Chapter 1
Definition of Multibody System

Abstract This chapter presents a general view of multibody system concept and definition by describing the main features associated with spatial systems. The mechanical components, which can be modeled as rigid or flexible, are constrained by kinematic pair of different types. Additionally, the bodies can be actuated upon by force elements and external forces due to interaction with environment. This chapter also presents some examples of application of multibody systems that can include automotive vehicles, mechanisms, robots and biomechanical systems.

Keywords Multibody systems · Definition · Spatial systems

In a simple manner, it can be said that a general multibody system (MBS) embraces two main characteristics, namely: (*i*) mechanical components that describe large translational and rotational displacements and (*ii*) kinematic joints that impose some constraints or restrictions on the relative motion of the bodies. In other words, a multibody system encompasses a collection of rigid and/or flexible bodies interconnected by kinematic joints and possibly some force elements (Nikravesh 2008). Driving elements and prescribed trajectories for given points of the system components, can also be represented under this general concept of multibody system. Figure 1.1 depicts an abstract representation of a multibody system (Flores et al. 2008).

The bodies that belong to a multibody system can be considered as rigid or flexible. A body is said to be rigid when its deformations are assumed to be small such that they do not affect the global motion produced by the body. Such a body can translate and rotate, but it can not change its shape. In contrast to this concept, a flexible body has an elastic structure. In the three-dimensional space, the motion of a free rigid body can be fully described by using six generalized coordinates associated with the six degrees of freedom. In turn, when a body includes some amount of flexibility, it has six rigid degrees of freedom plus the number of generalized coordinates necessary to describe the deformations (Shabana 1989). The expression flexible multibody system refers to a system holding deformable bodies with internal dynamics. In fact, rigid bodies are a representation of reality because bodies are not absolutely rigid in nature. However, in a good number of common

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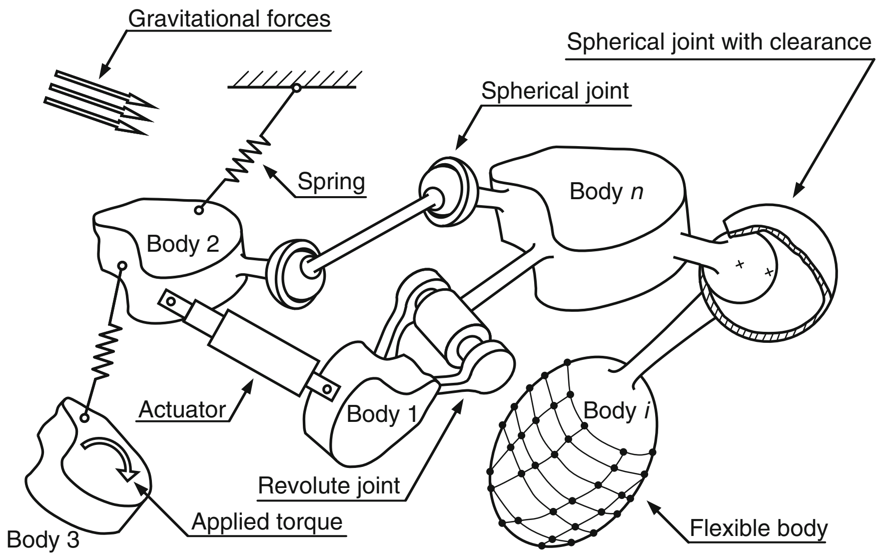

Fig. 1.1 Abstract representation of a multibody system with its most significant components: bodies, joints and forces elements

applications, the bodies are significantly stiff and, therefore, their flexibility can be disregarded and the bodies can be considered to be perfectly rigid. This assumption simplifies, in a significant manner, the process of modeling of multibody systems. Within the scope of the present work, only rigid bodies are considered.

By and large, the kinematic joints that can exist in multibody systems constrain the relative motion between the bodies connected by them. While the force elements represent the internal forces that are produced in the system and they are associated with the relative motion of the bodies. Two of the most typical kinematic joints employed in multibody systems are the revolute and the translational joints. The forces applied over the multibody system components can be the result of springs, dampers, actuators or external forces. External applied forces of different nature and different level of complexity can act on a multibody system with the purpose to simulate the interactions among the system components and between these and the surrounding environment (Nikravesh 1988; Schiehlen 1990).

A multibody system can be used to study the kinematic and dynamic motion characteristics of a wide variety of systems in a large number of engineering fields of application. Multibody systems can vary from very simple to highly complex. There is no doubt that multibody systems are ubiquitous in engineering and research activities, such as robotics (Zhu et al. 2006), automobile vehicles (Ambrósio and Veríssimo 2009), biomechanics (Silva and Ambrósio 2002), mechanisms (Flores 2011), railway vehicles (Pombo and Ambrósio 2008), just to mention a few. Figure 1.2 shows two multibody system examples of application,

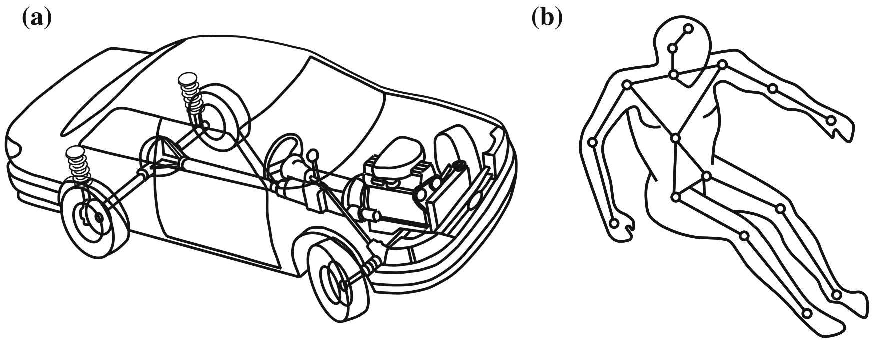

Fig. 1.2 Examples of application of multibody systems: **a** automobile vehicle model; **b** human biomechanical model

which result from the association of structural and mechanical subsystems with the purpose to transmit or transform a given motion.

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