4.4. I see that this question has taken you unawares. Experiments show that Newton's first law is not valid for all reference systems. Consider the example with the body lying on the floor of the railway car. We shall neglect the friction between the body and the floor. First we shall deal with the position of the body with respect to a frame of reference attached to the car. We can observe the following: the body rests on the floor and, all of a sudden, it begins to slide along the floor even though no action of any kind is evident. Here we have an obvious violation of Newton's first law of motion. The conventional explanation of this effect is that the car, which had been traveling in a straight line and at uniform velocity, begins to slow down, because the train is braked, and the body, due to the absence of friction, continues to maintain its state of uniform straight-line motion with respect to the railway tracks. From this we can conclude that Newton's law holds true in a frame of reference attached to the railway tracks, but not in one attached to a car being slowed down.

Frames of reference for which Newton's first law is valid are said to be inertial; those in which it is not valid are non-inertial. For most of the phenomena we deal with we can assume that any frame of reference is inertial if it is attached to the earth's surface, or to any other bodies which are at rest with respect to the earth's surface or travel in a straight line at uniform velocity. Non-inertial frames of reference are systems traveling with acceleration (or deceleration), for instance rotating systems, accelerating or decelerating lifts, etc. *Note that not only Newton's first law of motion is invalid for non-inertial reference systems, but his second law as well (since the first law is a particular case of the second law).* ◊

. But if Newton's laws cannot be employed for frames of reference traveling with acceleration, then how can we deal with mechanics in such frames ? ■

4.5. Newton's laws of motion can nevertheless be used for non-inertial frames of reference. To do this, however, it will be necessary to apply, purely formally, an additional force to the body. This force, the so called *inertial force*, equals the product of the mass of the body by the acceleration of the reference system, and its direction is opposite to the acceleration of the body. *I should emphasize that no such force actually exists but, if it is formally introduced, then Newton's laws of motion will hold true in a non-inertial frame of reference.*

I want to advise you, however, to employ only inertial frames of reference in solving problems. Then, all the forces that you have to deal with will be really existing forces. ◊

. But if we limit ourselves to inertial frames of reference, then we cannot analyze, for instance, a problem about a body lying on a rotating disk. ■