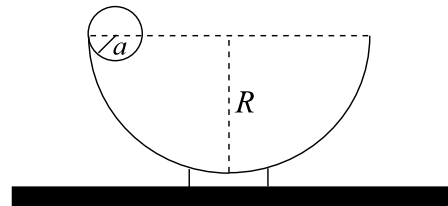


Consider a bowl, whose inside surface is a half-sphere of radius R . A ball of radius a and mass m moves on the inside surface of the bowl with its center remaining in a perpendicular plane through the lowest point. The ball is assumed to be solid and of uniform density.



- (a) Suppose the bowl is fixed on the table. The inside surface of the bowl and the surface of the ball are both frictionless. Initially, the ball is at rest and its center is in the horizontal plane through the center of the bowl. (See figure.) What is the speed of the center of the ball, when it passes the bottom point of the bowl? What is the normal force of the ball on the bowl at that moment?
- (b) Now suppose there is no slipping between the ball and the bowl with the same initial conditions for the ball as shown in the figure. What is the speed of the center of the ball and the normal force acting on the bowl when the ball passes the bottom point of the bowl?
- (c) Now suppose the bowl, as a whole, can move freely (with no friction) on the horizontal surface of the table, but there is friction between the ball and the bowl with the same initial conditions as before. Because of friction, the ball will finally sit motionlessly at the bottom of the bowl. Determine the displacement of the ball and specify the direction of the displacement. (Here we need to assume the mass of the bowl to be M .)