CHAPTER 15

Circular motion of a particle

After movement on straight lines the next important special motion is rotation on a circular path. Polar coordinates and base vectors are introduced in this simplest possible context. The key new idea is that not just coordinates, but base vectors, can change with time.

We covered the special case of straight-line motion in the previous chapter. But an unconstrained particle, such as a thrown ball, generally moves on a curved path as pushed by gravity and aerodynamic forces. Also, when a rigid object moves, it translates and rotates while the points on the object move on complicated curved paths. Now we consider the archetypal curved motion, motion along a circular path. Circular motion deserves special attention because

- the most common connection between moving parts on a machine is with a bearing (or hinge or axle) (fig. 16.1), if the axle on one part is fixed then all points on the part move in circles;
- circular motion is the simplest case of curved-path motion;
- circular motion provides a simple way to introduce time-varying base vectors;
- circular motion includes most of the conceptual ingredients of more general curved motions;
- at least in 2 dimensions, the only way two particles on one rigid object can move relative to each other is by circular motion (no matter how the object is moving); and
- circular motion is the simplest case with which to introduce two important rigid-object concepts:
  - angular velocity, and
  - moment of inertia.

Many useful calculations can be made by approximating the motion of particles as circular. For example, the motions of points on a jet engine's turbine blade, a car engine's crank shaft, a car's wheel, a windmill's propeller, the earth spinning about its axis, a clock pendulum or watch balance wheel, all the points on a bicycle when it is going around a corner, a satellite orbiting the earth or a spinning satellite going around its spin axis, might all be approximately described as having circular motion about some appropriate point or axis.

This short chapter concerns only motion in two dimensions, namely the kinematics and mechanics of a single particle going in circles. The next chapter concerns the kinematics and mechanics of rigid objects. A later chapter discusses circular motion, which is always planar, in a three-dimensional context.