relative to a space station. Astronauts on the spacecraft measure the length of the space station to be 0·60 km.

   Calculate the length of the space station according to a technician on the space station.

   A 0·42 km

   B 0·52 km

   C 0·60 km

   D 0·69 km

   E 0·85 km

9. A π meson has a lifetime of approximately 2·6 x 10^{-8} s when at rest. A π meson moves with a speed of 0·99c towards the surface of Earth.

   Calculate the mean lifetime of the π meson as measured by an observer on the Earth.

   A 2·60 x 10^{-9} s

   B 3·67 x 10^{-9} s

   C 2·60 x 10^{-8} s

   D 1·84 x 10^{-7} s

   E 2·60 x 10^{-7} s

10. A spacecraft travels a distance of 4·2 light years to the nearest star beyond the Sun at a speed of 0·51c. The spacecraft measures the distance travelled to be 3·6 light years.

    Calculate the journey time as measured by a clock on board the spacecraft.

    A $7{\cdot}4 \times 10^{-1}$ s

    B $8{\cdot}8 \times 10^{-1}$ s

    C $2{\cdot}2 \times 10^{8}$ s

    D $2{\cdot}6 \times 10^{8}$ s

    E $6{\cdot}7 \times 10^{16}$ s

Full Response Questions 11 → 12

11. A beam of charged particles is accelerated in particle accelerators to a speed of $2{\cdot}0 \times 10^{8}$ ms^{-1}.

    (a) The particles are unstable and decay with a half-life of $8{\cdot}2 \times 10^{-7}$ s when at rest.

    Calculate the half-life of the particles in the beam as observed by a stationary observer.

    (b) Calculate the mean distance travelled by a particle in the beam before it decays as observed by a stationary observer.

12. Muons are particles that have a mean lifetime of 2.2 μs. Muons are produced 10 km above the surface of Earth and move with a speed of 0·995c towards the surface.

    (a) Calculate the mean lifetime of the moving muons as measured by an observer on Earth's surface.

    (b) Calculate the mean distance travelled by the muons as measured by an observer on Earth's surface.

    (c) Calculate the mean distance travelled by the muons as measured by the muons.