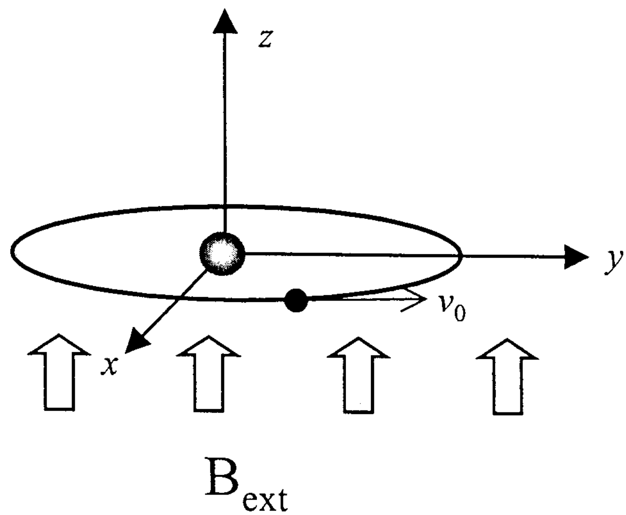
EM Spring 00A

Consider a classical model of an electron held by the Coulomb force in a circular orbit of radius r_0 about a positive nucleus (charge Q) located at the origin. The electron has speed v_0, charge q, and mass M. The orbit lies in the xy plane. B_{ext} represents the external magnetic field. Neglect intrinsic spin throughout this problem.



(a) With $B_{ext} = 0$, write down the orbital magnetic dipole moment, $\vec{m}$, for the electron and indicate its direction.

(b) A uniform magnetic field oriented in the $+\hat{z}$ direction is slowly turned on to a final value $\vec{B}_f$. Assuming that the radius r_0 of the orbit is unchanged, find the change in the orbital speed, $\Delta\vec{v}$, of the electron in terms of $\vec{B}_f$. What force causes the charge to accelerate?

(c) Explicitly justify the assumption that r_0 is unchanged. You may drop terms in $(\Delta v)^2$.

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(d) Find the change in the orbital magnetic dipole moment $(\Delta\vec{m})$ resulting from the external field. Express your answer in terms of $\vec{B}_f$, q, r_0 and M and indicate its direction. Does your answer depend on the sense of rotation of the electron?

(e) Consider a solid with a random initial orientation of the orbital magnetic moments of its atoms. When an external magnetic field is applied, what do the conclusions of part (d) tell you about the direction of the induced magnetization relative to the external field?