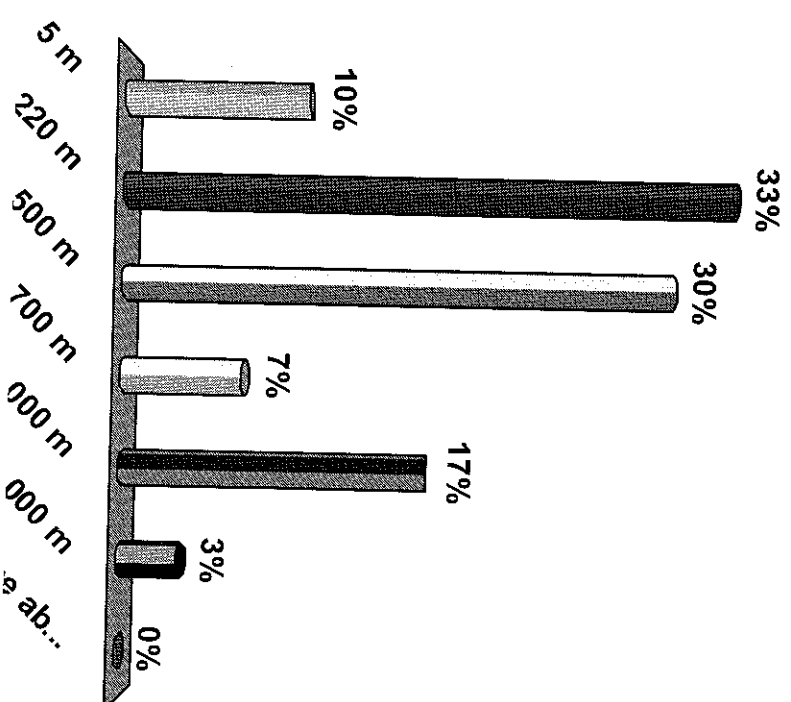


In the frame of reference of a μ -meson traveling toward earth at a constant speed of $0.999c$ (for which $\gamma = 22$), the earth's atmosphere, which extends roughly to a height of 5000 m is observed to be about _____ m thick, most nearly.

- a) 5 m
- b) 220 m
- c) 500 m
- d) 700 m
- e) 5,000 m
- f) 110,000 m
- g) None of the above is within 20%.



The correct answer is b): 220 m; 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 $0.999 c$.
- Therefore it is a moving length and is contracted by a factor of $\gamma = 22$ to a length of $5000/22 \approx 220$ m, most nearly: answer c).
- (Note that for an observer at rest on earth, the μ lifetime, $2.2 \mu\text{s} = 2.2 \times 10^{-6}$ s, is DILATED to $\Delta t = \gamma \Delta t' = (22) * (2.2) \times 10^{-6} \text{ s} \approx 49 \text{ s}$. This allows the μ -meson easily to travel the 5000 m to arrive at earth before decaying, which is impossible in $2.2 \mu\text{s}$, even at the speed of light.