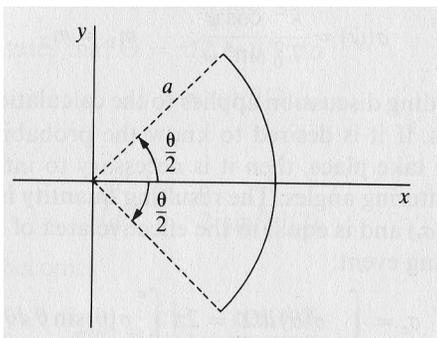


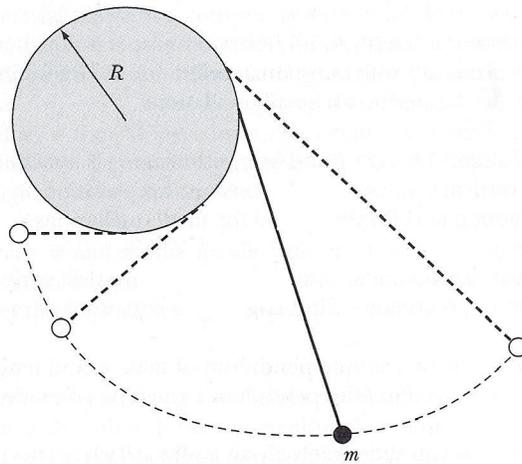
Physics 106a/196a – Problem Set 2 – Due Oct 13, 2006

These problems cover the material on dynamics of systems of particles in Sections 1.3 of the lecture notes. Problems 1, 2 are for 106a students only, 3-5 for 106a and 196a students, and 6, 7 for 196a students only.

1. (106a) Find the center of mass of a uniform wire of mass m that subtends an arc θ if the radius of the circular arc is a , as shown in the figure.
2. (106a) A lunar landing craft approaches the moon's surface. Assume that one-third of its weight is fuel, that the exhaust velocity from its rocket engine is 1500 m/s, and that the acceleration of gravity at the lunar surface is one-sixth of that at the earth's surface. How long can the craft hover over the moon's surface before it runs out of fuel?
3. (106a/196a) A scoop of mass m_1 is attached to an arm of length l and negligible weight. The arm is pivoted so that the scoop is free to swing in a vertical arc of radius l . At a distance l directly below the pivot is a pile of sand. The scoop is initially lifted until the arm is at a 45° angle with the vertical, and then it is released. It swings down and scoops up a mass m_2 of sand. To what angle with the vertical does the arm of the scoop rise after picking up the sand? This problem is to be solved by considering carefully which conservation laws are applicable to each part of the swing of the scoop. Friction is to be neglected, except that required to keep the sand in the scoop.
4. (106a/196a) A particle of mass m is attached to the end of a string of length b and uniform mass density λ . The other end of the string is attached to the top of a cylinder of radius R ,



Problem 1



Problem 4

as shown in the figure. Let θ indicate the angle that the string makes with the horizontal. The system is in a uniform gravitational field, pointing downward. Find the total kinetic and potential energy of the system as a function of θ and $\dot{\theta}$.

5. (106a/196a) A proton of mass m_1 collides elastically with an unknown nucleus in a bubble chamber and is scattered through an angle ψ_1 . The ratio $p_{1,f}/p_{1,i}$ is determined from the curvature of its initial and final tracks under the influence of a magnetic field perpendicular to the plane in which the scattering occurs. Why does the track curvature give the momenta directly rather than the velocities (recall that the Lorentz force is $\vec{F} = q\vec{v} \times \vec{B}$)? Find the mass m_2 of the target nucleus in terms of m_1 , ψ_1 , and the momentum ratio $\alpha = p_{1,f}/p_{1,i}$. Hint: this can be a bit of a long slog of algebra if you blindly apply results from class without thinking. There is a less painful way.
6. (196a) Even when the total force on a system of particles vanishes, the total torque may be nonzero. Show that the total torque is independent of which *inertial* frame it is calculated in.
7. (196a) Recall the scattering problem we have studied in class: m_1 incident at speed u_1 onto a particle of mass m_2 at rest in the lab frame. Suppose that the scattering is isotropic in the center-of-mass frame, meaning that the probability of the particles coming out with center-of-mass frame scattering angle between $\cos\theta$ and $\cos\theta + d\cos\theta$ is independent of $\cos\theta$. What is the distribution of the the final state kinetic energies of the two particles in the lab frame as compared to the initial lab frame kinetic energy $T_0 = \frac{1}{2}m_1u_1^2$? (This problem does *not* require much calculation!)