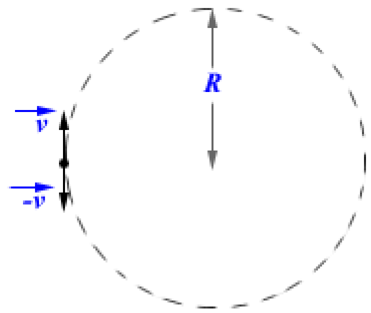
435.

Problem 34.25 (RHK)

A neutral particle is at rest in a uniform magnetic field of magnitude B. At time $t = 0$ *it decays into two charged particles each of mass m.* (a) *If the charge of one of the particles is q, we have to identify the charge of the other particle.*(b) *The two particles move off in separate paths both of which lie in the plane perpendicular to* $\vec{B}$. *At a later time the particles collide. We have to express the time from decay until collision in terms of m, B, and q.*



Solution:

(a)

As a neutral particle has decayed into two charged particles, as one of them has charge *q* the charge of the other has to be $-q$. This follows from the conservation of charge.

(b)

As a neutral particle at rest decays into two charged particles each of mass m, from the principle of conservation of momentum it follows that if one has velocity $\vec{v}$ the velocity of the other has to be $-\vec{v}$.

As the particles move in magnetic field $\vec{B}$ at right angles to $\vec{v}$ the force on the two charged particles will be perpendicular to both $\vec{v}$ and $\vec{B}$. The two particles will move in circular orbits. If one moves in the clockwise direction, the other will move in the counter-clockwise direction. Let the radii of their circular orbits be *R*. from the symmetry of the problem we expect the two particles to collide with each other after each has travelled a distance πR.

As each particle is undergoing circular motion with speed *v* and the centripetal force is provided by the magnetic field *B* on moving charge *q*, we have

$$\frac{mv^2}{R} = qvB,$$

and

$$\frac{\pi R}{v} = \frac{\pi m}{qB},$$

the decayed particles will collide after a lapse of time

$$t = \frac{\pi m}{qB}.$$