CHAPTER 6

Trusses and frames

Here we consider collections of parts designed to hold something up or in place. Emphasis is on trusses, assemblies of straight bars connected by pins at their ends. Trusses are analyzed by drawing free-body diagrams of the pins (method of joints) or of bigger parts of the truss (method of sections). Frameworks, built with other than two-force bodies are also analyzed by drawing free-body diagrams of parts. Trusses and frames can be rigid or not and redundant or not, as can be determined by the equilibrium equations.

Many structures are built from two or more parts. If the parts are well-modeled as rigid, and the connections between them are also well-modeled as rigid,① then the separateness of the parts is not visible to the laws of mechanics. The collection is then, effectively, a single object. And the best we can do with statics is to treat the group as one object. And this has been the approach of the previous chapter.

Either by accident or design, however, the connections between solid parts often are not well-modeled as rigid. Rather, the connections are sometimes reasonably approximated as *freely* allowing some relative motion.

① Any connection between two parts that allows no relative motion (neither displacement nor rotation) is called a *rigid connection*. Examples of connections usually modeled as rigid are welds, bolted connections (with multiple bolts) and good glue joints.

This chapter concerns the analysis of arrays of parts connected by these means:

- with **pin joints**. A pin joint allows relative rotation of the parts; it does not transmit moments. Forces are transmitted in all directions. The pin connection is, by far, the most common model for connections in structures.
- a **round pin in a slot**. A pin in slot allows relative rotation of the two parts and relative motion in one direction. The only force transmitted is orthogonal to the slot.
- **square pin in a slot** (or shaft around a rod). This connection allows sliding in the slot but does not allow rotation. A force orthogonal to the slot is transmitted; so is a moment.

As is always the case at free-body diagram cuts, if translation or rotation is assumed to be freely allowed there is no force or moment, respectively. If translation or rotation are restricted there is a corresponding force or moment. The list above includes all of the standard models for motion-allowing connections between parts (see the table on page 1219). In 3D the array of standard connections is more complex, as discussed in Chapter 3.

In the previous chapter we only considered one object, and thus one free-body diagram, at a time. Here we need to consider, all at once, a collection of objects and the associated collection of free-body diagrams. The new skills that are thus needed are

- Use of the principle of action and reaction in the representation of forces on the free-body diagrams of pairs of interacting objects, and
- The solution of a larger number of simultaneous equilibrium equations.

We start with the analysis of trusses, structures built out of straight bars connected to each other by pins at their ends.