Electromagnetism I – Problem sheet 9

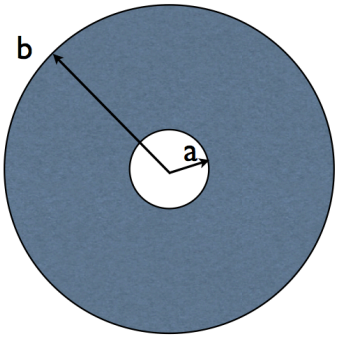
Problem 1.

A long straight cylindrical conductor has an outer radius b and a hollow core of radius a. The figure below shows the cross-sectional view of this conductor. There is an electrical current flowing in the direction perpendicular to the cross-section. The current density varies with radius r, for $a \leq r \leq b$ as

$$j(r) = j_0 \frac{r}{a},$$

where j_0 is constant.

1. Find an expression for the total current flowing in the conductor. **[2]**
2. Find an expression for the strength of the magnetic field in the three regions:
   (a) $r < a$; **[1]**
   (b) $a \leq r \leq b$; **[1]**
   (c) $r > b$; **[1]**



Problem 2.

A thin, uniform rod with negligible mass and length $L = 0.2$ m is attached to the floor by a frictionless hinge at point P. A horizontal spring with force constant $k = 4.8$ N m^{-1} connects the other end of the rod to a vertical wall. The rod is in a uniform magnetic field $B = 0.34$ T directed into the plane of the figure. There is a current $I = 6.5A$ in the rod in the direction shown.

1. Calculate the torque τ_B due to the force induced by the magnetic field, for an axis at P. Does the torque tend to rotate clockwise or counterclockwise the rod? **[2]**
2. At equilibrium, the rod makes an angle of 53° with respect to the floor (see figure): how much energy is stored in the spring? **[3]**