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A μ-meson, traveling toward earth at a constant speed of 0.99c (for which γ = 7.09), traverses the earth's atmosphere, about 5000 m deep, in a time of about $1.67 \times 10^{-5}$ s, all as measured by O in the earth's rest frame. How high is the earth's atmosphere for O' in the μ's rest frame, and how long does it take for the earth's atmosphere to move past the μ-meson at rest?

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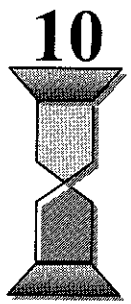
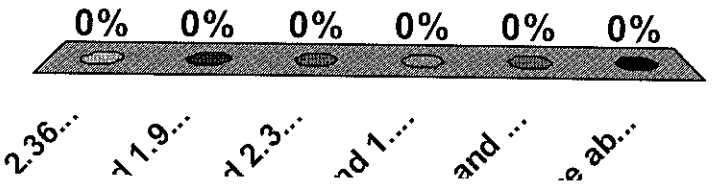
a) 70 m, and $2.36 \times 10^{-7}$ sec
b) 100 m, and $1.98 \times 10^{-7}$ sec
c) 700 m, and $2.36 \times 10^{-6}$ sec
d) 5000 m, and $1.67 \times 10^{-5}$ sec
e) 35,000 m, and $1.17 \times 10^{-4}$ sec
f) None of the above is within 10%.

0



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# The correct answer is c): 700 m, and 2.36x10-6 s; as follows.

- In the inertial rest-frame of the μ-meson, the height of the atmosphere is moving upward towards the μ-meson at a speed of 0.99 c.
- Therefore it is a moving **length** and is **contracted by a factor of γ** =7.09 to a length of 5000/7.09 ≈ 700 m, most nearly: answer c).
- For an observer at rest on earth, the μ's **traversal time**, $t_\mu$, **is DILATED** to $t_E = \gamma\, t_\mu' = (7.09)^* t_\mu' = 1.67\text{x}10^{-5}$ s.
- Therefore, $t_\mu' = t_E/\gamma = 2.36\text{x}10^{-6}$ s: the 2nd part of c).
- Note that the μ traverses a **contracted distance** in a shorter time, and computes the earth's speed to be $V = (700/2.36\text{x}10^{-6}) = 0.99c$, the same value as the earth observer computes from the full distance in the **dilated time**: $V = (5000/\ 1.67\text{x}10^{-5}) = 0.99c$.