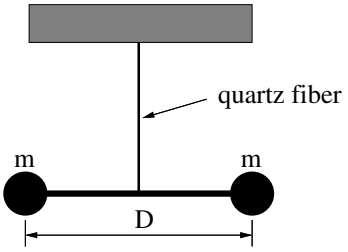
Physics 222 – Test 1 – Spring 2011

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

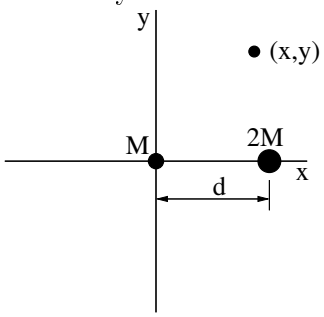
1. A quartz fiber supports a horizontal rod of length D at its mid-point as shown below. Equal masses m are attached to the ends of the rod and the rod itself has negligible mass. The quartz fiber exerts a restoring torque $\tau = -k\theta$ when twisted about the vertical axis through an angle θ, where 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.

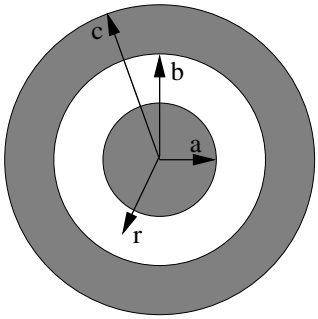
   (b) Using the torque/angular momentum equation, write down and solve the differential equation for the rotation angle θ of the rod as a function of time. Hint: The moment of inertia of the rod-mass system for rotations about the mid-point is $I = mD^2/2$ and the angular momentum is related to the angular 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.

   (a) Check to determine whether the Lorentz condition is satisfied.

   (b) If the particle is initially stationary ($v_x = 0$), what is the force on it at this time?

   (c) 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.

   (a) Estimate the virtual particle's lifetime using the uncertainty principle.

   (b) The virtual particle decays into two real particles of identical mass m. Compute the energy and momentum of each of these particles.

   (c) Compute these particle's speeds.