

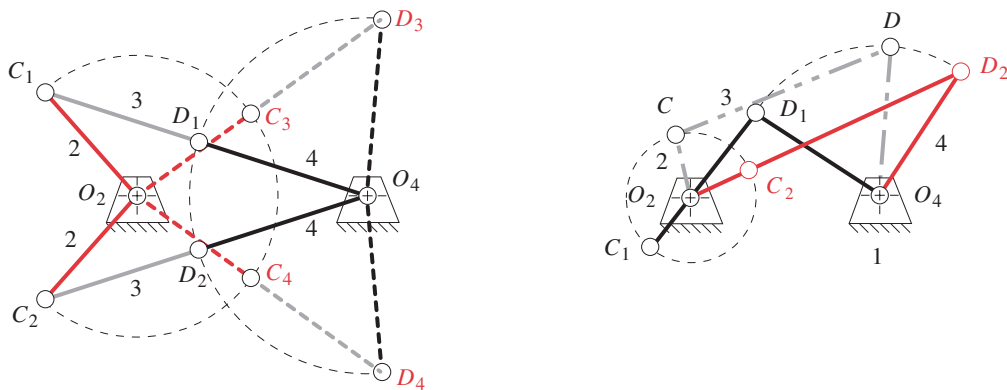
on each side of the car. The hood and the car body tie the two planar linkages together into a 3-D assembly. Look and you will see many other such examples of assemblies of planar linkages into 3-D configurations. So, the 2-D techniques of synthesis and analysis presented here will prove to be of practical value in designing in 3-D as well.

3.3 LIMITING CONDITIONS

The manual, graphical, dimensional synthesis techniques presented in this chapter and the computerizable, analytical synthesis techniques presented in Chapter 5 are reasonably rapid means to obtain a trial solution to a motion control problem. Once a potential solution is found, it must be evaluated for its quality. There are many criteria that may be applied. In later chapters, we will explore the analysis of these mechanisms in detail. However, one does not want to expend a great deal of time analyzing, in great detail, a design that can be shown to be inadequate by some simple and quick evaluations.

TOGGLE POSITIONS One important test can be applied within the synthesis procedures described below. You need to check that the linkage can in fact reach all of the specified design positions without encountering a limit position. Linkage synthesis procedures often only provide that the particular positions specified will be obtained. They say nothing about the linkage's behavior between those positions. Figure 3-1a shows a non-Grashof fourbar linkage at its limits of motion called **toggle positions**. The toggle positions are determined by the **colinearity** of two of the moving links. C_1D_1 and C_2D_2 (solid lines) are the toggle positions reached when driven from link 2. C_3D_3 and C_4D_4 (dashed lines) are the toggle positions reached when driven from link 4. A fourbar triple-rocker mechanism will have four, and a Grashof double-rocker two, of these toggle positions in which the linkage assumes a triangular configuration. When in a triangular (toggle) position, it will not allow further input motion in one direction from one of its rocker links (either of link 2 from positions C_1D_1 and C_2D_2 or link 4 from positions C_3D_3 and C_4D_4). A different link will then have to be driven to get it out of toggle.

STATIONARY POSITIONS A Grashof fourbar crank-rocker linkage will also assume two stationary positions as shown in Figure 3-1b, when the shortest link (crank O_2C) is



(a) Non-Grashof triple-rocker toggle positions

(b) Grashof crank-rocker stationary configurations

FIGURE 3-1

Linkage limit positions