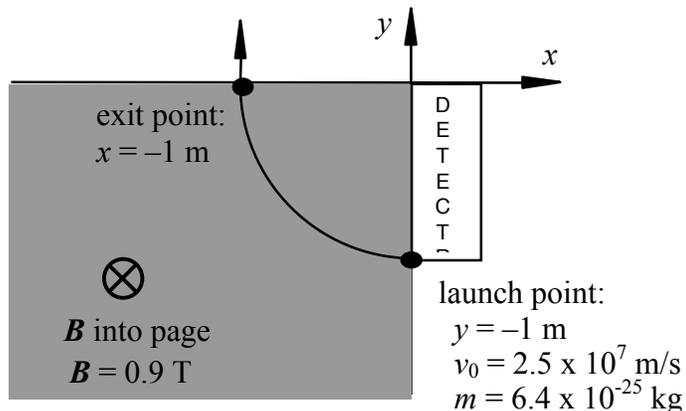


A charged particle of mass  $m$  and charge  $q$  is launched with initial velocity  $v_0$  in the negative  $x$  direction. The launch position is  $x = 0, y = -1$  m. After launch, the particle immediately finds itself in a constant  $\mathbf{B}$  field which extends throughout the shaded region ( $x < 0, y < 0$ ). A detector is located to the right of this region, but the particle's trajectory causes it to *miss* the detector. Instead, it leaves the field at the position  $x = -1$  m,  $y = 0$ .



- 1) Given the values shown, what is the particle's charge  $q$ ? Be sure to indicate both the magnitude and sign of the charge. [5]

$$|q| = mv/Br \rightarrow q = -1.78 \cdot 10^{-17} \text{ C}$$

Rubric:

Setup (2)

Correct value(2)

Correct sign(1)

- 2) What is the particle's kinetic energy  $T$  as it exits the  $\mathbf{B}$  field region? [3]

$$T = \frac{1}{2} mv_0^2 = 2 \cdot 10^{-10} \text{ J}$$

Rubric:

Setup (1)

Result (2)

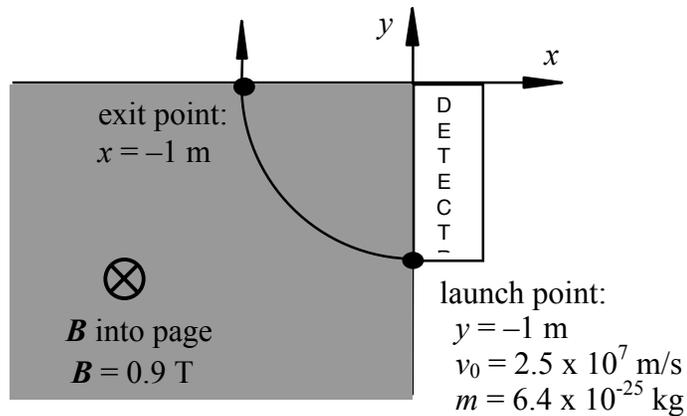
- 3) What numerical inequality would have to be placed on the particle's initial velocity  $v_0$  to ensure that curves sharply enough to enter the detector? [5]

$$v_{\max} = qBr/m \text{ where } r = 0.5\text{m} \rightarrow v_{\max} = 1.25 \cdot 10^7 \text{ m/s}$$

Rubric:

Setup (3)

Correct result (2)



- 4) Finally, a constant electric field  $E$  is added in the shaded region. The effect of this field is that all charged particles launched with initial speed  $v_0$  *continue* to travel in the  $-x$  direction, without being deflected at all! What is the magnitude and direction of this  $E$  field? [3]

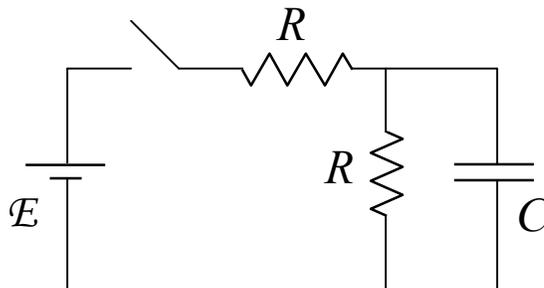
$E = v_0 B = 2.25 \times 10^7 \text{ N/C}$  in  $+y$  direction

Rubric:

Setup (2)

Correct result (1)

- 5) Two resistors and an ideal battery are connected as shown in the diagram below. At  $t = 0$ , the capacitor is uncharged and the switch is closed. What is  $V_C(0)$ , the voltage across the capacitor immediately after the switch is closed? Express your answer in terms of the given variables  $\mathcal{E}$ ,  $R$ , and  $C$ . [4]



$Q = 0 \rightarrow V = 0$

Rubric:

Situation at  $t=0 \rightarrow Q = 0$  (2)

$V = 0$  (2)