A particle with negative charge $-q$ and mass $m = 2.00 \times 10^{-15}$ kg is traveling at $t = 0$ with $(v_x, v_y, v_z) = 1.00 \times 10^6 (-3, 4, 5) \text{ m/s}$, at position $(x, y, z) = (a, 0, 0) \text{ m}$. At all times it travels in a region of constant magnetic field, $(B_x, B_y, B_z) = (0, 0, -0.100) \text{ T}$.

1) If at $t=0$, the magnitude of the force on the particle is 1.00 N, what is $q$ in $10^{-6} \text{ C}$?

   a) 0.500 b) 1.00 c) 2.00 d) 5.00 e) none of these

   

F = qv × B,

   = q(1.00 \times 10^6)(0.100)(-3i + 4j + 5k) × -k,

   = q(1.00 \times 10^5)(-3j - 4i),

   F = q(5.00 \times 10^5) = 1.00,

   q = 2.00 \times 10^{-6} \text{ C}. \ (c)

2) At some arbitrary later time the magnitude of the force

   a) increases b) decreases c) is the same d) could increase or decrease e) insufficient information

F · v = 0, thus $|v|$ is unchanged and since F ⊥ B, $F_z = 0, v_z$ is constant. So $|F|$ is constant, (c)

3) At $t=0$ the value of $a$ in cm is

   a) 0.500 b) 1.00 c) 2.00 d) 5.00 e) none of these

Particle moves in a circle with radius $a$ in the xy plane so,
\[ F = m(v_x^2 + v_y^2)/a, \]
\[ a = 100[2 \times 10^{-15}(3^2 + 4^2) \times 10^{12}/1.00] \text{ cm} \]
\[ = 5 \text{ cm} \]

4) What is the next time in $10^{-8}$ s that $(x, y) = (a, 0)$?

a) 6.28 b) 3.14 c) 1.57 d) 0.785 e) none of these

The time is the period for 1 revolution, so,
\[ t = \frac{2\pi a}{\sqrt{v_x^2 + v_y^2}}, \]
\[ = \frac{2\pi (0.05)}{5 \times 10^6} \text{ s} \]
\[ = 6.28 \times 10^{-8} \text{ s}, \ (a). \]

5) What is $z$ in cm at this time?

a) 62.8 b) 31.4 c) 15.7 d) 7.85 e) 0

\[ z = z(0) + v_z t, \]
\[ = 0 + 100[(5.00 \times 10^6)(6.28 \times 10^{-8})] \text{ cm}, \]
\[ = 31.4 \text{ cm}, \ (b) \]