1. A 2 lb football travels horizontally at 60 ft/s as it spins about its axis at 5 rad/s. A bird expresses an intelligent opinion about football by depositing a 0.05 lb particle P upon the ball in the position in the x-z plane shown. Immediately prior to impact, the particle P has a velocity of 60 ft/s in the direction of the ball, and is falling downwards with a velocity of 120 ft/s. The ball has the following radii of gyration: \( k_x = 2 \text{ in.}, \ k_y = k_z = 3 \text{ in.} \). The particle P sticks to the ball after impact, and its contribution to the ball’s inertia tensor may be neglected. Neglect gravity during the impact.

(a) What is the velocity of the particle P relative to the ball prior to impact?
(b) What is the linear velocity of the ball after collision (relative to a stationary observer)?
(c) What is the angular velocity of the ball after the collision?

2. An oscillating fan is pointed 30° above horizontal. It oscillates at a speed \( \omega_1 = \sin \pi t \) (\( t \) in seconds), and spins at the constant rate \( \omega_2 = 30 \text{ rad/s} \). At \( t = 0.25 \text{s} \), what are the angular velocity and angular acceleration of the fan blades?
3. An Olympic sprinter signs onto a major league baseball team, then runs off after her first hit holding her bat in her hand as shown. Treat her bat as a uniform rod of length \( l \) and mass \( m \). Without the aid of any substances banned by major league baseball, she runs 100m in 8.72s, accelerating constantly the entire way. At what constant angle \( \theta \) can she hold the bat?

4. A woman of mass \( m \) can escape from a burning building of height \( l \) by swinging to the ground on one of two massless rope of length \( l \). Rope (a) is connected to a rigid support, and rope (b) is connected to a cart of mass \( 2m \), that can move frictionlessly in the horizontal direction. With what speed \( v \) will she reach the ground in each case?