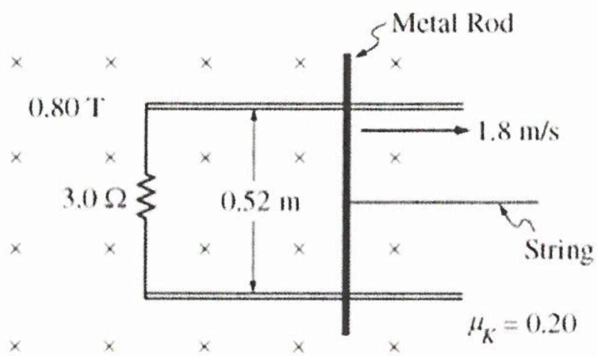
Electromagnetism Exam Review

Directions – Complete the following problems to help prepare you for the upcoming test.

2009 AP® PHYSICS B FREE-RESPONSE QUESTIONS



Top View

3. (15 points)

A metal rod of mass 0.22 kg lies across two parallel conducting rails that are a distance of 0.52 m apart on a tabletop, as shown in the top view above. A 3.0 Ω resistor is connected across the left ends of the rails. The rod and rails have negligible resistance but significant friction with a coefficient of kinetic friction of 0.20. There is a magnetic field of 0.80 T perpendicular to the plane of the tabletop. A string pulls the metal rod to the right with a constant speed of 1.8 m/s.

(a) Calculate the magnitude of the current induced in the loop formed by the rod, the rails, and the resistor.

(b) Calculate the magnitude of the force required to pull the rod to the right with constant speed. $\Sigma F = 0N$

(c) Calculate the energy dissipated in the resistor in 2.0 s.

(d) Calculate the work done by the string pulling the rod in 2.0 s.

(e) Compare your answers to parts (c) and (d). Provide a physical explanation for why they are equal or unequal.

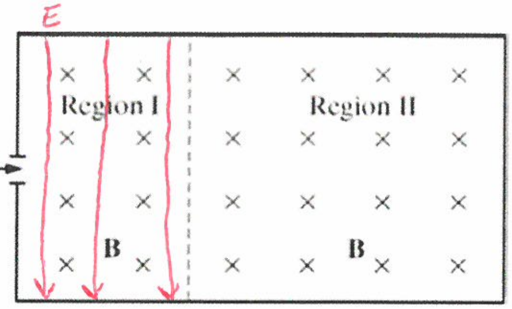
a) $I = \frac{\Delta V}{R} = \frac{\varepsilon}{R} = \frac{B\ell v}{R} = \frac{(.80T)(.52m)(1.8m/s)}{3.0\Omega} = \boxed{.25A}$

b) $F_A = F_B + F_f = BI\ell + \mu F_N = BI\ell + \mu mg$
$= (.80T)(.25A)(.52m) + (.20)(.22kg)(9.81m/s^2)$
$\boxed{= .53N}$

c) $U = P \cdot t = I^2Rt = (.25A)^2(3.0\Omega)(2.0s) = \boxed{.38J}$ or $U = \frac{V^2t}{R}$ or $U = VIt$

d) $W = Fd = F_A(vt) = .53N(1.8m/s)(2.0s) = \boxed{+1.9J}$

e) The work done is greater than the energy dissipated because the work is also being done against friction.



a) i $\uparrow F_B$ $\downarrow F_e$

F_e must be down to oppose F_B

2. (10 points)

A beam of particles of charge $q = +3.2 \times 10^{-19}$ C and mass $m = 6.68 \times 10^{-26}$ kg enters region I with a range of velocities all in the direction shown in the diagram above. There is a magnetic field in region I directed into the page with magnitude $B = 0.12$ T. Charged metal plates are placed in appropriate locations to create a uniform electric field of magnitude $E = 4800$ N/C in region I. As a result, some of the charged particles pass straight through region I undeflected. Gravitational effects are negligible.

(a)

i. On the diagram above, sketch electric field lines in region I.

ii. Calculate the speed of the particles that pass straight through region I.

ii) $F_B = F_e$, $qvB = Eq$, $v = \frac{E}{B} = \frac{4800 \text{ N/C}}{.12 \text{ T}} = 4.0 \times 10^4$ m/s

The particles that pass straight through enter region II in which there is no electric field and the magnetic field has the same magnitude and direction as in region I. The path of the particles in region II is a circular arc of radius R.

(b) Calculate the radius R.

$F_c = F_B$, $\frac{mv^2}{r} = qvB$, $r = \frac{mv}{qB} = \frac{(6.68 \times 10^{-26} \text{ kg})(4.0 \times 10^4 \text{ m/s})}{(3.2 \times 10^{-19} \text{ C})(.12 \text{ T})} = .070$ m

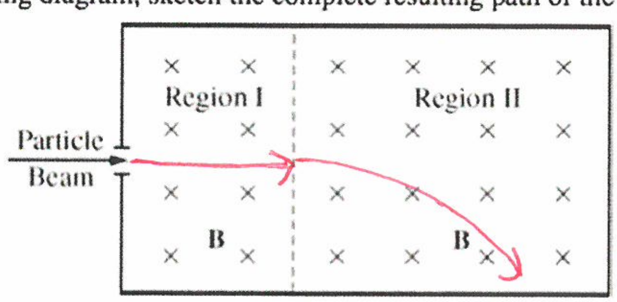
(c) Within the beam there are particles moving slower than the speed you calculated in (a)ii. In what direction is the net initial force on these particles as they enter region I?

____ To the left ____ Toward the top of the page ____ Out of the plane of the page

____ To the right __X__ Toward the bottom of the page ____ Into the plane of the page

Justify your answer. $F_B = qvB$ With less v, F_B would decrease leading to an overall net downward force since F_E would be larger than F_B

(d) A particle of the same mass and the same speed as in (a)ii but with charge $q = -3.2 \times 10^{-19}$ C enters region I. On the following diagram, sketch the complete resulting path of the particle.



$\uparrow F_e$ $\downarrow F_B$ balance so no deflection

LEFT hand force pushes negative q down