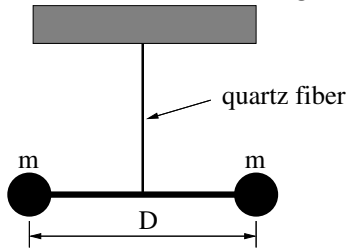


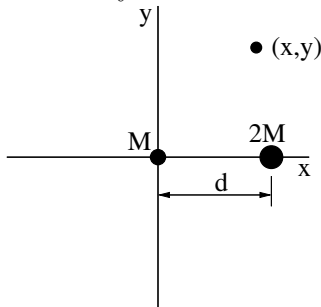
Physics 222 – Test 1 – Spring 2011

One-page reminder sheet allowed. *Show all work – no credit given if work not shown!*

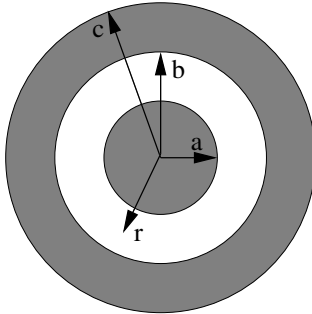
1. A quartz fiber supports a horizontal rod of length D at its mid-point as shown below. Equal masses m are attached to the ends of the rod and the rod itself has negligible mass. The quartz fiber exerts a restoring torque $\tau = -k\theta$ when twisted about the vertical axis through an angle θ , where k is a positive constant.
 - (a) If the rod is rotated by some angle about the vertical axis and released, describe qualitatively the subsequent motion.
 - (b) Using the torque/angular momentum equation, write down and solve the differential equation for the rotation angle θ of the rod as a function of time. Hint: The moment of inertia of the rod-mass system for rotations about the mid-point is $I = mD^2/2$ and the angular momentum is related to the angular velocity by $L = I\omega$ where the angular velocity is $\omega = d\theta/dt$.



2. A mass M is located at the origin in the $x - y$ plane and a mass $2M$ is located at $(d, 0)$ as shown below. Compute the (vector) gravitational field at the arbitrary point (x, y) . Present your answer in component form, not magnitude and direction.



3. An infinitely long, hollow, circular cylinder has at its center a solid cylinder of smaller radius as shown in cross-section below. Both cylinders have mass density ρ . The radius of the inner cylinder is a and the inner and outer radii of the outer cylinder are b and c respectively. Use Gauss's law to compute the gravitational field for radii $a < r < b$.



4. Suppose a particle is moving with initial velocity $(v_x, 0, 0)$ subject to the potential momentum $\mathbf{Q} = (0, C \exp(ax + bt), 0)$ and potential energy $U = 0$, where a , b , and C are constants, x is its position on the x axis, and t is the time.
- Check to determine whether the Lorentz condition is satisfied.
 - If the particle is initially stationary ($v_x = 0$), what is the force on it at this time?
 - For what value of v_x is the force zero for all x and t ?
5. A stationary virtual particle has real mass M_R and virtual mass M_V .
- Estimate the virtual particle's lifetime using the uncertainty principle.
 - The virtual particle decays into two real particles of identical mass m . Compute the energy and momentum of each of these particles.
 - Compute these particle's speeds.