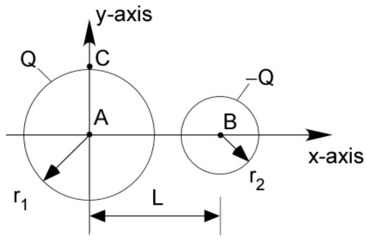
Physics 9C-A	**Final Exam**	**Winter of 2016**

1. Two thin insulating spherical shells with radius r_1 and r_2 carry uniformly distributed charges + Q and - Q, respectively. The centers of the shells are separated by a distance L > $(r_1 + r_2)$.

(a) (**10 points**) Find the direction and magnitude of the electric field at the center (A) of the positively charged shell;

(b) (**10 points**) Find the electric field just outside the positively charged shell at C;

(c) (**15 points**) Find the potential difference between the center of the positively charge shell and the center of the negatively charged shell, V_A - V_B.

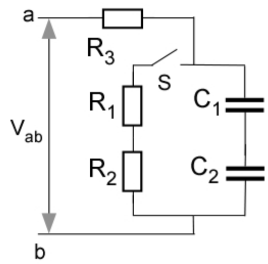


2. In the following circuit with R_1, R_2, R_3, C_1, and C_2, a potential difference V_{ab} is maintained between *a* and *b*.

(a) (**10 points**) Find charges on the two capacitors *before* the switch is closed and yet long after V_{ab} is applied;

(b) (**10 points**) Find the charges on the capacitors *long after* the switch is closed.

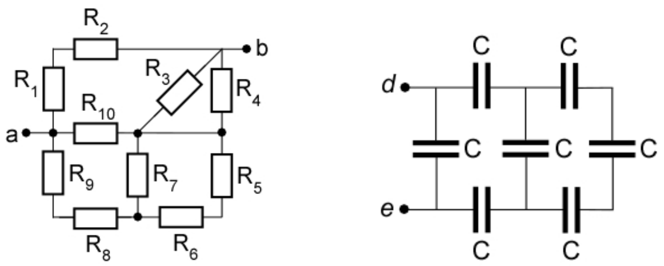
(c) (**10 points**) Find the current through each of the three resisters *immediately after* the switch is closed.



3. In the following circuits,

(a) (**15 points**) Find the equivalent resistance R_{ab} of the network between *a* and *b*;

(b) (**10 points**) Find the equivalent capacitance C_{de} between *d* and *e*.

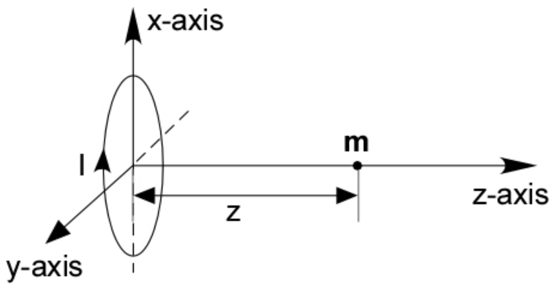


4. A loop of radius R carries a clockwise current I in the x-y plane. A small permanent magnet of dipole moment **m** is on the axis of the loop at a distance z > 0 from the loop center.

(a) (**10 points**) If **m** is along the positive x-axis, find the magnitude and direction of the torque on **m**;

(b) (**5 points**) If **m** is along the positive z-axis, find the direction of the force on **m**;

(c) (**10 points**) Continuing with Part (b), find the magnitude of the force on **m**. (Hint: Starting with the potential energy of **m** in the magnetic field of the loop).

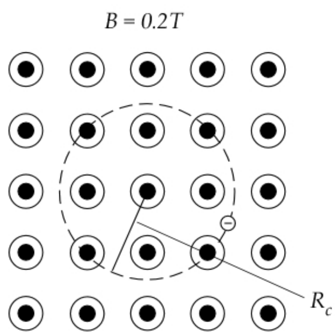


5. A uniform magnetic field **B** = 0.2 T is pointing out of the page. An electron ($m_e = 9.1 \times 10^{-31}$ kg, $q_e = -1.6 \times 10^{-19}$ C) is moving inside the plane of the page at a speed $v = 4 \times 10^7$ m/s.

(a) (**5 points**) Find the direction of cyclotron motion of the electron and explain your choice;

(b) (**5 points**) Find the radius R_c of the circular motion;

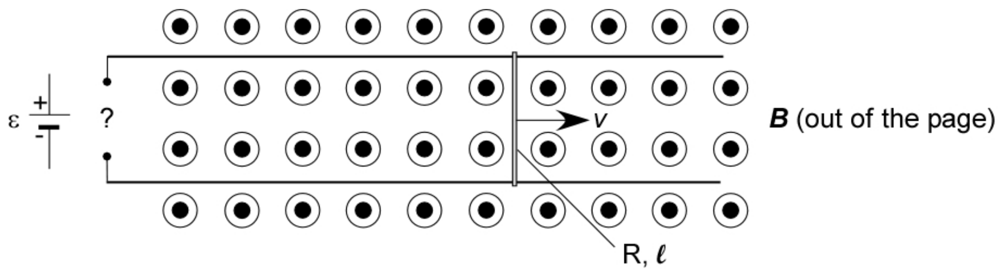
(c) (**15 points**) When the electron is moving to the left, you apply an electric field so that the electron keeps on moving to the left at the same velocity. What is the direction and magnitude of the applied electric field?



6. As shown in the figure on the next page, a conducting bar of length ℓ can slide without friction on two long parallel conducting rails in the plane of the page. The resistance of the bar is R. The resistance of the rails can be neglected. At the far left side, the two rails are connected to a battery of ε. A uniform magnetic field **B** is pointing out of the page.

(a) (**15 points**) If a battery with a value ε and is connected from the lower rail to the upper rail, find the direction and the magnitude of an external force required to keep the bar not moving?

(b) (**15 points**) If one wants the bar to move to the right at a constant speed of v, what is the required magnitude of ε in terms of R, **B**, v, and ℓ? And how should the battery be connected to the two rails?



7. A long wire caries a current I. A slender rectangular wire loop ($a << r$) is placed next to the long wire. The loop has resistance R.

(a) (**15 points**) Find the magnitude and direction of the net magnetic force on the loop if there is a current I_1 flowing counterclockwise in the loop;

(b) (**15 points**) If the current in the long wire increases with time as $I = I_0 + \alpha t$ ($\alpha > 0$), find the magnitude and direction of the induced current in the loop due to the current in the long wire at t = 0.
(Hint: treat the magnetic field through the loop a constant throughout the loop).