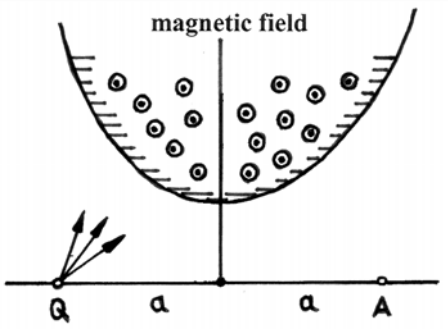
Theoretical problem 3: "Ions in a magnetic field"

A beam of positive ions (charge +e) of the same and constant mass *m* spread from point Q in different directions in the plane of paper (see figure[2]). The ions were accelerated by a voltage *U*. They are deflected in a uniform magnetic field *B* that is perpendicular to the plane of paper. The boundaries of the magnetic field are made in a way that the initially diverging ions are focussed in point A ($\overline{QA} = 2 \cdot a$). The trajectories of the ions are symmetric to the middle perpendicular on $\overline{QA}$.



[2] Remark: This illustrative figure was not part of the original problem formulation.

Among different possible boundaries of magnetic fields a specific type shall be considered in which a contiguous magnetic field acts around the middle perpendicular and in which the points Q and A are in the field free area.

a) Describe the radius curvature R of the particle path in the magnetic field as a function of the voltage U and the induction B.

b) Describe the characteristic properties of the particle paths in the setup mentioned above.

c) Obtain the boundaries of the magnetic field boundaries by geometrical constructions for the cases $R < a$, $R = a$ and $R > 0$.

d) Describe the general equation for the boundaries of the magnetic field.