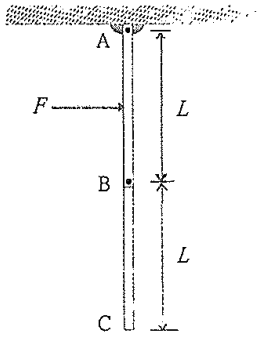
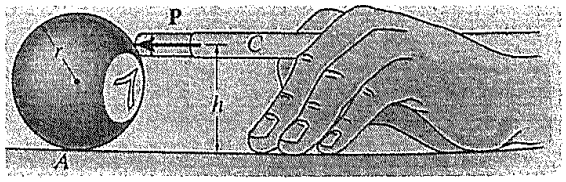
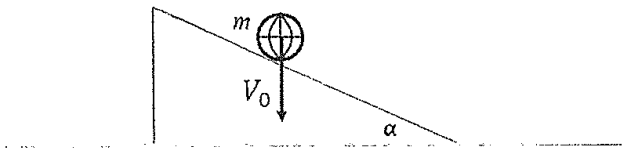
1. (25%) Two identical bars, each of mass $m$ and length $L$, hang freely from the vertical. A force $F$ is applied at the center of the upper bar **AB**.
   (i) Please find the angular acceleration of the bar **AB**. (12%)
   (ii) Find the angular acceleration of the bar **BC**. (13%)



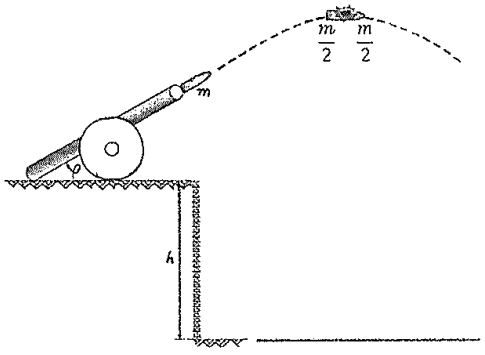

2. (25%) Consider a billiard ball of radius $r$ and mass $m$ in contact with the flat surface of a table.
   (i) The moment of inertia of the ball is $2mr^2/5$. Please derive it. (10%)
   (ii) Determine the height $h$ at which the ball must be struck so that no frictional force develops between it and the table at $A$. Assume that the cue $C$ only exerts a horizontal force **P** on the ball. (15%)




3. (25%) A homogeneous sphere of mass $m$ and radius $r$ falls without rotation upon a fixed and perfectly rough surface inclined at an angle $\alpha$ to the horizontal plane. The vertical velocity before impact is $V_0$, and the coefficient of restitution for the collision is $e$. Determine the angular velocity of the sphere, the velocity, and the direction of motion of the center of mass of the sphere after the impact. (The moment of inertia of the sphere is $\frac{2}{5}mr^2$.)




4. (25%) A cannon in a fort at height $h$ from the sea level overlooking the ocean fires a shell of mass $m$ at an angle of $\theta$ and muzzle velocity $v_0$. See the figure below. At the highest point the shell explodes, with additional energy $E_a$, into two fragments with equal mass, travelling in the original horizontal direction. Neglect the air drag. Find the distance separating the two fragments when they land into the ocean.

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