

MODERN PHYSICS (351 PHYS)
PROBLEM SET 1

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PROBLEM (1)

A billiard ball of mass 0.3 kg moves with a speed of 5m/s and collides elastically with a ball of mass 0.2kg moving in the opposite direction with a speed of 3m/s.

Show that because momentum is conserved in the rest frame, it is also conserved in a frame of reference moving with a speed of 2m/s in the direction of the second ball.

PROBLEM (2)

With what speed will a clock have to be moving in order to run at a rate that is one-half the rate of a clock at rest?

PROBLEM (3)

How fast must a meter stick be moving if its length is observed to shrink to 0.5m ?

PROBLEM (4)

A clock on a moving spacecraft runs 1 s slower per day relative to an identical clock on Earth. What is the relative speed of the spacecraft? (Hint: For $v/c \ll 1$, note that $\gamma \approx 1 + \frac{1}{2}(v^2/c^2)$).

PROBLEM (5)

The average lifetime of a pi meson in its own frame of reference is 2.6×10^{-8} s.
If the meson moves with a speed of $0.95c$, what is:

1. its mean lifetime as measured by an observer on Earth
2. the average distance it travels before decaying, as measured by an observer on Earth?

PROBLEM (6)

An electron moves to the right with a speed of $0.90c$ relative to the laboratory frame. A proton moves to the right with a speed of $0.70c$ relative to the electron.
Find the speed of the proton relative to the laboratory frame.

PROBLEM (7)

An observer in frame S sees lightning simultaneously strike two points 100 m apart. The first strike occurs at $x_1 = y_1 = z_1 = t_1 = 0$ and the second at $x_2 = 100\text{m}$, $y_2 = z_2 = t_2 = 0$.

1. What are the coordinates of these two events in a frame S' moving in the standard configuration (x -direction) at $0.70c$ relative to S ?
2. How far apart are the events in S' ?
3. Are the events simultaneous in S' ? If not, what is the difference in time between the events, and which event occurs first?