1. (20%) The position vector of the point P in terms of *spherical coordinates* and the corresponding unit vectors is simply (Figure 1)

   $$\mathbf{r} = r\mathbf{e}_r$$

   Derive the a) velocity, v, and b) acceleration, a, of P in terms of r, θ, ϕ, $\mathbf{e}_r$, $\mathbf{e}_\theta$, and $\mathbf{e}_\phi$.

2. (20%) The uniform slender rod of mass m and length L is initially at rest in a centered horizontal position on the fixed circular surface of radius $R = 0.6\,L$ (Figure 2). If a force P normal to the bar is gradually applied to its end until the bar begins to slip at the angle $\theta = 20°$, determine the coefficient of static friction μ_s.

3. (20%) Explain the following terminology: a) particle, b) rigid body, c) stable equilibrium, d) unstable equilibrium, e) neutral equilibrium, f) d'Alembert's principle, g) radius of gyration, and h) Coriolis acceleration.

4. (20%) Knowing that rod AB rotate with an angular velocity ω and an angular acceleration α (Figure 3), both counterclockwise, derive expressions for the velocity and acceleration of collar C.

5. (20%) The thin plate $ABCD$ weighs 16 kg and is held in position by the three inextensible wires AE, BF, and CH (Figure 4). Wire AE is then cut. Determine a) the acceleration of the plate, b) the tension in wires BF and CH immediately after wire AE has been cut.

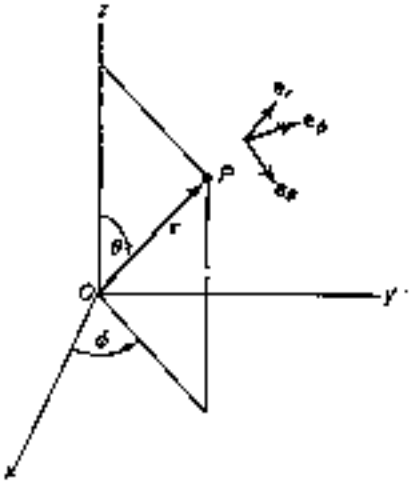

Figure 1 Spherical coordinates and unit vectors.

Figure 3

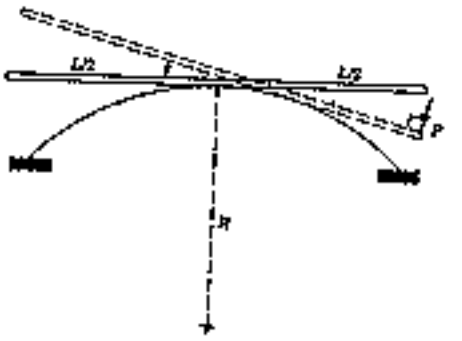

Figure 2

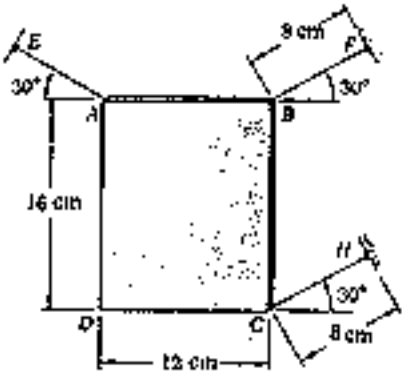

Figure 4