2.S: Floating Free (Summary)

what a free-float frame is and what it's good for

The **free-float frame** (also called the **inertial frame** and the **Lorentz frame**) provides a setting in which to carry out experiments without the presence of so-called "gravitational forces." In such a frame, a particle released from rest remains at rest a particle in motion continues that motion without change in speed or in direction (Section 2.2), as Newton declared in his First Law of Motion.

Where does that frame of reference sit? Where do the east-west, north-south, up-down lines run? We might as well ask where on the flat landscape in the state of Iowa we see the lines that mark the boundaries of the townships. A concrete marker, to be sure, may show itself as a corner marker at a place where a north-south line meets an east-west line. Apart from such on-the-spot evidence, those lines are largely invisible. Nevertheless, they serve their purpose: They define boundaries, settle lawsuits, and fix taxes. Likewise imaginary for the most part are the clock and rod paraphernalia of the idealized inertial reference frame. Work of the imagination though they are, they provide the conceptual framework for everything that goes on in the world of particles and radiation, of masses and motions, of annihilations and creations, of fissions and fusions in every context where tidal effects of gravity are negligible.

Our ability to define a free-float frame depends on the fact that a **test particle** made of any material whatsoever experiences the same acceleration in a given gravitational field (Section 2.5).

Near a massive ("gravitating"’) body, we can still define a free-float frame. However, in such a frame, free test particles typically accelerate toward or away from one another because of the nonuniform field of the gravitating body (Section 2.3). This limits - in both space and time - the size of a free-float frame, the domain in which the laws of motion are simple. The frame will continue to qualify as free-float and special relativity will continue to apply, provided we reduce the spatial extent, or the time duration of our experiment, or both, until these relative, or **tidal**, motions of test particles cannot be detected in our circumscribed region of spacetime. This is what makes special relativity "special" or limited (French: *relativité restreinte*: "restricted relativity"). General relativity (the theory of gravitation) removes this limitation (Chapter 9).

So there are three central characteristics of a free-float frame. (1) We can "get rid of gravity" by climbing onto (getting into) a free-float frame. (2) The existence of a free-float frame depends on the equal acceleration of all particles at a given location in a gravitational field - in Newton’s way of speaking. (3) Every free-float frame is of limited extent in spacetime. All three characteristics appear in a fuller version of the quotation by Albert Einstein that began this chapter:

> *At that moment there came to me the happiest thought of my life ... for an observer falling freely from the roof of a bouse no gravitational field exists during his fall-at least not in his immediate vicinity. That is, if the observer releases any objects, they remain in a state of rest or uniform motion relative to him, respectively, independent of their unique chemical and physical nature. Therefore the observer is entitled to interpret his state as that of "rest."*