Collins Turning Points Questions – C2T

QUESTIONS

1. Describe how overlapping light beams from the same original source produce a series of light and dark fringes.
2. In the Michelson–Morley experiment, what was the expected observation and what can be deduced from the experiment's null result?

QUESTIONS

3. State what is meant by an *inertial frame of reference*.
4. **a.** At what speed would a clock have to be moving relative to an observer's inertial frame of reference to be running at half the rate it would have if it was stationary relative to the observer?
   b. At what speed would a spacecraft have to be travelling relative to an observer if its length appeared contracted by half?
5. **a.** Using values given in the text, calculate the percentage of the muons that Rossi and Hall detected at an altitude of 2 km that would be expected to reach sea level, ignoring relativistic effects.

One of the first experiments to detect the effect of time dilation was undertaken in 1941 by Bruno Rossi and David Hall working at the University of Chicago. The experiment involved the use of a Geiger counter to detect cosmic muons at an altitude of 2 km and at sea level. Muons are unstable particles that decay . Those created in the laboratory have a half-life of 1.5 μs. Cosmic muons, which travel at 99.6% of the speed of light, take about 6.7 μs to travel the 2 km, so it would be expected that most of the muons would decay before reaching sea level.

However, Rossi and Hall's experiments showed that about 80% of the muons *did* reach sea level.

   b. i. Using the time dilation equation calculate the relativistic half-life for muon decay.
   ii. Using your value for relativistic half-life from **b i**, calculate the percentage of muons that time dilation predicts should reach sea level. Comment on your answer.

QUESTIONS

6. **a.** State what is meant by the *Lorentz factor* in special relativity.
   b. Calculate the Lorentz factor for an electron travelling at $2.5 \times 10^8 \,\mathrm{m\,s^{-1}}$.
   c. Calculate the Lorentz factor for an astronaut travelling in a spacecraft at $10 \,\mathrm{km\,s^{-1}}$.
   d. Comment on your answers to parts **b** and **c**.

QUESTIONS

7. Calculate the total energy of an electron accelerated through 1.2 MV, given that the rest energy of an electron is 0.551 MeV.
8. Calculate the total energy of a proton travelling at $0.999c$, given that its rest energy is 938.3 MeV.