VISUAL PHYSICS ONLINE

Special Relativity

Question 1

The idea of a universal aether was first proposed to explain the transmission of light through space. Michelson and Morley attempted to measure the speed of Earth through the aether. Evaluate the impact of the result of the Michelson and Morley experiment on scientific thinking.

Question 2

Einstein's 1905 theory of special relativity made several predictions that could not be verified for many years.

(a) State ONE such prediction.

(b) Describe an experiment to test this prediction.

(c) Explain how technological advances since 1905 have made it possible to carry out this experiment.

Question 3

Describe an experiment that you could perform in a reference frame to determine whether or not the frame was non-inertial.

Question 4

A spacecraft is travelling at 0.99*c*. An astronaut inside the craft records a time of 1 hour for a certain event to occur. How long would an observer stationary relative to the craft record for this event?

Question 5

Two clocks are synchronized and then one is sent into space at 0.45*c* for one hour of its time. (a) Calculate the time passed for the clock left behind in the stationary frame of reference. (b) Describe and draw the space of the moving clock as observed from the stationary clock. Assume they are circular to start. (c) What shape will the moving clock to an observer moving with the clock? (d) If the moving clock had a mass of 294 g when stationary, calculate the mass when it is moving at 0.45*c*.

Answer 1

The Michelson-Morley experiment used the interference of light to try and detect the aether. The experiment was very sensitive but failed to detect any indication of the aether.

Experiment repeated many times without detecting the aether.

The null result was a great puzzle and to explain it was a difficult challenge. The idea of the aether was so strong amongst physicists, they found that it was difficult to let go of the idea until Albert Einstein in 1905 showed that the aether was not at all necessary in his theory of special relativity

$\Rightarrow$ measurement of speed of light independent of the motion of source or observer

$\Rightarrow$ shift in thinking from classical physics (time & space independent – Newton's Law) to time and space are relative.

Answer 2

(a) Time dilation

Length contraction

mass / energy equivalence $E = m c^2$

atomic clocks – one ground based, one flown in high speed aircraft

(b) Time dilation – muon decay in atmosphere

Length contraction – muon decay in atmosphere

(c) Technological advances since 1905:

Muon experiment – detection of fundamental particles

Nuclear fission, atomic bomb – fissile material: enrichment of uranium need $^{235}U_{92}$

Atomic clocks – very accurate, high speed aircraft

mass / energy equivalence $E = m c^2$ - nuclear fission, atomic bomb

Answer 3

Suspend an object on a length of string. If the string falls vertically, the frame of reference is moving at a constant velocity and the frame of reference is an inertial frame of reference.

In a non-inertial frame of reference, the string will be inclined at an non-zero angle to the vertical.

Answer 4

0.709 hours

Answer 5

(a) 1.12 h

(b) ellipse

(c) circular

(d) 329 g