

## Steady Flow

Often the term *steady flow* will be used in characterizing a flow. This refers to a flow (and the frame of reference of the observer) in which all the Eulerian time derivatives are zero. Of course this does depend on the frame of reference of the observer. For example, a passenger in a vehicle may observe that the flow around the vehicle is steady; but the stationary observer who watches that vehicle (and its flow) go past sees an unsteady flow. In fluid mechanics it is always advisable to make a Galilean change to the frame of reference in order to observe or analyze a steady flow when that is possible. Of course, there are many circumstances when that is not possible, for example the flow around any vehicle that is accelerating. The value in switching to a frame in which the flow is steady can be seen not only in the many analyses described in these pages but can also be recognized by the experimenter who observes the flow in a wind tunnel or water tunnel. Of course, almost no flow is truly steady for all time. Thus the flight of an airplane over the long time from take-off to landing is unsteady; but a plane in cruise can be seen to manifest a steady flow for short times.

Sometimes there are flows which are mostly steady and in which analyses or observations in a frame of reference in which most of the Eulerian time derivatives are close to zero is recommended. An example is the flow of a constant uniform stream around a fixed object. Most of the flow may be steady but the unsteady motions in a turbulent boundary layer are manifestly unsteady. Sometimes, as will be described in the sections on boundary layers, the mean or time-averaged effects of the turbulence on the mean flow are included in the analysis and the unsteadiness is set aside so the result is an effectively steady flow.