1. (40) The particle at A is given a downward velocity \( v_0 \) and swings in a vertical circle of radius \( r \) and center \( O \). Determine the smallest velocity \( v_0 \) for which the particle will travel around a circle if \( OA \) is:
   (a) a rope
   (b) a thin rod with negligible mass
   Ans. \( \sqrt{3gr} , \sqrt{2gr} \)

2. (30) The sphere of mass \( m_1 \) travels with an initial velocity \( v_1 \) directed as shown and strikes the stationary sphere of mass \( m_2 \). For a given coefficient of restitution \( e \), what condition on the mass ratio \( m_1/m_2 \) ensures that the final velocity of \( m_2 \) is greater than \( v_1 \)?
   Ans. \( \frac{m_1}{m_2} > \frac{1}{e} \)

3. (30) The ice hockey puck with a mass of 0.2 kg has a velocity of 12 m/s before being struck by the hockey stick. After the impact the puck moves in the new direction shown with a velocity of 18 m/s. If the stick is in contact with the puck for 0.04 s, compute the magnitude of the average force \( F \) exerted by the stick on the puck during contact, and find the angle \( \beta \) made by \( F \) with the x-direction.
   Ans. 147.81 N, 12.02°

Useful equations

Work and energy: \( T_1 + U_{1 \rightarrow 2} = T_2 \)
Work of a spring force: \( U_{1 \rightarrow 2} = \frac{1}{2} kx_1^2 - \frac{1}{2} kx_2^2 \)
Conservation of energy: \( T_1 + V_1 = T_2 + V_2 \)
Impulse and momentum: \( m\ddot{v}_1 + \int_{t_1}^{t_2} \vec{F}dt = m\ddot{v}_2 \)
Coefficient of restitution: \( e = \frac{v'_B - v'_A}{v_A - v_B} \)