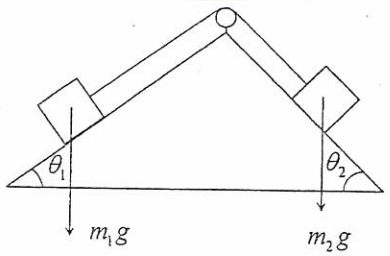
1. (25%) A cannon in a fort at height h from the sea level overlooking the ocean fires a shell of mass m at an angle of $45°$ and muzzle velocity v_0, cf. the figure below. At the highest point the shell explodes into two fragments with equal mass, with an additional energy E_a, traveling in the horizontal direction. Find the distance separating the two fragments when they land in the ocean. (You may need to use the Conservation Law of Total Linear Momentum.)

2. (25%) Consider two blocks with masses m_1, m_2 moving on two inclined planes, respectively, as shown in the following figure. The inclined planes are assumed to be smooth and the inclined angles are θ_1 and θ_2, respectively. The string connecting the two blocks through the pulley is assumed to be massless and inextensible. Please determine the accelerations of the two blocks along the inclined planes.



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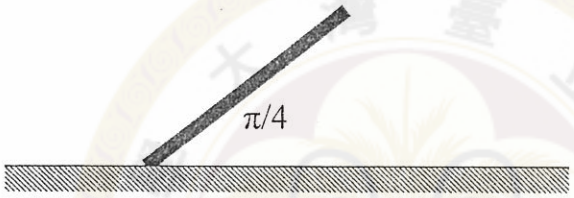
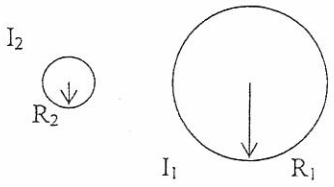
3. (25%) A homogeneous bar, with length l, mass m, and with one end in contact with a horizontal plane, is initially in a configuration shown in the figure. Under the action of gravitational force, the bar is allowed to fall.
   (a) Without friction (the contact point moves horizontally), please find the angular velocity of the bar when it strikes the horizontal plane.
   (b) With friction (the contact point is fixed), find the angular velocity of the bar at that time.



4. (25%) Two cylinders having radii R_1 and R_2 and rotational inertias I_1 and I_2, respectively, are supported by axes perpendicular to the plane of the figure. The large cylinder 1 is initially rotating with angular velocity ω_0. The small cylinder 2 is moved to the right until it touches the large cylinder and is caused to rotate by the frictional force between the two. Eventually, slipping ceases, and the two cylinders rotate at constant rates in opposite directions.
   (a) Is total energy conserved in this case? Why?
   (b) Is total angular momentum conserved in this case? Why?
   (c) Find the final angular velocity ω_2 of the small cylinder in terms of I_1, I_2, R_1, R_2 and ω_0.



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