B38EM - Introduction to Electricity and Magnetism
Tutorial 6

Questions

$\varepsilon_0 = 8.85\text{x}10^{-12}\ \text{Fm}^{-1}$, $e = 1.6\text{x}10^{-19}\ \text{C}$, $\mu_0 = 4\pi\ 10^{-7}\ \text{N/A}^2$

1.

A horizontal wire with a mass per unit length of 0.2 kg/m carries a current of 4 A in the $+x$-direction. If the wire is placed in a uniform magnetic flux density **B**, what should the direction and minimum magnitude of **B** be in order to magnetically lift the wire vertically upward?
(Hint: The acceleration due to gravity is $\mathbf{g} = -\hat{\mathbf{z}}9.8\ \text{m/s}^2$.)

Answer: $\mathbf{B} = \hat{\mathbf{y}}0.49\ \text{T}$

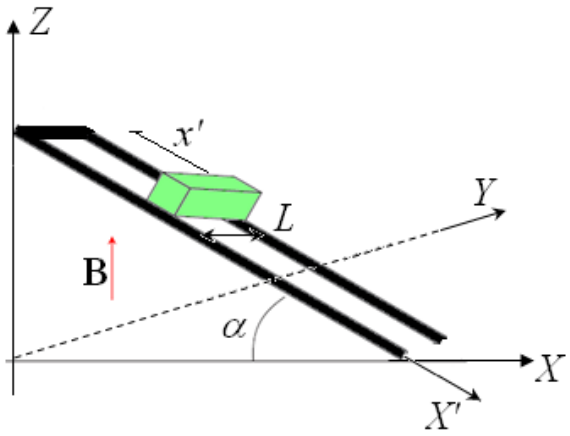
2. A rectangular conducting rod of mass *m* and length L is placed on top of two conducting rails inclined at an angle of α from the horizontal, as in the Figure. If the resistance of the conducting rails changes according to $R=R_0\,x^2$ and there is a magnetic field $B=B_0x$ directed upwards in the system. The rod slides down the rails due to the force of gravity with an increasing velocity *v*.

a) Estimate the retarding force
b) If the rod was at rest, estimate the time that it will take it to reach a velocity v_0

Hint: $\int c/(ax+b)\,dx = c/a\,\ln(ax+b) + C$

Consider: $B_0 = 1\ \text{Tm}^{-1}$, m=2Kg, L=30cm, α=30°, $R_0 = 3\ \Omega\text{m}^{-2}$, $v_0 = 10\ \text{ms}^{-1}$.

Answers: a) $F_m = (B_0L)^2\cos^3\alpha\ v/R_0$
b) t =2.0586 s (for the given values)



3. Consider an infinitely large sheet of thickness b lying in the xy plane with a uniform current density $\mathbf{J}=J_0\hat{\mathbf{x}}$. Find the magnetic field everywhere.

Answer: $\mathbf{B} = -\hat{\mathbf{y}}J_0b\mu_0/2$ $\quad z > b/2$
$\mathbf{B} = \hat{\mathbf{y}}J_0b\mu_0$ $\quad -b/2 < z < +b/2$
$\mathbf{B} = +\hat{\mathbf{y}}J_0b\mu_0/2$ $\quad z < -b/2$