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**Problem 21.1 (RHK)**

*Quite apart from effects due to the Earth's rotational and orbital motions, a laboratory frame is not strictly an inertial frame because a particle placed at rest there will not, in general remain at rest; it will fall under gravity. Often, however, events happen so quickly that we can ignore free fall and treat the frame as inertial. Consider, for example, a* 1.0-MeV *electron* (*for which* $v = 0.941\ c$) *projected horizontally into a laboratory test chamber and moving through a distance of* 20 cm. *We have to find* (a) *the time it would take to travel* 20 cm *and* (b) *the distance the electron would fall during this interval. We have to comment on the suitability of the laboratory as an inertial frame in this case.*

**Solution:**

(a)

The speed of 1.0-MeV electron is 0.941 *c*. The electron has been projected horizontally into a laboratory test

chamber and it moves through a distance of 20 cm Time taken by the electron to travel 20 cm will be

$$t = \frac{0.2}{0.941 \times 3 \times 10^8} \text{ s} = 7.1 \times 10^{-10} \text{ s.}$$

(b)

In this time the electron would have dropped vertically because of the surface gravity of the Earth by distance

$$y = \frac{1}{2} g t^2 = \frac{1}{2} \times 9.81 \times \left(7.1 \times 10^{-10}\right)^2 \text{ m} = 2.5 \times 10^{-18} \text{ m.}$$

(c)

We can therefore safely conclude that effects of the Earth's gravity will be insignificant and as time intervals involved in relativistic motion of elementary particles are of the order of $10^{-10}$ s, non-inertial effects due to Earth's rotational and orbital motions will also be negligible and thus the laboratory can be treated as an inertial frame.