Physics Competition
Electromagnetism Track

The Physics Department is excited to present the second edition of the Physics Competition! Give the problems below your best shot for an opportunity to win PRIZE MONEY. Last year $700 in prize money was given out to students like you!
Submit your solutions online by April 20. More information and submission at the website:
`http://ctp.citytech.cuny.edu/~physolympic/index.php`

1. Suppose a particle of charge $Q = 3.0 * 10^{-19}$ Coulombs is moving in a magnetic field $\vec{B}$ which is oriented perpendicular to the velocity of the particle, $\vec{v}$. The mass of the particle is $m = 7.0 * 10^{-24}$ grams . What is the period of motion of the particle i.e. how long does it take to complete a circle? Take $v = 2.0 * 10^6$ meters per second, and $B = 4.0$ Tesla.

2. If we lived in a two dimensional world, a charge q would experience the following electric potential energy change due to moving from a distance of r_a to a distance of r_b from another point charge Q: $U_b - U_a = k_{2d} q Q \ln \frac{r_a}{r_b}$. (This is the analog of the usual expression that you are used to in 3 dimensions $U_b - U_a = kqQ(\frac{1}{r_b} - \frac{1}{r_a})$. k and k_{2d} are the Coulomb's constants in 3 and 2 dimensions respectively.) Suppose charge Q is held in place but charge q is released from rest. The mass of charge q is m. The speed at the distance r_a is v_a. The speed at the distance r_b is v_b. Find v_b as an algebraic expression in terms of k_{2d}, q, Q, r_a, v_a, and r_b. Hint: Remember that potential energy plus kinetic energy is conserved.

3. Compute the equivalent resistance of the circuit below in terms of R, which you should consider as given. Each individual resistor has resistance R and the triple dots indicate that the diagram continues forever. Hint: Consider the circuit as a parallel arrangement of the leftmost resistor and the rest of the resistor ladder. Now describe the latter as an arrangement of the original entire circuit (since it's infinite removing the front pieces doesn't matter) and some other resistors.